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An examination of the 1976 USSR assessment of the Div. 4VWX silver hake fishery

by

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This paper presents an assessment of the Div. 4VWX silver hake fishery based on the data presented by Noskov (1976). Catch data (numbers at age) were given by Noskov (1976) for 1963-1975 for Div. 4W. These data were prorated to include the total catch in Div. 4VWX (Table 1). Virtual population analysis (VPA) was performed using M=0.5 for all ages and F=1.0 for ages 3 and older in 1975, as assumed by Noskov (1976). Terminal F for those year-classes having passed through the fishery prior to 1975 was assumed to be the mean F for the fully-recruited age groups (weighted by stock size) in that particular calendar year.

Partial recruitment at ages 1 and 2 averaged 3% and 12% during 1963-1974 and 5% and 18% during 1968-1974 (Table 2), as indicated by fishing mortality rates calculated from VPA. Partial recruitment of 5% at age 1 and 18% at age 2 was assumed for 1975-1977. Fishing mortality at ages 1 and 2 in 1975 was assumed to be 0.05 and 0.18, respectively.

Mean weights at age (given in Table 4) used in this assessment were those presented by Noskov (1976) which were calculated from Halliday (1973). These weights were applied to the numbers caught at age to determine the calculated catch in each year. The ratio between calculated and observed catch in each year (Table 3) varied from 0.8251 to 1.2824 and averaged 1.0264 for 1963-1975. The mean weights at age were also used to calculate stock biomass in each year, and the total weight was corrected using the calculated/observed catch ratio for that year. The ratio in 1975 (0.8994) was used to correct the catch and stock biomass predictions for 1976-1977 (Table 4).

Results of the VPA are given in Table 1 and Figures 1 and 2. Fishing mortality was high in 1963-1965 (mean of 1.28), declined to a low of 0.024 in 1968, averaged about 0.32 during 1969-1972, and then increased sharply to 1.44 in 1973. Fishing mortality dropped to 0.66 in 1974 and then increased to an estimated level of 1.0 in 1975.

Stock biomass (age 1+) decreased from about 392,000 tons in 1963 to 186,000 tons in 1966, increased rapidly to 1,261,000 tons in 1971, and decreased sharply to 335,000 tons in 1975 (Table 1, Figure 1). Catches tended to cycle with the biomass; catches decreased after 1963 as biomass decreased, increased after 1968 as biomass increased, and decreased again in 1971 and 1972 as biomass again began to decrease. However, in 1973, nearly half of the estimated biomass

of 630,000 tons was removed by the fishery. This catch (299,000 tons) generated a fishing mortality (F=1.44) twice the optimal level which, according to Noskov (1976), is 0.7 (F_{opt}) for M=0.5.

Results of the VPA show that the cyclic fluctuation in biomass resulted directly from a cyclic fluctuation in recruitment. The strongest year-class during the period was produced in 1969 (5.5 billion fish at age 1) which was followed closely in size by the 1967, 1968, and 1970 year-classes which averaged 4.5 billion fish each (Table 1, Figure 2). The strength of the year-classes produced after 1970 declined steadily each year. Given the catch in 1975 of age 1 and 2 fish and assuming partial recruitment of 5% and 18%, respectively, the sizes of the 1974 and 1973 year-classes at age 1 were calculated to be 0.9 and 1.35 billion fish, respectively. The mean size of the 1962-1974 year-classes at age 1 was 2.6 billion fish.

