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Scotian Shelf Silver Hake (*Merluccius Bilinearis*) Population Abundance
in 1981 with Projections to 1983

by

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INTRODUCTION

SILVER HAKE (*MERLUCCIVS BILINEARIS*) BELONGS TO THE GADIDAE FAMILY WHICH ALSO INCLUDES THE COMMON COD, HADDOCK, AND POLLOCK. SPECIES DISTRIBUTION RANGES FROM THE GRAND BANKS TO DELAWARE (LIEM AND SCOTT, 1966). TWO STOCKS SOUTH OF BROWN'S BANK HAVE BEEN REFERRED TO BY ANDERSON (1977). ALTHOUGH THERE IS NO SPECIFIC DELINEATION OF A THIRD STOCK SILVER HAKE ON THE SCOTIAN SHELF HAVE BEEN HISTORICALLY REGARDED AS A SEPARATE UNIT (HALLIDAY ET AL., 1978). A DISTINCT SCOTIAN SHELF SPAWNING CONCENTRATION WAS OBSERVED AS EARLY AS 1962 BY RESEARCH VESSELS FROM THE USSR (SARNITS AND SAUSKAN, 1967). SAUSKAN (1964) ALSO SUPPORTS THE THEORY OF A SEPARATE SCOTIAN SHELF STOCK. CURRENT DATA FROM THE CANADIAN SCOTIAN SHELF ICHTHYOPLANKTON SURVEYS SUGGEST THREE SEPARATE SPAWNING LOCATIONS, ONE EACH ON BANQUEREAU, SABLE ISLAND AND BROWN'S BANKS (WALDRON, 1981B.)

SARNITS AND SAUSKAN (1967) IDENTIFIED SEASONAL AREAS OF SILVER HAKE STOCK CONCENTRATIONS AS THE SHELF BREAK AND SABLE ISLAND BANK. CLAY (1979) SUMMARIZED 1961 TO 1968 USSR SCOUTING VESSEL DATA WHICH DESCRIBED MONTHLY CONCENTRATIONS OF SILVER HAKE FROM MAY TO JULY IN AN AREA SEAWARD OF THE SMALL MESH GEAR LINE. RECENTLY, SCOTT (1967 AND 1980) PRESENTED RESULTS FROM CANADIAN RESEARCH VESSEL SURVEYS WHICH SHOW THAT BOTH ADULT AND JUVENILE (AGE 1) FISH ARE HIGHLY CONCENTRATED ON EMERALD BANK AND THE SLOPE BREAK, THEREFORE IF THERE IS MORE THAN ONE STOCK ON THE SCOTIAN SHELF IT IS PROBABLE THAT THE SILVER HAKE FISHERY COULD CONCENTRATE ON A SEPARATE BUT DISTINCT UNIT, THIS POSSIBILITY IS CURRENTLY BEING INVESTIGATED.

SPAWNING OCCURS OVER THE SCOTIAN SHELF FROM MAY TO OCTOBER, PEAKING IN JUNE AND AUGUST (SARNITS AND SAUSKAN, 1967; MOSKOV, 1976 AND MOSKOV ET AL, 1978). SAUSKAN (1968) SUGGESTS THAT SILVER HAKE FEMALES ARE SEQUENTIAL SPAWNERS WITH EACH FEMALE SPAWNING AT LEAST TWICE. HICKLING AND RUTENBERG (1971) SUPPORT THIS HYPOTHESIS WITH OBSERVATIONS ON *MERLUCCIVS*. SILVER HAKE HAVE BEEN OBSERVED AT AGES TO 12 YEARS, AT THIS AGE THEY HAVE AN AVERAGE WEIGHT AND LENGTH OF 1.4KG AND 67 CM RESPECTIVELY. THE MAXIMUM POSSIBLE LENGTH (L_{∞}) HAS BEEN CALCULATED AT 94 CM WHICH SUGGESTS THE TERMINAL AGE TO BE 20 YEARS.

RECORDS OF A SCOTIAN SHELF COMMERCIAL FISHERY FOR SILVER HAKE DATE BACK TO THE EARLY 1950'S (CLAY, 1979). THE INTRODUCTION OF THE SOVIET FLEET IN 1962 SIGNALLED THE START OF A TRULY DIRECTED FISHERY. PEAK CATCHES OCCURRED IN 1963 (123,000T), 1970 (169,000T) AND THE LARGEST IN 1973 (300,000T). RECENT CATCHES HAVE REMAINED NEAR 50,000 TONS (FIGURE 1). ALTHOUGH SOME COUNTRY ALLOCATIONS HAVE NOT ALWAYS BEEN CAUGHT, THE USSR HAS BEEN ABLE TO CATCH THE MAJOR PORTION OF THEIR ALLOCATION.

WHEN CANADA PROCLAIMED A 200 MILE MANAGEMENT ZONE IN 1977, FOREIGN FLEETS WERE RESTRICTED TO THE SEAWARDSIDE OF WHAT IS NOW REFERRED TO AS THE SMALL MESH GEAR LINE (SMGL) (FIG. 2). SINCE 1977, A LARGE BODY OF DATA HAS BEEN COLLECTED ON CATCH, EFFORT AND MORPHOLOGICAL DATA BY TRAINED OBSERVERS. THIS INFORMATION HAS BEEN AND IS USED TO EVALUATE THE SILVER HAKE STOCK.

CATCH AND EFFORT

PROVISIONAL 1981 CATCHES WERE OBTAINED FROM NAFO STATISTICS AND CIRCULAR LETTERS AND CANADIAN STATISTICS (TABLES 1+2). DIRECTED SILVER HAKE EFFORT FOR 1981 WAS ESTIMATED FROM THE OBSERVED DIRECTED CPUE FOR EACH FLEET (TABLE 3). DIRECTED CATCH AND EFFORT FOR 1979 AND 1980 WERE OBTAINED FROM NAFO AND ADJUSTED BY TONNAGE CLASS AND GEAR TO USSR DTB2, TONNAGE CLASS 7 VESSELS FISHING FOR SILVER HAKE. EFFORT FOR PREVIOUS YEARS WAS OBTAINED FROM CLAY AND BEAHLANDS (1980) WHO ADJUSTED REPORTED EFFORT TO THE USSR DTB2, TO7 DIRECTED SILVER HAKE FISHERY (IE, WHEN SILVER HAKE WAS THE MAJOR SPECIES CAUGHT). DETAILED DIRECTED CATCH AND EFFORT FROM THE OBSERVER PROGRAM ARE SUMMARIZED IN APPENDIX 1.

1981 SAMPLING INTENSITY

SAMPLING FOR CATCH, EFFORT, LENGTH AND AGE WAS CONDUCTED BY THE CANADA SCOTIA-FUNDY OBSERVERS. FROM THE APPROXIMATELY 44,000 TONS OF SILVER HAKE REPORTED CAUGHT, 22,000 TONS, OR 50 PERCENT WAS OBSERVED FOR ALL FLEETS. COVERAGE LEVELS FROM 1978 TO 1980 ARE GIVEN IN WALDRON 1981A.

SAMPLING LEVELS FOR LENGTHS WERE ABOVE THE NAFO RECOMMENDED LEVELS FOR ALL MONTHS (TABLE 4). OTOLITH SAMPLES WERE ADEQUATE FOR ALL MONTHS. AGEING WAS DONE AT THE ST. ANDREWS LABORATORY, NEW BRUNSWICK, CANADA.

RESEARCH VESSEL SURVEYS

MINIMUM ESTIMATES FROM JULY-AUGUST CANADIAN RESEARCH SURVEYS ON THE SCOTIAN SHELF ARE REPORTED IN APPENDIX 2. THE DESIGN AND SAMPLING METHODOLOGIES OF THESE CRUISES ARE DISCUSSED IN HALLIDAY (1974). ALTHOUGH EARLIER BIOMASS ESTIMATES ARE AVAILABLE (DOUBLEDAY AND HUNT, 1976) THESE WERE NOT USED, SINCE AGEING HAS NOT BEEN COMPLETED FOR THE YEARS 1970 AND 1971. RESEARCH VESSEL ESTIMATED NUMBERS AND BIOMASS AT AGE FOR 1972 TO 1981 ONLY ARE SUMMARIZED IN TABLES 5 AND 6.

