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Silver Hake Stock Assessment in the 4VWX NAFO Subareas Without Age Data Use

by

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INTRODUCTION

The assessment of the silver hake stock state in the 4VWX NAFO subareas is a traditional problem which is carried out for many years. Before 1989 such estimates were calculated by VPA method with tuning for argumentation of terminal coefficients for fishing mortality (Waldron D.E *et al*,1988).

In 1989 such estimates were not obtained during the NAFO Meeting (Anon.,1989),and an attempt to obtain them during the Working Group Meeting held in January 1990 in Copenhagen failed because of great differences in the silver hake age determination by the canadian and soviet scientists (Lassen H.,1990). Then it was recommended before clearing up the difference in age determination to assess the silver hake stock with the methods which do not require the data on catch at age composition.

Production models and models constructed on the basis of size structure are to be pointed out first of all among such methods. Attempts of using production models, including Deriso's model (Deriso R.B.,1980) failed as well which had evidently been related to high degree of variability in the silver hake recruitment values. Among methods constructed with size structure using methods suggested by Fournier D.A. and Doonan I.J.(1987) and Schnute J.(1987) are singled out. These methods are a priori prospective for the silver hake stock assessment. More detailed consideration indicated that the paper by Fournier and Doonan , in spite of great degree of detailization for practical use had some weak points related with the preparation of initial data. In particular, one may expect difficulties for argumentation of coefficients determinations which define the transition of fish from one group to another. That is why as the methodical background Schnute model was adopted that is general cohort analysis suggested by Schnute on the basis of his structural model.

MODEL BY SCHNUTE AND THE METHODS FOR ITS PARAMETERS DETERMINATION

On the background of Schnute model (Schnute J.,1987) there is the hypothesis that the individual growth satisfies the next equition

$$w' = W + \rho \cdot w \qquad (1)$$

where w - fish weight at a certain time;
w' - weight of the same fish in a year;
W and ρ - parameters.

In this case it is possible to introduce the structure for this population dividing all the range of weight change into a number of uncrossed semiintervals

$$[U, U_1), \ldots, [U_{g-1}, U_g), [U_g, U_{g+1}), [U_{g+1}, U_{g+2}) \qquad (2)$$

bounderis of each of them are related by

$$(U_{t-1})' = U_t \qquad (3)$$

where ' means change of corresponding value for one year. The last interval in (2) is the most important and includes all the individuals, weight of which are greater than U_{g+1} grammes.

Populational dynamics in the model is described by abunance density $N(w,t)$ at t moment in w point, with which it is possible to determine fish abundance at t moment and weight of which is inside a given interval $[V, V')$

$$N_t = \int_V^{V'} N(w,t)dw \qquad (4)$$

Beside the abundance Schnute model uses other momentum characteristics. Thus,

$$N_t^{[n]} = \int_V^{V'} w^n \cdot N(w,t)dw \qquad (5)$$

determines n-th momentum of abundance density which with n=1 corresponds to biomass in the weight intervals $[V, V')$

$$N_t^* = \int_V^{V'} w \cdot N(w,t)dw \qquad (6)$$

Mean values of these momenta can be written as follows:

$$X_t^{[n]}=N_t^{[n]} / N_t \qquad (7)$$

that with n=1 determines fish mean weight in the interval $[V,V')$

$$X_t=N_t^* / N_t \qquad (8)$$

Similarily to (5) and (6) central momenta relatively to mean value are determined

$$N_t^{[n]} = \int_V^{V'} (w - X_t)^n \cdot N(w,t)dt \qquad (9)$$

Main equition of abundance dynamic in Schnute model written for densities is as follows:

$$\tau \cdot N(w,t)=\sigma[N(w,t)-\mu \cdot C(w,t)]-(1-\mu)\cdot C(w,t) \qquad (10)$$

where
- τ_t – survival $e^{-(F+M)}$ at t moment;
- σ – survival e^{-M};
- F – fishing mortality coefficient;
- M – natural mortality coefficient;
- μ – timming parameter which determines interaction of natural and fishing mortality in time.