The sizes of the 1973-1975 year-classes are quite critical in determining stock size at the beginning of 1977 and, accordingly, the 1977 TAC. Noskov (1976) assumed that the 1973 and 1975 year-classes at age 1 were equal to the mean of the 1968-1972 year-classes. In the present analysis, the mean size of the 1968-1972 year-classes is 3.64 billion fish. If the size of the 1973 year-class at age 1 is assumed equal to 3.64 billion fish, this would constitute an estimate which is 2.7 times greater than that calculated by VPA in the present analysis (1.35 billion fish). Results of the present VPA (Table 1) indicate that F=0.032 for the 1973 year-class at age 1 which represents partial recruitment of 4.9% (Table 2). If a year-class of 3.64 billion fish is assumed, the reported catch of 332×10^5 fish would have generated an F of only 0.0117 which represents partial recruitment of only 1.8%. This value is substantially below the mean of 6.0% for 1972-1973, 4.9% for 1968-1973, and 2.9% for 1963-1973. Furthermore, the resulting size of the 1973 year-class at age 2 would have been 2.18 billion fish instead of 0.80 billion as calculated in the present VPA. The reported catch of 1039×10^5 fish (1973 year-class, age 2) would have generated an F of 0.062 (6.2% partial recruitment) instead of 0.18 (18% partial recruitment) as assumed in the present VPA. Partial recruitment of 6.2% at age 2 was observed in 1973, but the 1963-1974 and 1968-1974 means were 12.3 and 17.7%, respectively. For the purposes of prediction, the conservative approach would imply that a mean of the recent values be employed for partial recruitment instead of the lowest of the recent values.

In the present analysis the 1975 and 1976 year-classes at age 1 were assumed equal to the mean of the 1962-1974 year-classes at that age (2.6 billion fish). Following the assumption by Noskov (1976) would result in an estimate for the 1975 year-class (3.64 billion fish) which is 1.4 times larger than that used in the present analysis. Figure 2 clearly illustrates the past (1962 year-class - present) pattern in year-class size at age 1. Results of the VPA suggest a pronounced rise and fall of year-class strength from the early 1960's to the early 1970's with the present trend being in a downward direction. The assumption made in this assessment, therefore, that the 1975 and 1976 year-classes are equal in size to the mean of the 1962-1974 year-classes, may be optimistic. The assumed size of these year-classes exceeds the sizes of the 1971-1974 year-classes which were calculated from the present VPA. This assumption tends to reverse the observed decline in the strength of recent year-classes. A more conservative approach may be to use the mean of the last several years or the lowest observed size that is known with some degree of confidence.

The 1974 year-class at age 2 was assumed by Noskov (1976) to be strong and to equal the mean of the 1968-1969 year-classes. From the present analysis, this would result in 2.97 billion fish at age 2. Given the catch of 349×10^5 fish from the 1974 year-class at age 1, a year-class size of 2.97 billion fish at age 2 implies a fishing mortality of 0.009 at age 1 and a year-class size of 4.95 billion fish at age 1. This is 5.5 times greater than the 0.9 billion fish calculated in the present analysis, and would make the 1974 year-class almost as strong as the 1969 year-class, the largest on record. An F of 0.009 at age 1 in 1975 implies partial recruitment of less than 1% compared to a mean of 5% in 1968-1974 (range of 1.5 to 8.1%). Therefore, unless the fishing pattern suddenly changed in 1975 and the catch of age 1 fish in proportion to their abundance was, for some reason, substantially less than in past years, the assumption by Noskov (1976) concerning the size of the 1974 year-class would result in a considerable overestimate of stock size.

Given the estimated number of fish age 2 and older present at the beginning of 1976 (1.1 billion) as calculated from VPA and assuming that the 1975 year-class at age 1 contained 2.6 billion fish (mean of 1962-1974 year-classes), an F of 1.42 for ages 3 and older (with partial recruitment of 18% at age 2 and 5% at age 1) would be required to generate the 1976 TAC of 100,000 tons (Table 4). Given the resulting estimated stock size of age 2 and older fish at the beginning of 1977 (1.8 billion fish) and assuming that the 1976 year-class at age 1 also contained 2.6 billion fish, fishing mortality of 0.7 in 1977 would result in a TAC of 47,000 tons.

The recommended 1977 TAC from the assessment by Noskov (1976) was 125,000 tons, assuming M=0.5 and F=0.7. The assessment by Doubleday et al. (1976) resulted in a recommended TAC of 60,000-70,000 tons. The TAC which is advised on the basis of the present assessment is lower than that recommended by Noskov (1976) mainly because of the differences in the estimated sizes of the 1973-1975 year-classes. In order to justify a TAC larger than that calculated in the present assessment, strong evidence from research vessel surveys must be presented which would support the optimistic assumption concerning the strength of the 1973-1975 year-classes.