RESEARCH NUMBERS PEAKED AT 228 MILLION FISH IN 1973, WHICH IS ALSO THE PEAK FISHING YEAR. SINCE THAT TIME THE ESTIMATED NUMBERS HAVE FLUCTUATED UNTIL 1978 WHEN THEY STABILIZED IN THE RANGE OF 43 TO 48 MILLION FISH. HOWEVER, BOTH NUMBER AND BIOMASS TRENDS HAVE INCREASED IN 1981. THIS CAN BE ACCOUNTED FOR BY THE PRESENCE OF THE STRONG 1978 AND 1979 YEAR CLASSES (FIGS 3A AND 3B).

CATCH AT AGE

LENGTH FREQUENCY DATA COLLECTED BY THE OBSERVER PROGRAM IN 1981 WAS SUMMARIZED BY MONTH AND SEX FOR EACH COUNTRY SAMPLED. THESE MONTHLY LENGTH SUMMARIES WERE ADJUSTED TO ESTIMATED MONTHLY CATCHES DERIVED FROM VARIOUS SOURCES AND REPORTED IN TABLE 1, USING MONTHLY AGE-LENGTH KEYS SUPPLIED BY THE AGEING GROUP IN ST. ANDREWS, THE NUMBERS-AT-AGE FOR EACH SEX WERE CALCULATED BY MULTIPLYING THE MATRIX OF PERCENT AGE-AT-LENGTH BY A NUMBERS-AT-LENGTH VECTOR, MONTHLY NUMBERS-AT-AGE WERE WEIGHTED TO CATCH FOR EACH COUNTRY AND SUMMED IN ORDER TO ARRIVE AT THE ESTIMATED REMOVALS-AT-AGE FOR 1981 (TABLES 7 AND 8).

REMOVALS-AT-AGE FOR 1962 TO 1978 WERE DERIVED BY CLAY AND BEANLANDS (1980). THE 1979 AND 1980 REMOVALS-AT-AGE WERE PRESENTED BY WALDRON (1981A) BASED ON A 44,373 TON CATCH, THESE WERE ADJUSTED UPWARDS WITH THE FINAL 1980 CATCH OF 44,377 TONS.

MEAN WEIGHTS-AT-AGE

MEAN WEIGHTS-AT-AGE FOR 1962 TO 1979 WERE DERIVED BY CLAY AND BEANLANDS (1980). THE 1980 MEAN WEIGHTS-AT-AGE WERE COMPUTED USING THE JULY, 1980 RESEARCH VESSEL WEIGHT-LENGTH RELATIONSHIP FOR EACH SEX APPLIED TO MONTHLY COMMERCIAL MEAN LENGTHS, MEAN WEIGHTS-AT-AGE FOR 1981 WERE CALCULATED FROM WEIGHT-LENGTH RELATIONSHIPS OBSERVED IN THE COMMERCIAL FISHERY (TABLE 9), MEAN WEIGHTS FOR PROJECTIONS WERE AVERAGED FROM 1977-1981.

AGE	1	2	3	4	5	6	7	8	9	10
1980 WT AT AGE	0.041	0.141	0.213	0.280	0.322	0.366	0.520	0.601	0.892	1.452
1981 WT AT AGE	0.036	0.143	0.193	0.248	0.318	0.369	0.672	1.547	1.316	1.409
AVE 1977 - 1981	0.050	0.139	0.198	0.258	0.321	0.385	0.530	0.849	0.927	0.942

CATCH BIOMASS-AT-AGE WAS CALCULATED BY MULTIPLYING THE REMOVALS-AT-AGE BY THE MEAN WEIGHTS-AT-AGE (TABLE 10). AGREEMENT BETWEEN REPORTED NOMINAL CATCH AND CALCULATED $\pm$ BIOMASS WAS GOOD CONSIDERING POSSIBLE SAMPLING ERRORS FOR THE MEAN WEIGHTS-AT-AGE AND SMALL ERRORS IN CALCULATING NOMINAL CATCH.

YEARS	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
CATCH	81147	50022	10323	2477	3471	46323	169045	128657	114048	298621	95745	116286	97184	35762	48200	56391	44377	43000
EST	81426	50051	10401	2516	3562	46598	169663	127698	113188	298933	95598	116562	97243	36833	48176	56402	44726	44953
DIFF.	-279	-29	-78	-39	-91	-275	-618	959	860	-312	147	-276	-59	-1071	24	-11	-349	-1953

NATURAL MORTALITY AND CPUE-AT-AGE

THE SAME M (0.4) AS USED IN THE PREVIOUS ASSESSMENT (WALDRON, 1981) WAS PRESENTED BY TERRE AND MARI (1977). A CPUE-AT-AGE MATRIX WAS CALCULATED BY DIVIDING THE CATCH REMOVALS-AT-AGE (NUMBERS) BY THE APPROPRIATE YEARLY DIRECTED EFFORT (TABLE 11). PALOHEIMO Z VALUES WERE CALCULATED ($Z = -\ln[(C/F)^2 / (C/F)]$) AND REGRESSED AGAINST MEAN EFFORT, THE INTERCEPT (M) AND SLOPE (F) WERE UNREALISTIC AND THE ORIGINAL ESTIMATE OF $M=0.4$ WAS AGAIN USED FOR THIS ANALYSIS.

VIRTUAL POPULATION ANALYSIS (VPA), TERMINAL F AND RECRUITMENT

PARTIAL RECRUITMENT AND F AT AGE 10 USED IN THE PREVIOUS ASSESSMENT (WALDRON, 1981A) WERE INITIALLY USED FOR THIS 1981 ASSESSMENT, F AT AGE 10 WAS CALCULATED BY AVERAGING F'S FROM AGES 2 TO 6 FOR ALL YEARS EXCEPT 1981, THESE CALCULATED F VALUES WERE THEN USED IN THE NEXT VPA ITERATION, THIS PROCESS CONTINUED UNTIL NO CHANGE IN F'S AT AGE 10 WERE NOTED.

IN ORDER TO DETERMINE THE TERMINAL F FOR THE VPA, SEVERAL VARIABLES WERE CALCULATED, TO DETERMINE WEIGHTED F, THE F MATRIX FROM 1967 TO 1981 WAS WEIGHTED BY POPULATION NUMBERS FOR AGES 2 TO 6 ($F \times POP: SUM POP$), CATCH PER UNIT OF EFFORT (CPUE) WAS CALCULATED BY FIRST SUMMING THE PRODUCT OF THE CATCH-AT-AGE AND THE MEAN WEIGHTS-AT-AGE FOR AGES 2 TO 10 WHICH WAS THEN DIVIDED BY DIRECTED EFFORT, ONLY THE YEARS 1967 TO 1981 WERE USED, COMPARISON OF POPULATION WEIGHTED F AGAINST DIRECTED EFFORT AND 2+ POPULATION CPUE AGAINST 2+ POPULATION BIOMASS INDICATED THAT A TERMINAL F OF 0.20 WITH AN $M=0.40$ GAVE THE BEST COMBINATION OF R AND THE DIFFERENCE BETWEEN THE OBSERVED AND PREDICTED VALUES (TABLE 12). MATRICES OF POPULATION NUMBERS, POPULATION BIOMASS AND F AT TERMINAL $F=0.20$ AND $M=0.40$ ARE PRESENTED IN TABLES 13, 14 AND 15.