Integration of equation (10) leads to the corresponding expression, which describes biomass dynamics

$$\tau_t \cdot N_t^*=\sigma[N_t^*-\mu \cdot C_t^*]-(1-\mu)\cdot C_t^* \qquad (11)$$

Variations in the above mentioned formulas are evident if it is nessessery to write them for t interval from the sequence (2). So

$$N_{tt}= \int_{U_{t-1}}^{U_t} N(w,t)dw \qquad (12)$$

$$N = \int_{U_{t-1}}^{U_t} w \cdot N(w,t)dw \qquad (13)$$

$$X_{tt}=N_{tt}^* / N_{tt} \qquad (14)$$

However, taken into account a special importance of intervals $[U_g,U_{g+1})$ and $[U_{g+1},U_{g+2})$, we will use according Schnute simple t index for the values that charactarize fish weight of which exceeds U_g. Then

$$\tau_t(w)=\begin{cases} \tau_{lt}, \text{ if } w \quad [U_{l-1},U_l),\ l=1,2,\cdots,g \\ \tau_t, \text{ if } \ w > Ug \end{cases} \tag{15}$$

N_t means quantity of fish , weight of which is more than U_g and so on.

Now we can write formulae of general cohort analysis by Schnute :

for groups $1,2,\ldots,g$

$$N_{l+1,t+1}=\tau_{lt}\cdot N_{lt} \tag{16}$$

$$X_{l+1,t+1} = w + \rho\cdot X_{lt} \tag{17}$$

$$X^{(n)}_{l+1,t+1} = \rho^{n}\cdot X^{(n)}_{lt} \tag{18}$$

for groups $g+1$, $g+2$

$$N_{g+2,t+1}=\tau_t\cdot N_t \tag{19}$$

$$X_{g+2,t+1} = w + \rho\cdot X_t \tag{20}$$

$$X^{(n)}_{g+2,t+1}= \rho^{(n)} \cdot X^{(n)}_t \tag{21}$$

It must be noted that there is no necessity to give both fishing mortality and natural mortality as a constant for all the groups. This values must be constant only for groups $g+1$ and $g+2$.

It is important to note in above mentioned formulae the concept of age groups is not used what give us a key to solution of the problem of the silver hake stock assessment without using catch at age information.

As in a traditional cohort analysis in Schnute's cohort analysis supposing natural mortality coefficients and fish capture in specimens by groups and fishing years and some additional information to be known, it is necessary to determine abundance , biomass and indices of abundance decrease by fishing.

As the method for unknown values determination it is the most reasonable to use the method similar to the CAGEAN - method(Deriso R.B.,*et all.*,1985). One may use as values observed which characterize the silver hake stock state standardized catch rate by fishing years ,abundance index by weight according to the data of trawl surveys and possibly abundance index for recruitment. For the latter it is possible to use the abundance of the first or the second age group index by the canadian trawl surveys data or estimates of recruitment obtained during USSR - Canada juvenile surveys.

One more source of information on the silver hake stock state may be estimates of abundances and biomass obtained with the Adaptive Framerwork for 1977 - 1988.

Let it be suggested that catch rate is a linear function of biomass with the q proportionality coefficient

$$cpue(y)=q\cdot\frac{B(y)+B(y+1)}{2} \qquad (22)$$

where $cpue$ - standardized catch rate ;
$B(y)$ - biomass estimate in y year;
q - proportionality coefficient.

Then, similar to (Deriso R.B. *et all.*,1985),

$$SSQ(cpue)=\sum_{y=1}\left[cpue'(y)-cpue(y)\right]^2 \qquad (23)$$

where $cpue'(y)$ - catch rate calculated by the formula (22).