Literature Cited

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Table 1. Catch, fishing mortality (F), and stock sizes for silver hake in Div. 4VWX, 1963-1975, assuming M=0.5

		YEAR-CLASS												
	Year	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965
Catch (10^5)	1963	1	3	6	6	21	442	2045	2778	689	12			
	1964					6	83	342	1702	1188	86	10		
	1965						4	44	301	1050	452	5	1	
	1966							1	16	107	182	123	102	1
	1967								1	3	22	69	20	2
	1968								1	4	6	9	20	107
	1969									12	20	103	300	786
	1970									1	13	29	45	626
	1971										19	41	28	93
	1972										12	5	8	27
	1973										1	5	10	35
	1974												2	7
	1975													
F	1963	(1.370)	(1.370)	(1.370)	(1.370)	.913	1.384	1.373	.512	.118	.002			
	1964					(1.189)	2.279	1.635	1.080	.432	.026	.002		
	1965						(1.277)	2.006	.848	1.417	.261	.002	<.001	
	1966							(.297)	.128	.772	.221	.074	.036	<.001
	1967								.014	.057	.051	.074	.012	<.001
	1968								(.024)	.137	.024	.017	.020	.025
	1969									1.200	.141	.376	.673	.360
	1970									(.399)	.177	.239	.276	.817
	1971										.615	.948	.392	.378
	1972										1.866	.393	.258	.250
	1973										(1.436)	(1.436)	.895	.895
	1974												(.657)	(.657)
	1975													
Stock size (10^5)	1963	2	5	10	10	43	710	3296	8628	7844	6907			
	1964					10	108	506	3136	4229	4182	5889		
	1965						7	60	646	1666	2471	3573	5778	
	1966							5	168	245	1154	2174	3634	14130
	1967								90	69	561	1224	2126	8767
	1968								54	39	323	690	1274	5506
	1969									21	192	412	758	3257
	1970									4	101	172	234	1379
	1971										51	82	108	370
	1972										17	19	44	154
	1973										2	8	21	72
	1974												5	18
	1975													
	1976													

1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
1										
77	8									
837	261	440								
1952	3648	1400	921							
777	2758	2769	1603	201						
146	1015	1531	2617	1374	430					
146	528	2297	6765	7612	981	591	14			
21	35	82	362	1645	2716	1081	332			
2	14	50	109	427	1491	2155	1039	349		
<.001										
.006	<.001									
.110	.012	.013								
.578	.312	.069	.021							
.715	.599	.261	.064	.006						
.397	.685	.316	.195	.069	.022					
1.476	1.675	1.985	1.961	.983	.089	.054				
1.597	.678	.496	.825	.909	.537	.181	.032			
1.000	1.000	1.000	1.000	1.000	1.000	1.000	.180	.050		
25448										
18629	46227									
10153	28524	44703								
5516	17090	26787	55075							
1877	7590	15173	32696	43483						
557	2529	7092	18601	26238	24667					
227	733	3137	9281	14860	14634	14309				
31	88	261	792	3374	8123	8223	13537			
4	27	96	210	824	2879	4161	7956	9075		
1	6	21	47	184	642	928	4031	5236	(26000)	
										(26000)

	CATCH	
Wtd F	Total No. (10^5)	Tons
	6003	123,028
	3417	81,147
	1857	50,022
	532	10,323
	118	2,483
	232	3,523
	2759	46,564
	8635	169,045
	8289	128,653
	7165	114,048
	18985	298,621
	6283	95,601
	5636	110,250
1.370 (4+)		
1.189 (4+)		
1.277 (4+)		
.297 (4+)		
.064 (4+)		
.024 (3+)		
.203 (3+)		
.399 (3+)		
.400 (3+)		
.273 (3+)		
1.436 (3+)		
.657 (3+)		
1.000 (3+)		

Stock size		
Number (10^5)		Tons
Age 2+	Age 1+	Age 1+
20548	27455	391,621
12171	18060	264,515
8423	14201	202,606
7380	21510	185,709
12837	38285	301,239
24715	70942	578,285
43317	88020	758,080
51283	106358	1,261,209
57947	101430	903,049
55251	79918	835,949
43015	57324	630,749
20915	34452	358,066
16157	25232	334,506
11096	37096	364,750

Table 2. Partial recruitment (percentage) at age 1-2 as indicated from fishing mortality calculated from VPA.