BOTH NUMBERS AND BIOMASS FOR AGED 3 FISH HAVE INCREASED SINCE 1976 AND PROBABLY REFLECT THE SHIFT IN MESH SIZE FROM 40MM TO 60MM CODEMS. ESTIMATED 1+ POPULATION BIOMASS HAS INCREASED IN 1980 TO LEVELS REMINISCENT OF THE BIOMASS PRESENT DURING THE FISHERY IN THE EARLY 1970'S. THIS IS DUE TO THE PRESENCE OF THE LARGE 1978 YEAR CLASS, PREDOMINANT IN 1981. HOWEVER, THE 1980 YEAR CLASS IS EXTREMELY LOW WHEN COMPARED TO PREVIOUS YEARS (FIG. 4, TABLE 15), THIS TREND IS NOT EVIDENT IN THE RESEARCH VESSEL DATA (FIG. 5, TABLE 16) WHICH COULD SUGGEST AN AVAILABILITY PROBLEM.

THE FINAL PARTIAL RECRUITMENT FOR 1981 WAS DERIVED SIMILARLY TO THE 1980 ASSESSMENT BY AVERAGING THE 1977 TO 1980 F'S-AT-AGE (FIGURE 6), FULL RECRUITMENT OCCURS AT AGE 4 WHICH IS ONE YEAR LATER THAN THE AVERAGE OF F'S-AT-AGE USED IN THE PREVIOUS ASSESSMENT AND 2 YEARS LATER THAN THAT PRIOR TO 1977.

PARTIAL RECRUITMENT USED IN THIS AND PREVIOUS ASSESSMENTS

AGE	1	2	3	4	5	6	7	8	9	10
FR(PREVIOUS)	0.044	0.444	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
FR(1977-'80)	0.029	0.273	0.855	1.000	1.000	1.000	1.000	1.000	1.000	1.000
FR(1962-'76)	0.150	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

VALIDATION OF VPA

THE FISHING MORTALITY AT AGES 2 TO 6 WERE WEIGHTED BY POPULATION NUMBERS AND AVERAGED FOR THE YEARS 1966 TO 1981. THE PERIOD 1962 TO 1965 WERE OMITTED FROM THE CALCULATIONS BECAUSE THE FISHERY WAS DEVELOPING, FURTHER, DURING THE YEARS 1964 AND 1965 THERE WAS A LARGE SOVIET HADDOCK FISHERY WHICH COULD MASK SOME OF THE EFFORT DIRECTED TOWARDS SILVER HAKE.

REGRESSING WEIGHTED FISHING MORTALITY AGAINST DIRECTED EFFORT ($R=0.935$) AND DIRECTED CPUE (BIOMASS) AGAINST 2+ POPULATION BIOMASS ($R=0.709$) WAS OPTIMIZED WITH A TERMINAL F OF 0.20 (TABLE 12, FIGURES 7 AND 8).

YIELD PER RECRUIT

THE YIELD PER RECRUIT WAS CALCULATED USING THE THOMPSON AND BELL MODEL, MEAN WEIGHTS-AT-AGE WERE AVERAGED FOR THE YEARS 1977- 1981, FULLY RECRUITED F0.1 WAS 0.446 WITH A YIELD OF 0.060 KG, THE FMAX IS 3.555 WITH A YIELD OF 0.076 KG, (TABLE 18).

RECRUITMENT

RECRUITMENT FOR SILVER HAKE HAS BEEN RELATIVELY UNSTABLE SINCE 1966 AVERAGING 1.36 BILLION INDIVIDUALS, FOR PROJECTION PURPOSES RECRUITMENT WAS TAKEN AS THE GEOMETRIC AVERAGED FROM 1970 TO 1980 (1.29 BILLION) AND AS A RESULT IT IS POSSIBLY AN OVERESTIMATE OF THE 1980 RECRUITMENT.

CATCH PROJECTION

CATCH PROJECTIONS UNTIL 1983 WERE CALCULATED USING THE ABOVE PARTIAL RECRUITMENT, F0.1, M, MEAN WEIGHTS-AT-AGE AND THE GEOMETRIC MEAN OF RECRUITMENT FROM 1970 TO 1980 (1.29 BILLION FISH). THREE OPTIONS FOR THE 1983 CATCH WERE GENERATED, THE FIRST ASSUMED THE F0.1 CATCH OF 86,000 TONS IN 1982 WOULD PREDICT AN F0.1 CATCH IN 1983 OF 66,000 TONS (OPTION 1, TABLE 19). THE SECOND ASSUMED THE ASSIGNED 1982 TAC OF 80,000 TONS WOULD BE CAUGHT, THIS ASSUMPTION PREDICTED THE 1983 CATCH WOULD BE 68,000 TONS (OPTION 2, TABLE 19). THE THIRD ASSUMES AN AVERAGE CATCH IN 1982 WOULD BE 60,000 TONS (OPTION 3, TABLE 19). THE ESTIMATED 1982 CATCH OF 60,000 TONS INCREASED THE 1983 F0.1 PREDICTED CATCH FROM 66,000 (OPTION 1) TO 74,000 TONS (OPTION 3). GIVEN THE RECENT HISTORY OF ALLOCATIONS OPTION 3 WOULD BE A MOST REALISTIC PROJECTION.

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Table 1. 1981 Provisional Silver Hake Catch (t) in NAFO Divisions 4VWX.

COUNTRY	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	TOTAL
CANADA	-	1	-	-	-	-	2	3	6 ^{1,4}
CUBA	-	66	279	198	97	2	-	-	642 ^{3,6}
ITALY*	117	162	181	-	-	-	-	-	460 ⁵
JAPAN	-	-	-	-	70	43	7	-	120 ^{3,6}
POLAND	-	-	-	0.20	0.5	0.03	-	-	1 ⁵
PORTUGAL*	161	633	666	-	-	-	-	-	1460 ⁵
USA	-	-	-	-	1	-	-	-	1 ¹
USSR	459	11035	14498	11912	2333	-	-	-	40235 ^{3,6}
TOTAL	737	11897	15624	12110.2	2501.5	45.03	9	3	42924

¹ NAFO Circular Letters

² Canadian DFO FLASH System

³ NAFO Provisional STATS

⁴ Canadian Statistical Reporting System

⁵ Only Observer Program Data

⁶ Only monthly catch prorated by using FLASH data.

* Both Italy and Portugal Fished for Joint Trawler Companies.

Table 2. 1981 Monthly Percentage caught in the 4VWX Silver Hake Fishery (using FLASH and Observer Data).

COUNTRY	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	TOTAL CATCH (T)
CUBA ¹	-	10.27	43.42	30.87	15.13	0.31	-	-	642
ITALY ²	25.34	35.33	39.33	-	-	-	-	-	460
JAPAN ¹	-	-	-	-	58.21	35.59	6.20	-	120
POLAND ²	-	-	-	29.00	67.00	4.00	-	-	1
PORTUGAL ²	11.03	43.34	45.63	-	-	-	-	-	1460
USA ¹	-	-	-	-	100.00	-	-	-	1
USSR ¹	1.14	27.43	36.03	29.60	5.80	-	-	-	40235
TOTAL	37.51	116.37	164.41	89.47	246.14	39.90	6.20	-	42924

¹ FLASH monthly data used

² Observer Program monthly data used.

Table 3. Catch directed effort and CPUE for silver hake caught in NAFO Divisions 4V, 4W and 4X for all countries.