In the same manner

$$J(y)=q_J\cdot B(y) \qquad (24)$$

$$J(y)=q_J\cdot N_{1y} \qquad (25)$$

and

$$SSQ(SRV)=\sum_{y=1}\left[J'(y)-J(y)\right]^2 \qquad (26)$$

$$SSQ(SRVJ)=\sum_{y=1}\left[J'(y)-J(y)\right]^2 \qquad (27)$$

where $J'(y)$ and $J(y)$ - estimates of corresponding abundance indices by formulae (24) and (25);
SRV and SRVJ - mean that corresponding estimates are ....determined by the data of trawl surveys and juvenile surveys.

Therefore, we may put a problem of the unknown values determination from the minimization of the following function

$$SSQ=SSQ(cpue)+\lambda_1\cdot SSQ(SRV)+\lambda_2\cdot SSQ(SRVJ) \qquad (28)$$

The following parameters are used as arguments of this function:

a)abundance of size groups in the first fishing year;

b)abundance of the first size group by fishing year beginning from the second year.

λ_1 and λ_2 can be determined by the method (Gassuikov P.S.,1990),using for this purpose either time series of catch rate or biomass estimate for silver hake obtained by the Adaptive Framework.

SSQ function (28) certainly may be changed ommiting some components what corresponds to the equality to zero relavant λ coefficients.

As the second method for determination of unknown values the method similar to Gavaris (1988) Adaptive Framework may be used. However, in contrast to its traditional realization algoritm of determinations of fishing mortality coefficients for older intervals $[U_{g+1}, U_{g+2})$, $[U_{g+2}, U)$ has a certain specificity. The following sequence of calculations may be used for this porpose.

1.Let us consider that the current value of fishing motarlity coefficient in t terminal year for $g+1$ interval is determined. This coefficient may be among the colibration coefficients or it may be defined as a function of these coefficients.

2.Fish abundance in the $g+1$ interval is calculated by the formula

$$N_{g+1,t}=C_{g=1,t}\cdot\frac{Z}{F_{g+1,t}\cdot(1-exp(-Z))} \qquad (29)$$

3.Using the equality

$$F_{g+1,t}=F_{g+2}$$

for each t, from approximated relation

$$(N_{g+1,t} + N_{g+2,t})\cdot exp(-Z)=(N_{g+1,t} + N_{g+2,t})\cdot exp(-M) - (C_{g+1,t}+C_{g+2,t})\cdot exp(-M/2) \qquad (30)$$

$(N_{g+1,t}+N_{g+2,t})$ value may be determined and the $N_{g+2,t}$ value may be determined as well.

4.Further calculations are made for y values, $y=t-1,\ldots,1$

$$(N_{g+1,y} + N_{g+2,y})=\left[N_{g+2,y+1} +(C_{g+1,y}+C_{g+2,y})\cdot e^{-M/2}\right]\cdot e^{M} \qquad (31)$$

$$F_{g+1,y}=F_{g+2,y}=\left[-ln\frac{N_{g+1,y+1}}{N_{g+1,y} + N_{g+2,y}}\right]-M \qquad (32)$$

$$N_{g+1,y} = C_{g+1,y}\cdot\frac{Z}{F_{g+1,y}\cdot\left[1-exp(-Z)\right]} \qquad (33)$$

$N_{g+2;y}$ is defined from the calculation results of (31) and (33).

The rest of calculations totally corresponds to the selected versions of the Adaptive Framework (Gavaris S.,1988). The first approach based on the CAGEAN - method principle requires much relatively to the initial data, as uses greater number of unknown values than with the Adaptive Framework. The implementation of this method assumes using additional information which is in the estimates of momenta for different order weight of fish in some or another weight interval dynamics of variations of which is described by (17),(18),(20),(21).

DATA USED

The author has no at his disposal all the necessary row information which there exists in NAFO and that is available for canadian scientists. Further calculations must be considered as a conventional and illustrative form. The basic data used in the calculations correspond to adopted data base for the silver hake stock estimates (Lassen H.,1990). However, taking into account the spicific features of Schnute's general cohort analysis, it was requied to make the recalculations.