Year	Age 1	Age 2
1963	0.1	8.6
1964	0.2	2.2
1965	0.1	0.2
1966	0.3	12.1
1967	1.6	1.6
1968	4.2	25.0
1969	6.4	5.9
1970	5.3	17.3
1971	1.5	16.0
1972	8.1	25.3
1973	3.8	6.2
1974	4.9	28.0
Mean		
1963-1974	2.9	12.3
1968-1974	4.9	17.7

Table 3. Observed vs. calculated catch (tons) of silver hake in Div. 4VWX, 1963-1975.

Year	Observed catch	Calculated catch	Calculated / Observed
1963	123,028	108,485	.8818
1964	81,147	70,449	.8682
1965	50,022	41,274	.8251
1966	10,323	10,960	1.0617
1967	2,483	2,704	1.0890
1968	3,523	3,683	1.0454
1969	46,564	51,067	1.0967
1970	169,045	140,587	.8317
1971	128,653	152,313	1.1839
1972	114,048	130,830	1,1471
1973	298,621	382,964	1.2824
1974	95,601	108,064	1.1304
1975	110,250	99,158	.8994
		$\bar{x}$ =	1.0264

Table 4. Predictions of catch, fihsing mortality, and stock size for silver hake in Div. 4VWX in 1976-1977.

AGE	SEL. COEFF	AVE.WEIGHT
1	.05000	.06300
2	.18000	.09500
3	1.00000	.15100
4	1.00000	.21400
5	1.00000	.31900
6	1.00000	.47800
7	1.00000	.55000
8	1.00000	.63600
9	1.00000	.84500

DATA SET 1 YEAR 1975 M= .5000 F= 1.0000 Z= 1.5000

AGE	RECRUITS (NO.)	RECRUITS (WT.)	CATCH (NO.)	CATCH (WT.)
1	907.500	57.173	34.902	2.199

AGE	STOCK (NO.)	STOCK (WT.)		
2	795.600	75.582	103.906	9.871
3	416.100	62.831	215.504	32.541
4	287.900	61.611	149.107	31.909
5	82.400	26.286	42.676	13.614
6	21.000	10.038	10.876	5.199
7	9.600	5.280	4.972	2.735
8	2.700	1.717	1.398	.889
9	.400	.338	.207	.175

TOTAL STOCK AGE 2 TO 9	(NO.)	(WT.)	TOTAL CATCH AGE 1 TO 9	(NO.)	(WT.)
	1615.700	243.681		563.548	99.131

corrected = 110,250

DATA SET 1 YEAR 1976 M= .5000 F= 1.4200 Z= 1.9200

AGE	RECRUITS (NO.)	RECRUITS (WT.)	CATCH (NO.)	CATCH (WT.)
1	2600.000	163.800	140.645	8.861

AGE	STOCK (NO.)	STOCK (WT.)		
2	523.582	49.740	93.918	8.922
3	403.064	60.863	254.396	38.414
4	92.844	19.869	58.599	12.540
5	64.239	20.492	40.545	12.934
6	18.386	8.788	11.604	5.547
7	4.686	2.577	2.957	1.627
8	2.142	1.362	1.352	.860
9	.602	.509	.380	.321