YEAR	Nominal Catch ('000 t)	Directed ² Effort ¹ (hrs)	CPUE ¹ (Directed)	Observed ² CPUE	Observed ² Catch ('000 t)	Re-calculated ⁹ Effort
1963	123	55216	2.22	-	-	55216
64	81	38675	2.11	-	-	38675
1965	50	44696	1.12	-	-	44696
66	11	44175	.24	-	-	44175
67	3	3818	.66	-	-	3818
68	3	19295	.19	-	-	19295
69	47	36033	1.29	-	-	36033
1970	169	82710	2.05	-	-	82710
71	129	100624	1.27	-	-	100624
72	114	68313	1.66	-	-	68313
73	299	128061	2.33	-	-	128061
74	96	101283	.94	-	-	101283
1975	116	94997	1.23	-	-	94997
76	97	54430	1.79	-	-	54430
77	37	20382	1.81	1.30	-	20382
78	48	35154	1.37	1.30 ⁴	17	37058
79 ³	56	39994	1.41	1.88 ⁵	23	27574
1980 ⁶	44	33047 ⁷	-	1.33 ⁸	25	33628
81	43	28745 ⁷	1.30	1.18 ⁸	22	28745 ⁷

- 1 Effort adjusted to vessel class and gear (from Clay and Beanlands, 1980).
- 2 Data from Canadian and Joint Canada-USSR and Canada-Cuba observer programs.
- 3 Effort and CPUE calculated from provisional 1979 catch statistics.
- 4 ICNAF Res. Doc. 79/17 (Seaward of Small Mesh Gear Line).
- 5 ICNAF Res. Doc. 80/18 (Seaward of Small Mesh Gear Line).
- 6 Provisional NAFO Statistics.
- 7 Estimated from Observer Program; using 1980 FLASH effort adjusted by observer hours divided by Observer Days.
- 8 Observer data seaward of Small Mesh Gear Line.
- 9 Effort readjusted using reported catch and Observer Program directed CPUE.

Table 4. Summary of 1981 Observer Program Silver Hake Sampling.

COUNTRY	SAMPLE	APRIL	MAY	JUNE	JULY	AUG	SEPT	TOTAL
CUBA	Meas.	-	2772	6718	4581	-	-	14071
	Otoliths	-	29	48	0	-	-	106
ITALY	Meas.	2301	6234	5034	-	-	-	13569
	Otoliths	36	46	15	-	-	-	97
JAPAN	Meas.	-	-	-	-	8515	8873	17388
	Otoliths	-	-	-	-	333	195	528
POLAND	Meas.	-	-	-	-	217	-	217
	Otoliths	-	-	-	-	0	-	0
PORTUGAL	Meas.	2899	12302	10828	-	-	-	26029
	Otoliths	40	60	30	-	-	-	130
USSR	Meas.	3433	69583	30760	56566	5107	-	165429
	Otoliths	109	391	73	384	239	-	1196
TOTAL	Meas.	8633	90891	53340	61147	13839	8873	236703
	Otoliths	545	526	166	384	572	195	2057
	Ot./Meas.	.0001	.006	.003	.006	.041	.022	.009
	No. Smps.	43	454	267	306	69	44	1184
	Catch (t)	690	9583	5520	5933	285	33	22734
	No. Smp. ('000 t)	62.32	47.38	48.37	51.58	242.11	1333.33	52.08

TABLE 5. SCOTIAN SHELF SILVER HAKE RESEARCH VESSEL SURVEY NUMBERS AT AGE, ('000).

AGE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	27717	69273	37346	17591	17338	28714	13357	3846	7392	16376
2	45667	130968	120211	16722	49123	42738	12339	32796	11272	43909
3	6779	8900	17114	2658	4523	27769	8232	8694	14768	68530
4	3657	7394	2137	1494	2055	8399	4403	1619	4234	29338
5	1577	6880	2114	768	609	5405	3444	503	2174	8449
6	906	3179	2407	445	350	2428	1459	414	1596	2670
7	140	1108	443	128	94	1324	601	239	770	1471
8	330	684	254	202	132	497	233	0	446	436
9	58	61	0	19	89	107	469	0	189	254
10	225	343	22	0	0	257	221	0	331	227
TOTAL 1+	87056	228789	182047	40028	74313	117637	44757	48112	43173	171660

Table 6. Scotian Shelf, July-August Groundfish Survey Biomass at Age (Tons) for Silver Hake.

AGE	1972	1973	1974	1975	YEAR		1978	1979	1980	1981
1	1552	3117	2353	1179	1092	1780	654	235	303	619
2	5434	16764	15507	2592	7270	6282	1357	5051	1589	7357
3	1417	1922	3491	646	1113	5832	1432	1739	3146	15077
4	878	1848	662	354	561	2436	995	397	1186	8269
5	432	2030	837	366	248	2146	975	143	700	2788
6	505	1396	1297	203	185	1253	480	142	584	1190
7	68	537	432	145	78	883	230	98	400	958
8	416	598	293	254	166	535	116	0	268	358
9	52	72	0	31	77	117	368	0	169	302
10+	0	592	33	0	0	0	145	0	481	316
TOTAL	10754	28876	24906	5771	10789	21163	6752	7805	8826	37234

Table 7. Monthly removals-at-age ('000) for Silver hake in NAFO 4VWX (1981).

COUNTRY	AGES	M O N T H								YEARLY TOTAL
		APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	
CANADA	1	-	*	-	-	-	-	-	2	2
	2	-	1	-	-	-	-	-	5	6
	3	-	3	-	-	-	-	-	6	9
	4	-	1	-	-	-	-	-	2	3
	5	-	*	-	-	-	-	-	*	1
	6	-	*	-	-	-	-	-	*	*
	7	-	*	-	-	-	-	-	*	*
	8	-	-	-	-	-	-	-	*	*
	9	-	*	-	-	-	-	-	-	*
	10+	-	-	-	-	-	-	-	*	*
	TOTAL	-	6	-	-	-	-	-	16	22
	CATCH (T)	-	1	-	-	-	-	-	3	4
CUBA	1	-	2	9	*	10	2	-	-	23
	2	-	38	106	91	107	3	-	-	345
	3	-	208	795	458	265	4	-	-	1730
	4	-	85	224	171	77	1	-	-	558
	5	-	21	63	114	20	*	-	-	218
	6	-	13	46	20	4	*	-	-	83
	7	-	1	8	3	2	*	-	-	14
	8	-	*	*	2	0	*	-	-	2
	9	-	*	1	*	0	-	-	-	1
	10+	-	-	1	4	*	-	-	-	5
	Total	-	368	1253	865	484	11	-	-	2981
	Catch (t)	-	66	279	198	97	2	-	-	642
ITALY	1	5	28	8	-	-	-	-	-	41
	2	62	69	48	-	-	-	-	-	179
	3	384	506	455	-	-	-	-	-	1345
	4	95	222	165	-	-	-	-	-	482
	5	42	53	56	-	-	-	-	-	151
	6	7	30	39	-	-	-	-	-	76
	7	2	4	3	-	-	-	-	-	9
	8	1	-	-	-	-	-	-	-	1
	9	-	*	*	-	-	-	-	-	*
	10+	1	-	*	-	-	-	-	-	1
	TOTAL	599	912	774	-	-	-	-	-	2285
	CATCH (T)	117	162	181	-	-	-	-	-	460
JAPAN	1	-	-	-	-	47	33	5	-	85
	2	-	-	-	-	105	71	12	-	188
	3	-	-	-	-	147	90	15	-	252
	4	-	-	-	-	46	25	4	-	75
	5	-	-	-	-	17	6	1	-	24
	6	-	-	-	-	6	4	1	-	11
	7	-	-	-	-	3	2	*	-	5
	8	-	-	-	-	*	*	*	-	*
	9	-	-	-	-	-	-	-	-	-
	10+	-	-	-	-	*	*	*	-	1
	TOTAL	-	-	-	-	372	231	38	-	641
	CATCH (T)	-	-	-	-	70	43	7	-	120
POLAND	1	-	-	-	*	*	*	-	-	*
	2	-	-	-	*	*	*	-	-	*
	3	-	-	-	*	1	*	-	-	2
	4	-	-	-	*	*	*	-	-	1
	5	-	-	-	*	*	*	-	-	*
	6	-	-	-	*	*	*	-	-	*
	7	-	-	-	*	*	-	-	-	*
	8	-	-	-	*	-	-	-	-	*
	9	-	-	-	*	-	-	-	-	*
	10+	-	-	-	*	-	-	-	-	*
	TOTAL	-	-	-	1	2	*	-	-	3
	CATCH (T)	-	-	-	*	*	*	-	-	1

TABLE 7. (Continued).