To determine the parameters of growth equation (1) there have been used the values of fish mean weight for 1 through 7 age groups for 1977-1989 which are cited in the paper (Waldron D.E. *et all.*,1989). Parameters have been determined by the method of least squares , being coefficient correlation equal to 0.901, being correlation graph plotted in Figure 1.

The equation has the following form

$$w' = 83.23 + 0.8806 \cdot w \qquad (34)$$

In Table 1 boundaries of seven size and weight intervals calculated by this equation (34) and equation (35) are given.

Catch ammount by size groups (2) must be determined using the raw data. For this purpose one may construct the similarity of length frequency of catch. However, the absence of these data did not allowed for obtaining of real values.The following procedure was used to give an illustrative example. Age - length key for 1989 (Table 2) obtained by the soviet scientists and estimates of fish summary abundance in catches for 1977 - 1989 represented in the paper (Waldron D.E.*et al.*,1989) are in its background. Using age - length key and age composition of catches for the given period there was recalculated size composition of catches which permitted to obtain with the growth equation the amount of catch in numbers for the size interval (2). The equation

$$W = 0.002865 \cdot L^{3.225476} \qquad (35)$$

was used as the growth equation (Mari A.,Saba B.,1978). The author realizes the degree of correctness of this procedure, that is why the whole calculation is to be considered as illustrative one.

Similary, mean weight of fish by intervals and years is determined in an approximate manner using the equation (34) and initial values of weight, that is fish mean weight for age 1 from the paper (Waldron D.E. *et al.*,*1989)*. Corresponding data are represented in Tables 3 and 4.

As an additional information there were used with calculating:

- standardized catch rate for 1977 - 1989 by multiplicative model (Gavaris S.,1980). Standardization was made by initial data given in the paper (Lassen H.,1990);

- recruitment values - abundance of the first age group for 1977 - 1989 by the data of canadian trawl surveys (Waldron D.E. *et al.*,1989). These indices using corresponds to the adopted data base (Lassen H.,1990).

The additional information is represented in Tables 5 and 6.

ILLUSTRATIVE EXAMPLE: CALCULATION RESULTS

As it has been pointed out author's lack of the raw information necessary for formation of initial data for calculation did not permit implementation of the approach suggested in the form which had practical significance.

Therefore, the second method for parameters determination was used as illustration. The following fomulae were used as the object function in an Adaptive Framework

$$\sum\left[\frac{cpue_y - cpue_y'}{SE_y}\right]^2 \qquad (36)$$

$$\sum\left[\frac{cpue_y - cpue_y'}{SE_y}\right]^2 + W_1 \cdot \sum(J_y - J_y')^2 \qquad (37)$$

where J - abundance index for recruitment by the canadian trawl surveys data.

Tuning was made by coefficients of fishing mortality for 3,4,5 intervals. Multiplier W_1 for object function 2 is 0.01.

The calculation results are represented in the next manner:

a)for object function 1 - in Tables 7,8, and 9;

b)for object function 2 - in Tables 10,11 and 12.

If the calculations are compared with the values of the silver hake stock obtained in previous years, it must be adopted that the values of biomass in Tables 9 and 12 are overestimated. This bias in estimates is probably related to the bias in initial data (catch by size intervals, weight of fish in size intervals).

Nevertheless, coefficient of correlation between catch rate and biomass estimate was 0.84. In Figure 2 time trend for these values is plotted.

CONCLUSION

The approach suggested permits in principle to calculate the estimate of the silver hake stock in the 4VWX NAFO subareas without using data of age composition of catches. It is necessary to prepare initial data by size interval using raw data of observations to implement this method in practice. Such data are available in NAFO data base and are available for Canada scientists. It is the most important to obtain the catch values in numbers and estimates of abundance indices for each size group and fishing years, as well as the estimates of fish mean weight and some momenta of these values using the raw data observed.

It must be noted that in the case when for the silver hake stock assessments age data are also used the approach suggested may be implemented to obtain data of catch in the current year when age samples are not processed yet. Besides, numerous combinations of two approaches are possible for complete utilization of information.