TOTAL STOCK AGE 2 TO 9	(NO.)	(WT.)	TOTAL CATCH AGE 1 TO 9	(NO.)	(WT.)
	1109.545	164.200		604.397	90.025

corrected = 140,000

DATA SET 1 YEAR 1977 M= .5000 F= .7000 Z= 1.2000

AGE	RECRUITS (NO.)	RECRUITS (WT.)	CATCH (NO.)	CATCH (WT.)
1	2600.000	163.800	70.475	4.440

AGE	STOCK (NO.)	STOCK (WT.)		
2	1468.896	139.545	137.561	13.068
3	245.941	37.137	100.255	15.138
4	59.092	12.646	24.088	5.155
5	13.612	4.342	5.549	1.770
6	9.418	4.502	3.839	1.835
7	2.696	1.483	1.099	.604
8	.687	.437	.280	.178
9	.314	.265	.128	.108

TOTAL STOCK AGE 2 TO 9	(NO.)	(WT.)	TOTAL CATCH AGE 1 TO 9	(NO.)	(WT.)
	1800.641	200.355		343.273	42.297

corrected = 47,000

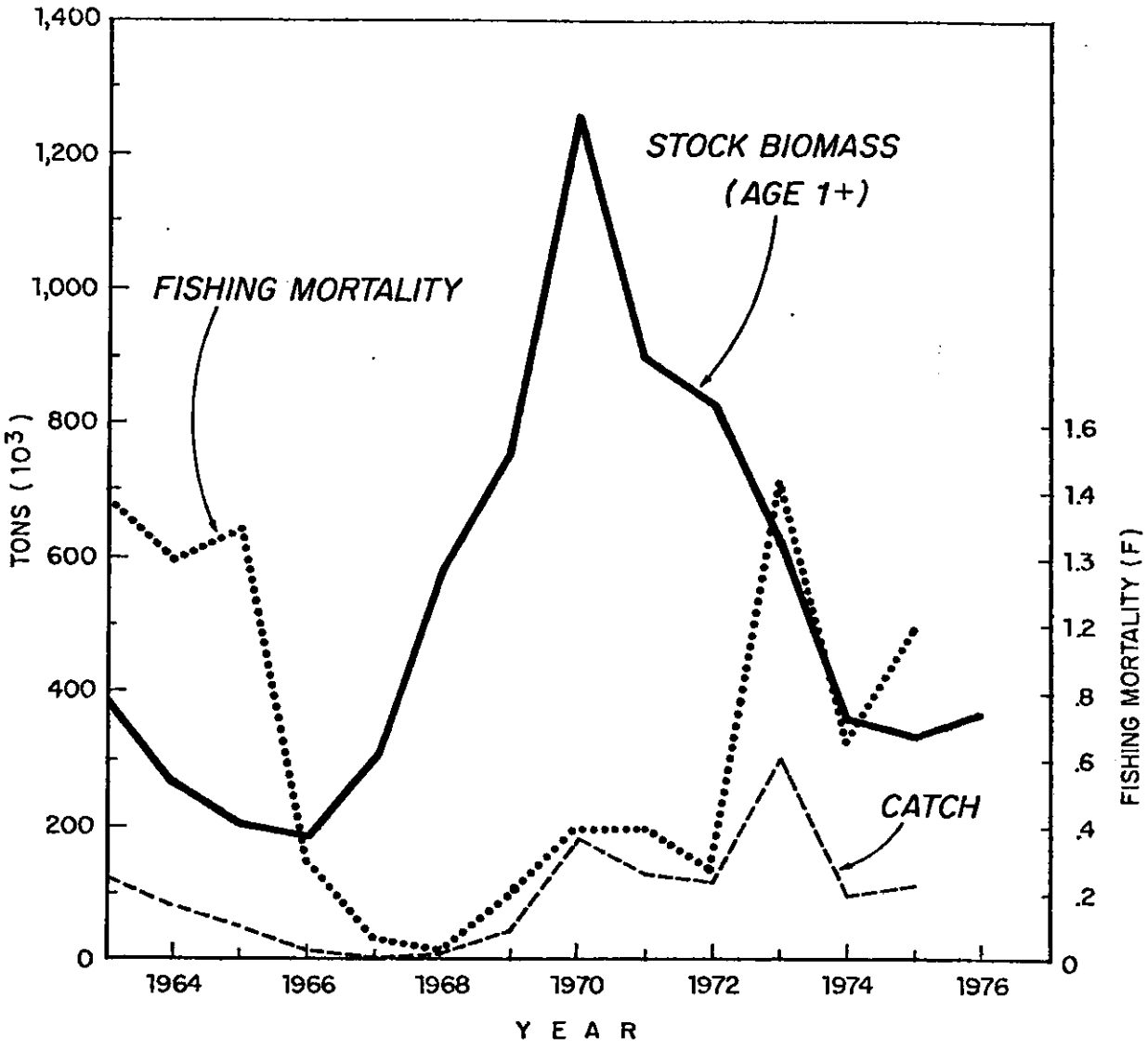

Fig. 1. Catch, stock biomass, and fishing mortality for silver hake in Div. 4VWX.