COUNTRY	AGES	M O N T H								YEARLY TOTAL
		APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	
PORTUGAL	1	22	37	10	-	-	-	-	-	69
	2	167	474	315	-	-	-	-	-	956
	3	451	2054	1964	-	-	-	-	-	4469
	4	115	780	553	-	-	-	-	-	1448
	5	32	193	156	-	-	-	-	-	381
	6	10	111	108	-	-	-	-	-	229
	7	6	13	10	-	-	-	-	-	29
	8	1	*	-	-	-	-	-	-	1
	9	-	1	1	-	-	-	-	-	2
	10+	-	-	*	-	-	-	-	-	1
TOTAL		804	3663	3117	-	-	-	-	-	7584
CATCH (T)		161	663	666	-	-	-	-	-	1460
USSR	1	8	847	297	74	235	-	-	-	1461
	2	206	6430	5634	4623	2570	-	-	-	19463
	3	1464	32662	43130	28929	6365	-	-	-	112550
	4	400	14649	12343	9896	1849	-	-	-	39137
	5	115	3934	3359	6785	472	-	-	-	14665
	6	47	2270	2082	1099	106	-	-	-	5604
	7	18	290	145	179	46	-	-	-	678
	8	6	3	3	126	-	-	-	-	138
	9	1	14	13	35	-	-	-	-	63
	10+	*	-	6	247	3	-	-	-	256
TOTAL		2265	61099	67012	51993	11646	-	-	-	194014
CATCH (T)		459	11035	14498	11912	2333	-	-	-	40237
GRAND TOTAL		3666	66049	72156	52859	12504	242	38	16	207530

* Data less than 1.

TABLE 8. COMMERCIAL SILVER HAKE REMOVALS AT AGE FROM THE NAFO DIVISION ANNUAL SILVER HAKE FISHERY.

AGE	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	18946	48573	19070	6547	8371	89	2270	27836	187298	219607	379314	245401	101158	144956	153535	2131	28807	10533	6272	1681
2	52677	368718	232433	115396	31209	5398	14130	189232	748021	410149	460610	1478425	390044	365624	381651	43528	91101	52675	60575	21137
3	7412	157119	121703	82387	14964	3607	4831	72147	216246	175005	71536	96490	150741	52788	72418	79226	90038	75250	82011	120357
4	2158	72382	50964	37225	7009	1779	1616	21971	59832	74755	47903	106351	7095	60750	31295	29556	43031	50720	35887	11704
5	714	32474	20575	14303	2672	855	627	6200	20695	22035	17822	96646	9789	38610	5582	6980	19511	32315	15293	15440
6	246	15992	9402	6083	1063	442	312	2038	9636	1877	7452	19611	3245	4799	2669	2904	8618	18485	6179	6094
7	67	5087	2971	1781	289	136	99	571	3608	5139	1160	15157	93	311	514	463	3234	5535	1482	735
8	18	2214	1146	588	78	54	32	143	1988	1333	437	5458	109	363	105	564	2016	1924	343	143
9	4	1121	570	209	20	20	9	29	1114	2062	607	483	60	360	390	522	421	1255	90	66
10	2	808	350	78	9	10	2	16	680	1900	2000	816	77	1000	82	1	645	533	44	263
TOTAL	82244	724398	459184	264597	65684	12390	23928	320183	1249118	913862	988841	2064838	662411	669561	648241	163995	287422	249225	208376	207530

TABLE 9. SCOTIAN SHELF SILVER HAKE COMMERCIAL CATCH MEAN WEIGHTS-AT-AGE (KG.).

AGE	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1.000	0.077	0.081	0.077	0.067	0.072	0.078	0.073	0.062	0.060	0.040	0.056	0.045	0.063	0.067	0.063	0.062	0.049	0.061	0.041	0.036
2.000	0.104	0.129	0.140	0.151	0.128	0.150	0.138	0.133	0.126	0.128	0.119	0.128	0.129	0.155	0.148	0.147	0.110	0.154	0.141	0.143
3.000	0.160	0.189	0.189	0.195	0.195	0.196	0.175	0.175	0.167	0.188	0.209	0.216	0.204	0.243	0.246	0.210	0.174	0.200	0.213	0.193
4.000	0.216	0.251	0.241	0.240	0.240	0.259	0.233	0.214	0.222	0.254	0.240	0.250	0.310	0.237	0.273	0.290	0.226	0.245	0.280	0.248
5.000	0.256	0.313	0.302	0.298	0.278	0.322	0.309	0.250	0.303	0.315	0.274	0.295	0.396	0.477	0.407	0.397	0.283	0.285	0.322	0.218
6.000	0.304	0.373	0.362	0.336	0.311	0.376	0.376	0.290	0.404	0.450	0.557	0.439	0.539	0.457	0.529	0.516	0.329	0.344	0.366	0.369
7.000	0.310	0.407	0.391	0.359	0.324	0.389	0.382	0.293	0.470	0.587	0.483	0.485	0.975	1.133	0.838	0.667	0.382	0.411	0.520	0.672
8.000	0.331	0.350	0.508	0.418	0.340	0.446	0.417	0.351	0.705	0.832	1.263	0.875	1.156	1.257	1.251	1.077	0.498	0.520	0.601	1.547
9.000	0.294	0.719	0.721	0.518	0.371	0.445	0.406	0.451	0.828	0.612	0.886	1.174	0.901	1.635	0.859	1.089	0.784	0.553	0.892	1.316
10.000	0.149	0.735	1.031	0.410	0.265	0.417	0.149	0.298	0.875	0.712	0.901	1.726	1.508	0.946	1.818	0.001	0.659	1.189	1.452	1.409
AGE 1+	0.219	0.375	0.396	0.298	0.252	0.308	0.265	0.252	0.416	0.412	0.409	0.563	0.528	0.661	0.643	0.446	0.349	0.396	0.483	0.625

TABLE 10. SCOTIAN SHELF SILVER HAKE CATCH BIOMASS-AT-AGE (T.).

AGE	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	1459	3934	1468	439	603	7	166	1726	11238	8784	21242	11043	6373	9712	9673	132	1412	643	257	61
2	5478	50145	32541	17425	3995	810	1809	25168	94251	52499	54813	189238	50316	56672	56484	6399	10021	8112	8541	3023
3	1186	29695	23002	16065	2918	707	845	12626	36113	32901	14951	20942	30751	12827	17815	16427	15667	15050	17468	23229
4	466	18168	12282	8934	1682	461	377	4702	13283	18988	11497	24588	2199	14398	8544	8571	9725	12426	10048	10343
5	183	10164	6214	4119	743	275	194	1550	6271	6941	4883	28511	3876	18417	2272	2771	5522	9210	4924	4910
6	75	5931	3404	2044	331	166	117	591	3893	845	4151	8609	1749	2193	1409	1034	2835	6359	2261	2215
7	21	2070	1162	639	94	53	38	167	1696	3017	560	7351	91	352	431	322	1235	2275	875	494
8	6	1218	582	246	27	24	13	50	1402	1109	552	4776	126	456	131	607	1004	1000	296	221
9	1	806	411	108	7	9	4	13	922	1262	538	567	0	589	335	568	330	694	80	87
10	0	594	361	32	2	4	0	5	595	1353	2	1408	116	946	149	0	425	634	64	371
TOTAL 1+	8875	122726	81426	50051	10401	2516	3562	46598	169663	127698	113188	298933	95598	116562	97243	36633	48176	56402	44726	44953