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Table 1.Boundaris for the size and weight intervals for silver hake

No	Size intervals	Weight intervals
1	15.0-25.4	17.75- 98.86
2	25.5-30.1	98.86-170.30
3	30.2-33.2	170.30-233.18
4	33.3-35.5	233.18-288.60
5	35.6-37.3	288.60-337.50
6	37.4-38.7	337.50-380.30
7	38.8-46.0	380.30- ∞

Table 2.Size - age key for 1989 for the silver hake size composition catches calculation

	1	2	3	4	5	6	7	8	9
13	9	0	0	0	0	0	0	0	0
14	19	0	0	0	0	0	0	0	0
15	21	0	0	0	0	0	0	0	0
16	27	0	0	0	0	0	0	0	0
17	30	0	0	0	0	0	0	0	0
18	34	0	0	0	0	0	0	0	0
19	43	0	0	0	0	0	0	0	0
20	38	0	0	0	0	0	0	0	0
21	38	2	0	0	0	0	0	0	0
22	22	15	0	0	0	0	0	0	0
23	7	37	0	0	0	0	0	0	0
24	0	41	0	0	0	0	0	0	0
25	0	47	0	0	0	0	0	0	0
26	0	77	0	0	0	0	0	0	0
27	0	75	2	0	0	0	0	0	0
28	0	68	8	0	0	0	0	0	0
29	0	42	37	0	0	0	0	0	0
30	0	7	70	1	0	0	0	0	0
31	0	4	55	4	0	0	0	0	0
32	0	0	12	34	0	0	0	0	0
33	0	0	8	34	0	0	0	0	0
34	0	0	4	36	3	0	0	0	0
35	0	0	0	7	30	3	0	0	0
36	0	0	0	4	18	3	0	0	0
37	0	0	0	0	19	3	0	0	0
38	0	0	0	0	20	3	0	0	0
39	0	0	0	0	12	8	0	0	0
40	0	0	0	0	9	15	0	0	0
41	0	0	0	0	3	15	3	0	0
42	0	0	0	0	0	5	14	0	0
43	0	0	0	0	0	3	11	0	0
44	0	0	0	0	0	1	11	3	0
45	0	0	0	0	0	1	10	4	0
46	0	0	0	0	0	0	8	4	0
47	0	0	0	0	0	0	5	9	0
48	0	0	0	0	0	0	5	7	0
49	0	0	0	0	0	0	1	9	1
50	0	0	0	0	0	0	0	5	7
51	0	0	0	0	0	0	0	1	5
52	0	0	0	0	0	0	0	0	4
53	0	0	0	0	0	0	0	0	5
54	0	0	0	0	0	0	0	0	6
55	0	0	0	0	0	0	0	0	3
56	0	0	0	0	0	0	0	0	1
57	0	0	0	0	0	0	0	0	2

Table 3. Commercial catches of silver hake ('000)

by weight intervals for 1977 - 1989

	77	78	79	80	81	82	83	84
1	37832	34779	32801	34822	10079	29319	32714	79090
2	70576	71376	58697	74713	53640	57676	83037	98303
3	47161	68591	59270	61018	86641	78159	50465	166337
4	11355	25988	26027	23895	27267	46982	20695	55951
5	1573	6843	9761	7153	6016	15087	5765	11012
6	923	6061	9887	6703	4963	14080	5186	8257
7	1095	10893	16382	9707	6384	15035	6816	9568

	85	86	87	88	89
1	49838	67760	71259	23430	41545
2	122250	117381	190093	125537	169325
3	116509	180458	93614	185769	199836
4	77477	61682	35319	37222	45327
5	18840	15182	6619	9387	10254
6	14935	13169	4594	9131	5993
7	18283	16041	8744	10548	4766