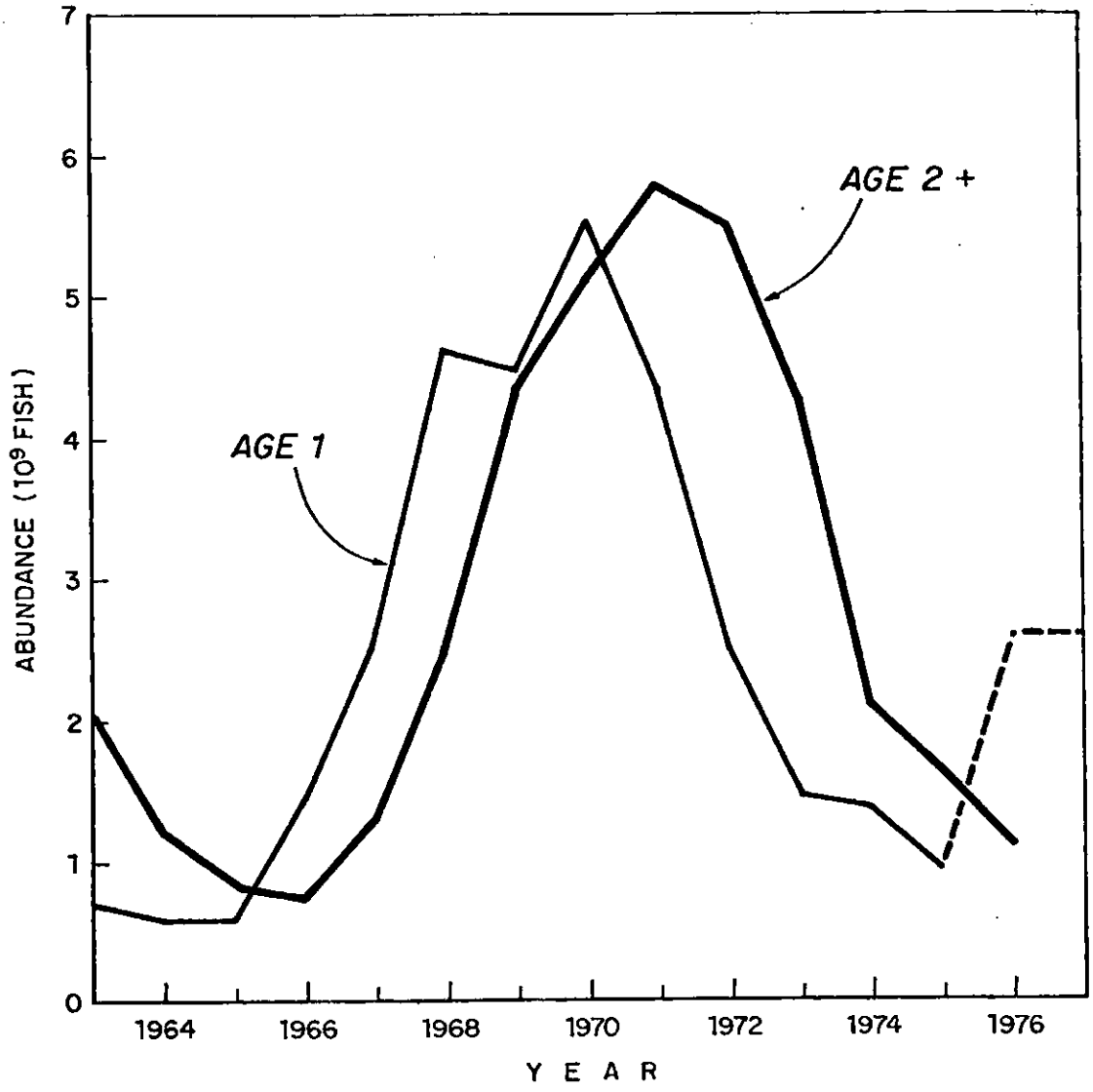

Fig. 2. Abundance of age 1 and age 2+ silver hake in Div. 4VWX.

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Addendum

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Revised 1975 catch at age data (Table 5) were utilized in a new virtual population analysis (VPA). The catch in 1975 as used in the previous VPA was 110,250 tons. The revised catch used in the new VPA was 116,285 tons.

Results of the analysis indicated that at the beginning of 1976, the stock of age 2+ fish was 1.18 billion fish or 192,600 tons.

Several options were considered for the size of the 1975 and 1976 year-classes at age 1. Results of the VPA gave estimates of the sizes of the 1962-1974 year-classes at age 1 (Table 6). These year-classes ranged in size from $5,778 \times 10^5$ fish (1964 year-class) to $55,253 \times 10^5$ (1969 year-class). The mean size was $24,035 \times 10^5$, while the median was $14,927 \times 10^5$. In the absence of any information concerning the size of the 1975 or 1976 year-classes, projections of catch and stock size were made assuming that they equalled (1) the poorest observed year-class ($5,800 \times 10^5$), (2) the median year-class size ($15,000 \times 10^5$), and (3) the mean year-class size observed during 1962-1974 ($24,000 \times 10^5$).