TABLE 11. SCOTIAN SHELF SILVER COMMERCIAL CPUE-AT-AGE (NUMBERS '000 PER HOUR),

AGE	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1.	0.880	0.493	0.146	0.189	0.023	0.118	0.773	2.265	2.182	5.553	1.916	0.999	1.526	2.821	0.105	0.777	0.382	0.187	0.058
2.	7.040	6.010	2.582	0.706	1.414	0.732	5.252	9.044	4.076	6.743	11.545	3.851	3.849	7.012	2.136	2.458	1.910	1.801	0.735
3.	2.846	3.147	1.843	0.339	0.945	0.250	2.002	2.615	1.739	1.047	0.753	1.488	0.556	1.330	3.838	2.430	2.729	2.439	4.187
4.	1.311	1.318	0.833	0.199	0.466	0.084	0.610	0.723	0.743	0.701	0.830	0.070	0.639	0.575	1.450	1.161	1.839	1.067	1.451
5.	0.588	0.532	0.320	0.060	0.224	0.032	0.172	0.250	0.219	0.261	0.755	0.097	0.406	0.103	0.342	0.526	1.172	0.455	0.537
6.	0.288	0.243	0.136	0.024	0.116	0.016	0.057	0.117	0.019	0.109	0.153	0.032	0.051	0.049	0.098	0.233	0.670	0.184	0.209
7.	0.092	0.077	0.040	0.007	0.036	0.005	0.016	0.044	0.051	0.017	0.118	0.001	0.003	0.009	0.024	0.087	0.201	0.050	0.026
8.	0.040	0.030	0.013	0.002	0.014	0.002	0.004	0.024	0.013	0.006	0.043	0.001	0.004	0.002	0.028	0.054	0.070	0.010	0.005
9.	0.020	0.015	0.005	0.000	0.005	0.000	0.001	0.013	0.020	0.009	0.004	0.001	0.004	0.007	0.026	0.011	0.045	0.003	0.002
10.	0.015	0.009	0.002	0.000	0.003	0.000	0.000	0.008	0.019	0.029	0.006	0.001	0.011	0.002	0.000	0.017	0.019	0.001	0.009
AVE [+]	1.312	1.187	0.592	0.149	0.325	0.124	0.889	1.510	0.908	1.448	1.612	0.654	0.705	1.191	0.805	0.776	0.904	0.620	0.722

Table 12. Summary of VPA Tuning for the Scotian Shelf Silver Hake Stock
Assuming an $M = 0.40$.

Terminal F	Criteria	Weighted F (Pop.#'s) vs Effort (hrs.)	CPUE vs 2+ Pop. Biomass
0.1	r	0.939	0.570
	Observed	0.089	0.174
	Predicted	0.159	0.211
	Diff.	-0.070	-0.037
	Intercept	-0.095	0.074
0.2	r	0.935	0.709
	Observed	0.178	0.174
	Predicted	0.197	0.167
	Diff.	-0.019	0.007
	Intercept	-0.053	0.019
0.25	r	0.932	0.680
	Observed	0.223	0.174
	Predicted	0.212	0.146
	Diff.	0.011	0.028
	Intercept	-0.035	0.027
0.3	r	0.928	0.640
	Observed	0.268	0.174
	Predicted	0.225	0.133
	Diff.	0.043	0.041
	Intercept	-0.018	0.039
0.40	r	0.918	0.574
	Observed	0.247	0.174
	Predicted	0.358	0.121
	Diff.	-	-
	Intercept	0.011	0.058

TABLE 13: SCOTIAN SHELF SILVER HAKE POPULATION NUMBERS $F_{2,2}, M_{2,4}$ FULL REC. AT AGE 4,

AGE	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	1469277	1092599	434211	300036	471776	866601	1496439	2700976	1733956	1697181	3853115	1451345	1390172	1525854	1091640	1019781	1270542	2177658	727294	353201
2	585447	969485	692959	275579	195800	309437	580828	1001247	1767889	1010681	960052	2275619	774781	849840	905394	607646	681847	828263	1451163	482421
3	216742	349758	340359	278623	92963	106045	203035	377860	518563	603613	351023	278997	375397	211274	279166	303476	372022	383394	512474	923563
4	92436	139267	109795	130960	120719	50231	68155	132173	195115	175622	264270	177656	109904	131618	99191	128954	140577	176972	196339	272294
5	42226	60208	36265	33212	57923	75234	32226	44372	70861	82855	58308	138502	35861	67916	40075	41432	62657	59756	77945	102662
6	13385	27724	14792	8155	10899	36658	49736	21092	24732	30906	37844	24806	18162	16180	15215	22351	22138	26374	14618	39921
7	5969	8772	6107	2589	803	6445	24213	33085	12488	8900	19194	19361	1729	9556	6999	8045	13359	7972	3402	4887
8	3592	3946	1891	1744	358	308	4209	16150	21714	5477	1935	11925	1443	1084	6153	4275	5001	6354	1065	951
9	2407	2393	906	372	699	177	163	2796	10709	12944	2600	945	3666	879	436	4039	2409	1747	2718	439
10	54	1612	716	163	85	452	102	102	1950	6277	7012	1254	252	2409	303	6	2285	1275	205	1749

TOTAL 1+ 2431536 2656765 1638002 1031431 952023 1451587 2459106 4329854 4377878 3634458 5555352 4380411 2711368 2816609 2444572 2140004 2572838 3669766 2987224 2187088

TABLE 14. SCOTIAN SHELF SILVER HAKE POPULATION BIOMASS (T), $F_{2,2}$ AND $M_{2,4}$,

AGE	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	113134	39500	33434	20102	33968	67595	109240	167461	104037	67887	215774	65311	87581	102232	68773	63226	62257	132837	29819	12715
2	60986	125064	97014	41612	25062	46416	74346	133166	225274	129367	114246	291279	99947	131725	123998	89324	75003	127553	204614	68996
3	34679	66104	64328	54331	18128	20785	35531	66125	86600	113479	73364	60263	76581	51340	68475	63730	64732	76679	109157	178248
4	19966	34956	26461	31430	28973	13010	15880	28295	43316	44608	63425	44414	34070	31193	27079	37397	31770	43358	54975	63769
5	10810	19845	10952	9565	16103	24225	9958	11093	21471	26099	15976	40958	14201	32396	16310	16448	17722	17031	25098	32647
6	4069	10341	5355	2740	3389	13783	18701	6117	9992	13907	21079	10890	9789	7394	8033	11533	7283	9923	5350	14731
7	1850	2570	3388	930	260	2507	9249	9694	5869	5224	9271	9390	1686	10827	5865	5366	5103	3277	1769	3204
8	1189	2171	961	729	122	137	1755	5669	15308	4557	2444	10434	1669	1362	7698	4604	2490	3304	640	1471
9	584	1721	653	193	259	79	66	1261	8867	7922	2303	1110	4	1438	375	4399	1889	966	2424	578
10	8	1185	738	67	23	188	15	30	1619	4469	7	2165	781	2279	551	0	1596	1516	299	2464

TOT. 1+ 247276 352457 242284 161699 126286 188725 274742 428901 522354 417521 517890 536115 325908 372186 337358 296027 269766 415593 434144 383892