Table 4. Mean weight of the silver hake individuals

in catches by weight intervals for 1977 - 1989

	77	78	79	80	81	82	83	84	85	86	87	88
1	.06	.06	.06	.06	.07	.06	.07	.05	.07	.05	.07	.07
2	.13	.13	.13	.13	.14	.13	.13	.14	.13	.14	.13	.14
3	.18	.19	.19	.19	.18	.19	.19	.18	.19	.18	.19	.18
4	.24	.24	.25	.24	.24	.25	.24	.24	.24	.24	.24	.24
5	.29	.29	.30	.29	.29	.29	.29	.29	.29	.29	.29	.29
6	.35	.35	.35	.35	.35	.35	.35	.35	.35	.35	.35	.35
7	.45	.50	.48	.47	.48	.45	.46	.45	.45	.45	.46	.47

	89
1	.06
2	.13
3	.19
4	.24
5	.29
6	.35
7	.44

Table 5. Standardized values of catch rate for the

silver hake fisheries in the NAFO 4**VWX** subareas

PREDICTED CATCH RATE

STANDARDS USED VARIABLE NUMBERS: 1 5 450 2 1

YEAR	TOTAL CATCH	PROP.	CATCH RATE MEAN	S.E.	EFFORT
77	37095	0.703	2.546	0.452	14569
78	48404	0.879	2.039	0.308	23739
79	51751	0.827	2.483	0.423	20843
80	44525	0.920	1.723	0.344	25845
81	44599	0.833	1.976	0.361	22572
82	60207	0.958	4.940	1.052	12187
83	35837	0.921	2.444	0.510	14662
84	74266	0.967	4.005	0.840	18544
85	75480	0.981	3.486	0.731	21653
86	82689	0.427	6.644	1.562	12446
87	61704	0.926	6.613	1.567	9331
88	74482	0.879	4.639	1.090	16057
89	86729	0.984	6.804	1.559	12747

AVERAGE C.V. FOR THE MEAN: .205

Tables 6.Abundance indices of recruitment by the canadian trawl surveys data

77	78	79	80	81	82	83	84	85	86	87	88
7.7	26.7	89.4	17.7	32.8	192.0	114.3	189.0	102.7	552.6	146.0	69.7

Table 7.Fishing mortality of silver hake in the NAFO 4**VWX** subareas

(object function 1)

	77	78	79	80	81	82	83	84	85	86	87	88	89
1	.040	.038	.029	.033	.009	.023	.025	.042	.028	.007	.104	.063	.223
2	.136	.122	.104	.107	.081	.079	.104	.119	.105	.106	.030	.340	1.114
3	.179	.238	.175	.185	.216	.204	.114	.394	.252	.280	.142	.046	2.228
4	.033	.176	.165	.122	.146	.217	.094	.223	.409	.257	.099	.095	.017
5	.019	.081	.114	.076	.050	.139	.045	.081	.134	.160	.048	.042	.041
6	.014	.117	.199	.130	.085	.195	.079	.103	.185	.160	.081	.106	.041
7	.014	.117	.199	.130	.085	.195	.079	.103	.185	.160	.081	.106	.041

Table 8.Silver hake abundance in the NAFO **4VWX** subareas by weight intervals

(object function 1)

	77	78	79	80	81	82
1	1178403	1129389	1387485	1292772	1391773	1574387
2	676476	758933	728578	903204	838061	924682
3	351570	395672	450291	440323	544266	517852
4	173458	197053	209069	253313	245200	293897
5	100919	106976	110812	118834	150237	142038
6	83257	66360	66105	66288	73801	95781
7	100073	121238	111871	97793	96551	104900
1+	2664155	2775620	3064210	3172527	3339890	3653538

	83	84	85	86	87	88
1	1640393	2330778	2195189	11622292	881222	468789
2	1031339	1072805	1497614	1430675	7735178	532359
3	572611	623343	638639	903791	862907	5029410
4	283135	342515	281654	332703	458082	501779
5	158539	172848	183786	125366	172517	278145
6	82859	101552	106848	107770	71605	110222
7	110684	119909	133856	134151	138250	129750
1+	3879561	4763749	5037585	14656748	10319760	7050455