In order to fully take the 1976 TAC of 100,000 tons, fishing mortality would vary from 1.49 to 1.32 depending on the size of the 1975 year-class. Biomass of age 2+ fish at the beginning of 1977 would vary from 103,400 tons to 218,800 tons. Fishing at the level of F = 0.7 in 1977 would result in a catch between 32,400 and 48,600 tons, depending on the various options concerning the sizes of the 1975 and 1976 year-classes, and leave a stock biomass of age 2+ fish in 1978, ranging from 94,400 to 302,400 tons (Fig. 5).

Assuming the lowest option on recruitment ($5,800 \times 10^5$), fishing at F = 0.7 in 1977 would reduce the biomass of age 2+ fish from 103,400 tons in 1977 to 94,400 tons in 1978. Only at levels of F less than 0.5 in 1977 (or catches less than 24,000 tons) could the stock increase in 1978.

If recruitment is assumed equal to either the median or mean level, then the stock will achieve some increase in size in 1978 compared to 1976 and 1977 if fishing mortality in 1977 does not exceed 0.7.

The above analysis, therefore, suggests that the TAC for 1977 could set at some level between 32,000 and 49,000 tons, depending on whether recruitment is as poor as previously observed or is as strong as the mean level observed. According to the VPA, however, a year-class as strong as the mean has not been produced since the 1971 year-class.

Table 5. Revised catch at age (10^5 fish) in 1975 for silver hake in Div. 4VWX.

Age	Number (10^5)
1	368
2	1,096
3	2,273
4	1,573
5	450
6	115
7	53
8	15
9	2
Total No.	5,945
Wt (tons)	116,285

Table 6. Size (10^5 fish) of the 1962-1974 year-class of silver hake in Div. 4VWX at age 1 as estimated by VPA.