TABLE 15. SCOTIAN SHELF SILVER HAKE TABLE OF F VALUES,

AGE	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1.000	0.016	0.055	0.055	0.027	0.022	0.000	0.002	0.013	0.140	0.170	0.127	0.228	0.092	0.122	0.186	0.003	0.028	0.006	0.011	0.006
2.000	0.115	0.647	0.511	0.687	0.213	0.021	0.030	0.258	0.686	0.658	0.836	1.402	0.899	0.713	0.693	0.091	0.176	0.080	0.052	0.055
3.000	0.042	0.759	0.555	0.436	0.216	0.042	0.029	0.261	0.683	0.426	0.281	0.532	0.648	0.356	0.372	0.370	0.343	0.269	0.214	0.171
4.000	0.029	0.946	0.796	0.416	0.073	0.044	0.029	0.223	0.456	0.703	0.246	1.200	0.081	0.789	0.473	0.322	0.455	0.420	0.248	0.200
5.000	0.021	1.004	1.092	0.714	0.057	0.014	0.024	0.185	0.430	0.384	0.455	1.632	0.396	1.096	0.184	0.227	0.465	1.008	0.269	0.200
6.000	0.023	1.113	1.343	1.918	0.125	0.015	0.008	0.124	0.622	0.076	0.270	2.263	0.242	0.438	0.237	0.115	0.621	1.648	0.696	0.200
7.000	0.014	1.134	0.854	1.580	0.560	0.026	0.005	0.021	0.424	1.126	0.076	2.196	0.667	0.040	0.093	0.075	0.343	1.613	0.875	0.200
8.000	0.006	1.072	1.227	0.515	0.394	0.237	0.009	0.011	0.117	0.345	0.316	0.779	0.096	0.510	0.021	0.173	0.652	0.449	0.486	0.200
9.000	0.002	0.806	1.317	1.076	0.035	0.147	0.069	0.013	0.134	0.213	0.329	0.920	0.020	0.666	1.889	0.170	0.236	1.743	0.041	0.200
10.000	0.046	0.894	0.859	0.834	0.137	0.027	0.024	0.210	0.575	0.449	0.418	1.406	0.453	0.679	0.392	0.225	0.412	0.685	0.297	0.200
AVE 1+	0.031	0.843	0.861	0.820	0.174	0.057	0.023	0.132	0.427	0.455	0.335	1.256	0.300	0.541	0.654	0.177	0.373	0.792	0.319	0.163

TABLE 18. PERCENT AT AGE OF THE NAFO DIVISIONS 4VWX SILVER HAKE CATCH.

[illegible]

TABLE 17. PERCENT-AT-AGE (NUMBERS) FOR JULY/AUGUST SCOTIAN SHELF SILVER HAKE RESEARCH SURVEYS

[illegible]

TABLE 18. YIELD PER RECRUIT FOR SILVER HAKE ASSUMING AVERAGE WEIGHTS FROM 1977 TO 1980.

YIELD PER RECRUIT

	FISHING MORTALITY	CATCH (NUMBER)	YIELD (KG)	AVG. WEIGHT (KG)	YIELD PER UNIT EFFORT
F0.1---	0.300	0.21802	0.052	0.241	1.000
	0.446	0.27175	0.060	0.221	0.769
	0.600	0.31293	0.064	0.206	0.614
	0.900	0.36832	0.069	0.188	0.440
	1.200	0.40612	0.072	0.177	0.342
	1.500	0.43438	0.073	0.168	0.279
	1.800	0.45679	0.074	0.162	0.236
	2.100	0.47530	0.075	0.157	0.204
	2.400	0.49104	0.075	0.153	0.179
	2.700	0.50472	0.075	0.149	0.160
	3.000	0.51693	0.076	0.146	0.144
	3.300	0.52768	0.076	0.143	0.131
	3.555	0.53610	0.076	0.141	0.122
FMAX---	3.600	0.53751	0.076	0.141	0.120
	3.900	0.54649	0.076	0.138	0.111
	4.200	0.55477	0.076	0.136	0.103
	4.500	0.56243	0.075	0.134	0.096
	4.800	0.56958	0.075	0.132	0.090
	5.100	0.57626	0.075	0.131	0.084
	5.400	0.58254	0.075	0.129	0.080
	5.700	0.58845	0.075	0.127	0.075
	6.000	0.59405	0.075	0.126	0.071

YIELD PER RECRUIT (KG) VS. FISHING MORTALITY

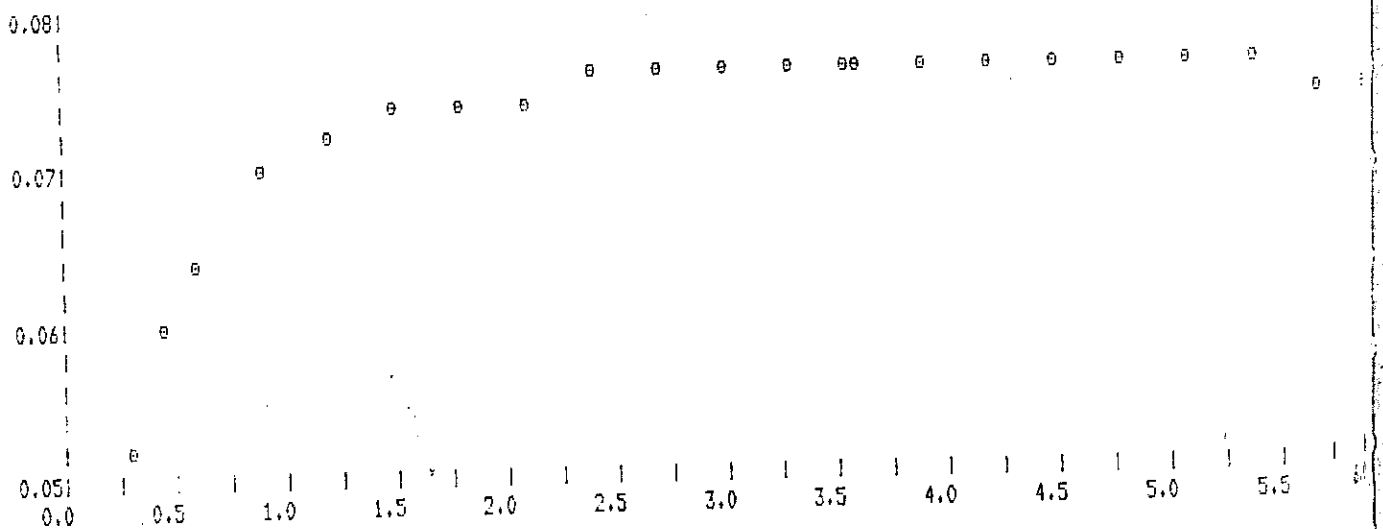


Table 19: Catch projections for Silver hake. $F = 0.2$. $M = 0.4$.

AGE	1	2	3	4	5	6	7	8	9	10
NATAGE	353201	482421	923563	277294	102662	39921	4887	951	439	1749
CATCH	1681	21137	120357	41704	15440	6004	735	143	66	263
WATAGE	0.050	0.139	0.198	0.258	0.321	0.385	0.530	0.849	0.927	0.942
RECRUT	1286145									
LOGREC	14.0672									
STDREC	19.9024									

YEAR	POP NUMBERS	POP BIOMASS	CATCH NUMBERS	CATCH BIOMASS	MATURE F
1981	2187088	392767	207530	45690.42	0.2000
1982	2583381	377046	344369	85929.30	0.4460
1983	2741264	365230	270962	65921.29	0.4460

Option 1

YEAR	POP NUMBERS	POP BIOMASS	CATCH NUMBERS	CATCH BIOMASS	MATURE F
1981	2187088	392767	207530	45690.42	0.2000
1982	2583381	377046	320315	80000.37	0.4090
1983	2760301	371283	276452	67706.47	0.4460

Option 2

YEAR	POP NUMBERS	POP BIOMASS	CATCH NUMBERS	CATCH BIOMASS	MATURE F
1981	2187088	392767	207530	45690.42	0.2000
1982	2583381	377046	239545	60000.06	0.2924
1983	2824556	391793	295030	73763.77	0.4460

Option 3

Table 20: Catch projections for Silver hake at $F_{0.1} = 0.446$.

M = 0.4. Option 3.