	89
1	250543
2	295056
3	254069
4	3219220
5	305878
6	178760
7	144746
1+	4648273

Table 9.Silver hake biomass in the NAFO **4VWX** subareas

(object function 1)

	77	78	79	80	81	82	83
1	70822	67312	78532	80798	95476	89740	115320
2	87062	99572	95735	116965	116993	122798	130980
3	64197	73239	83664	81548	100145	97978	106277
4	41855	48041	51368	61935	59584	72063	69142
5	29519	31504	32723	35032	44170	41859	46690
6	29082	23180	23091	23154	25779	33456	28943
7	45063	61031	53217	45865	45920	47289	50914
1+	367600	403879	418329	445298	488066	505183	548265

	84	85	86	87	88	89
1	105584	148614	576466	64946	31878	15834
2	150193	191994	197862	973085	74530	39744
3	115069	122108	166749	159983	912838	47384
4	83129	68724	81013	111131	121832	773900
5	50731	53996	36895	50599	82025	89928
6	35472	37322	37644	25012	38501	61905
7	53983	60249	60905	63526	61307	63529
1+	594160	683006	1157535	1448282	1322910	1092225

Table 10.Fishing mortality of silver hake in the

NAFO 4VWX subareas

(object function 2)

	77	78	79	80	81	82	83	84	85	86
1	.039	.038	.029	.033	.009	.023	.024	.041	.027	.008
2	.134	.120	.101	.104	.079	.077	.101	.114	.100	.100
3	.176	.233	.171	.181	.210	.197	.110	.383	.241	.264
4	.082	.172	.161	.119	.142	.210	.090	.213	.392	.243
5	.019	.080	.111	.074	.049	.134	.044	.078	.127	.151
6	.013	.115	.195	.127	.082	.189	.076	.099	.176	.151
7	.013	.115	.195	.127	.082	.189	.076	.099	.176	.151

	87	88	89
1	.050	.019	.044
2	.035	.143	.222
3	.133	.054	.443
4	.092	.089	.020
5	.045	.039	.038
6	.076	.098	.038
7	.076	.098	.038

Table 11.Silver hake abundance in the NAFO 4VWX

subareas by weight intervals

(object function 2)

	77	78	79	80	81	82
1	1199907	1151945	1417514	1328107	1434794	1607867
2	686570	773347	743697	923333	861747	953519
3	356902	402439	459953	450458	557759	533729
4	176378	200627	213605	259790	251994	302941
5	102654	108933	113207	121875	154578	146592
6	84688	67524	67417	67894	75839	98692
7	101792	123349	114066	100144	99204	108045
1+	2708892	2828164	3129461	3251601	3435915	3751385

	83	84	85	86	87	88
1	1696491	2431832	2311096	10033964	1801001	1559172
2	1053781	1110408	1565352	1508370	6670490	1148905
3	591942	638386	663845	949197	914987	4315728
4	293778	355473	291738	349599	488519	536690
5	164602	179982	192472	132125	183843	298547
6	85912	105616	111630	113593	76136	117814
7	114742	124675	139775	141325	146961	138627
1+	4001248	4946372	5275909	13228173	10281937	8115484

	89
1	1160931
2	1025961
3	667353
4	2740825
5	329279
6	192437
7	155785
1+	6272570

Table 12.Silver hake biomass in the NAFO 4VWX subareas

(object function 2)

	77	78	79	80	81	82	83
1	72114	68656	80231	83007	98427	91648	119263
2	88362	101463	97722	119572	120300	126627	133830
3	65170	74491	85459	83425	102628	100982	109864
4	42560	48913	52483	63519	61234	74281	71741
5	30026	32081	33430	35929	45446	43201	48475
6	29581	23586	23549	23715	26490	34473	30009
7	45837	62094	54261	46968	47181	48707	52781
1+	373651	411284	427135	456133	501707	519919	565964