Year-class	Number (10^5)
1962	6,907
1963	5,889
1964	5,778
1965	14,130
1966	25,448
1967	46,214
1968	44,844
1969	55,253
1970	43,854
1971	25,386
1972	14,927
1973	14,262
1974	9,569
Mean	24,035
Median	14,927
Lowest	5,778
Highest	55,253

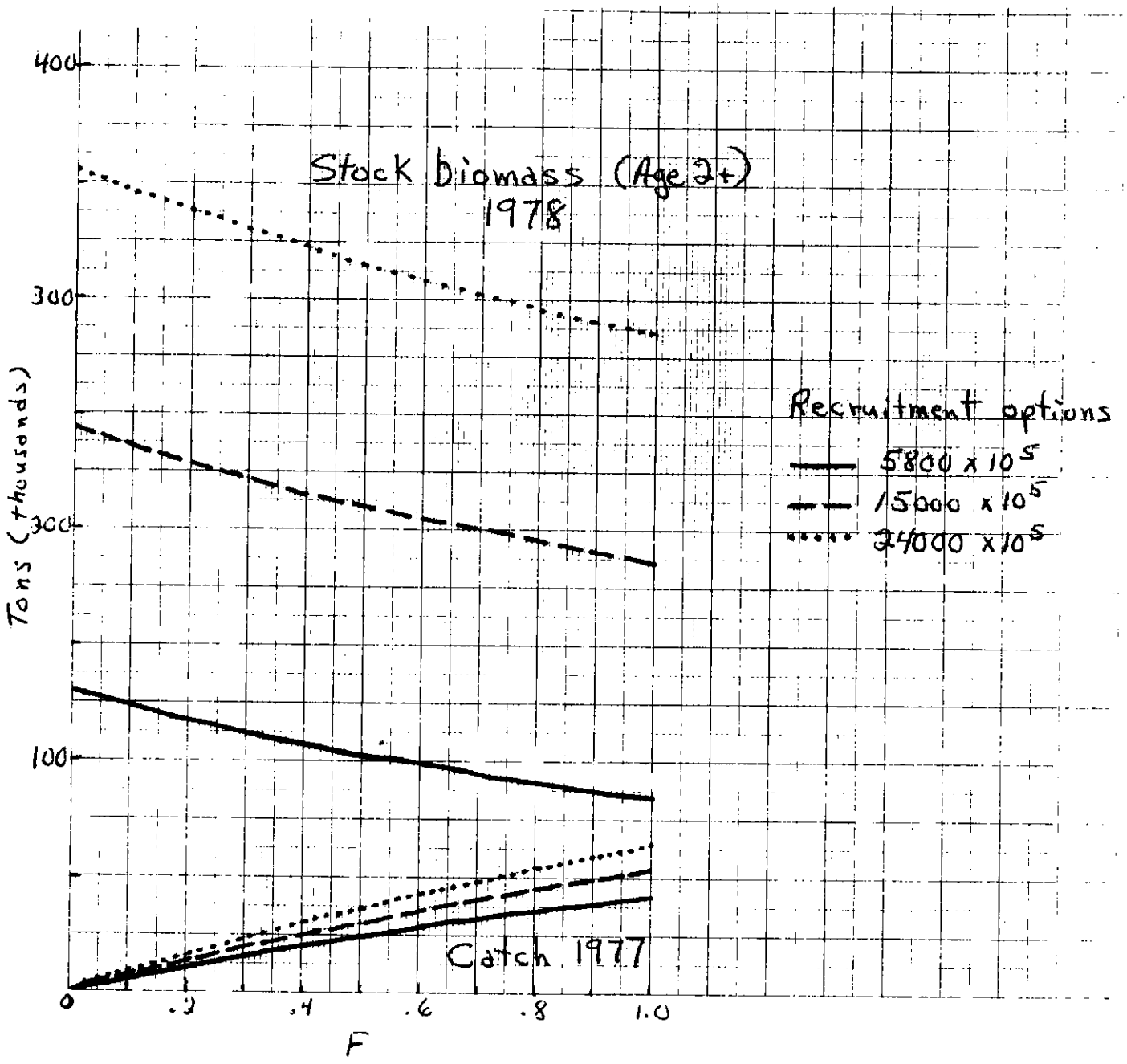
Stock biomass (Age 2+)
1978
Recruitment options
5800 x 10^5
15000 x 10^5
24000 x 10^5
Catch 1977
Tons (thousands)
400
300
200
100
0
.2
.4
.6
.8
1.0
F

Fig. 5