	84	85	86	87	88	89
1	110162	156461	497685	132734	106024	73371
2	155457	200678	208608	839148	160847	138197
3	117846	126927	175127	169639	783305	124461
4	86273	71184	85127	118515	130308	658894
5	52825	56548	38884	53921	88042	96808
6	36892	38992	39678	26594	41153	66641
7	56129	62913	64161	67529	65501	68374
1+	615584	713704	1109270	1408079	1375179	1226746

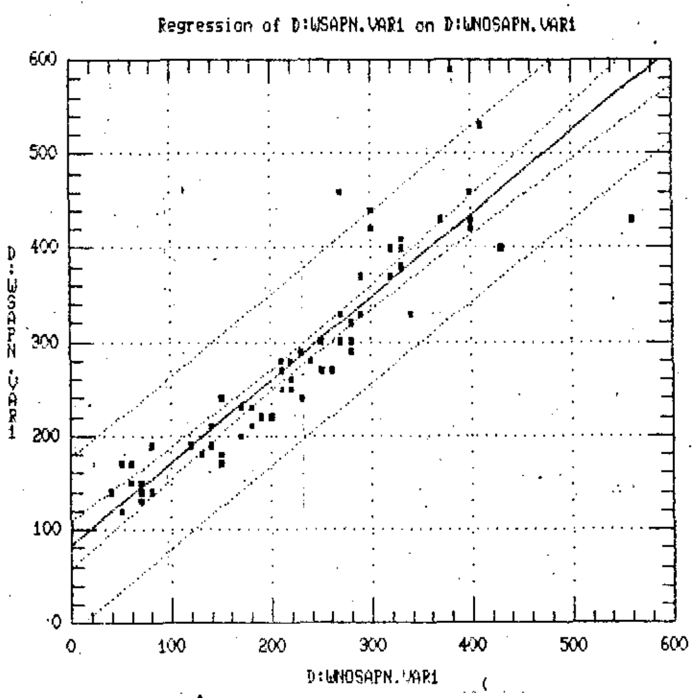

Figure 1. $w' = W + \rho \cdot w$ dependece for silver hake from the NAFO 4VWX subareas

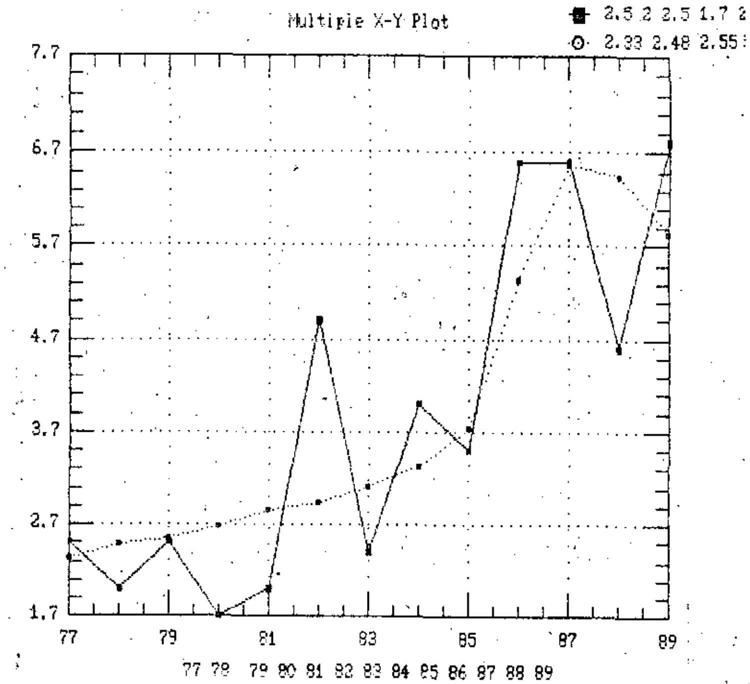

Figure 2.Trend of catch rate values and a biomass estimates for silver hake from the NAFO 4VWX subareas

■ - catch rate;

o - calculated by the eq. 0.8+0.0041·biomass