POPULATION BIOMASS				POPULATION NUMBERS			
	1981	1982	1983		1981	1982	1983
1	17589.40	64050.02	64050.02	1	353201	1286145	1286145
2	67056.49	32719.30	118825.92	2	482421	235391	854863
3	182865.46	60630.91	28848.50	3	923563	306217	145699
4	71486.49	134507.28	41210.34	4	277294	521750	159854
5	32954.57	48850.55	83807.63	5	102662	152182	261033
6	15361.69	21680.49	29303.20	6	39921	56342	76152
7	2592.11	11620.66	14953.85	7	4887	21909	28194
8	806.87	2276.03	9303.49	8	951	2682	10963
9	406.72	483.62	1243.87	9	439	522	1342
10	1647.29	226.97	245.97	10	1749	241	261
	392767.09	377045.72	391792.80		2187088	2583391	2824556

CATCH NUMBERS				FISHING MORTALITY			
	1981	1982	1983		1981	1982	1983
1	1681	8937	13605	1	0.006	0.008	0.013
2	21137	14902	80991	2	0.055	0.080	0.122
3	120357	56298	38565	3	0.171	0.250	0.381
4	41704	110069	48109	4	0.200	0.292	0.446
5	15440	32105	78575	5	0.200	0.292	0.446
6	6004	11886	22918	6	0.200	0.292	0.446
7	735	4622	8485	7	0.200	0.292	0.446
8	143	566	3299	8	0.200	0.292	0.446
9	66	110	404	9	0.200	0.292	0.446
10	263	51	79	10	0.200	0.292	0.446
	207530	239545	295030				

CATCH BIOMASS			
	1981	1982	1983
1	84	445	678
2	2938	2071	11258
3	23831	11147	7636
4	10751	28376	12403
5	4956	10306	25222
6	2310	4574	8819
7	390	2452	4500
8	121	480	2800
9	61	102	374
10	248	48	74
	45690	60000	73764

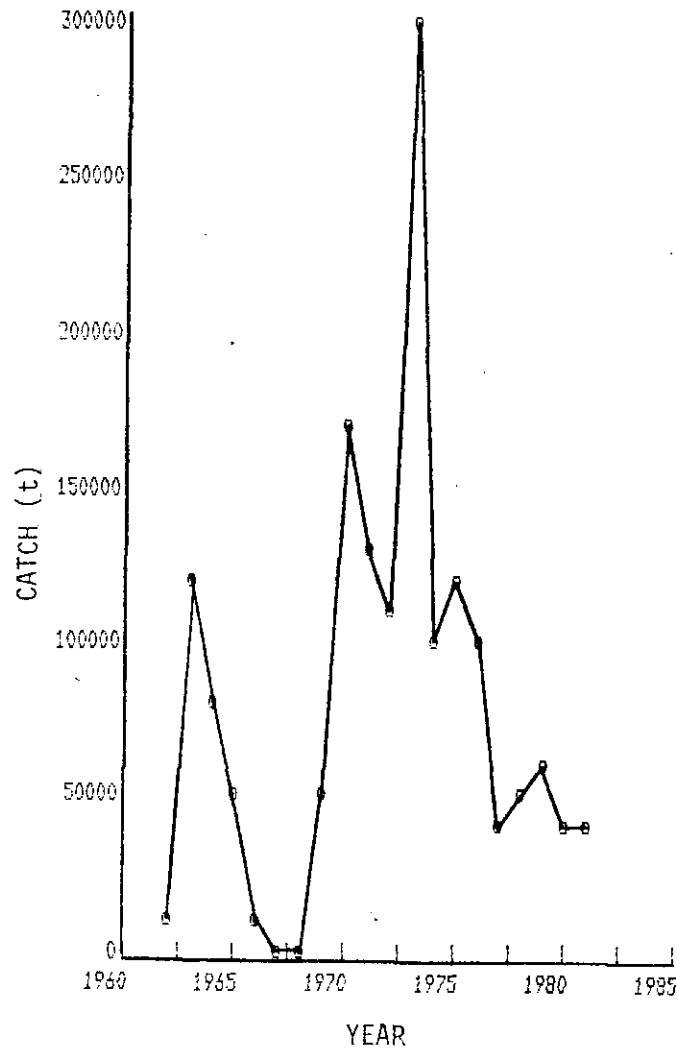


Figure 1. Scotian Shelf silver hake fishery catches (t).

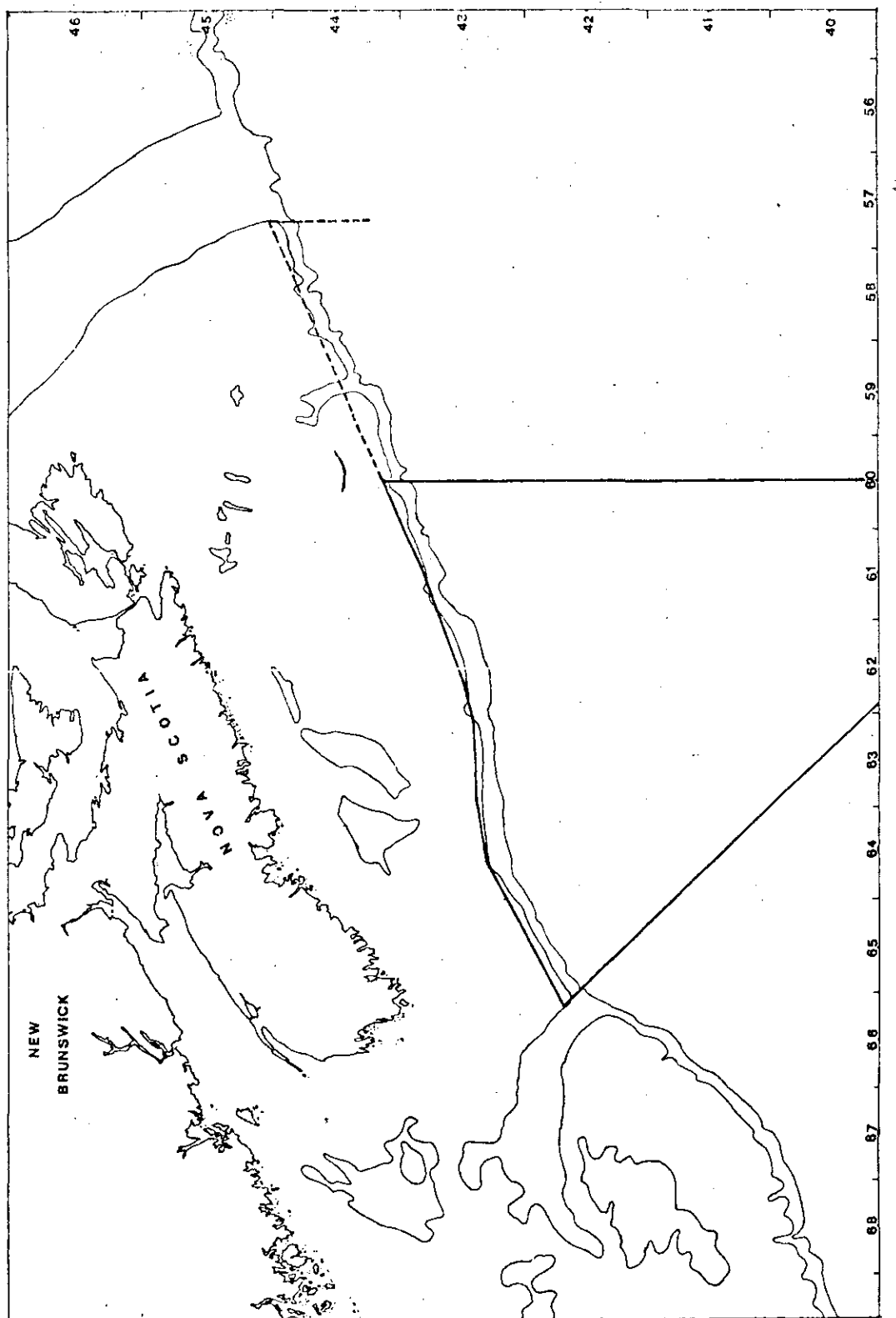


FIGURE 2: Small Mesh Gear Line.

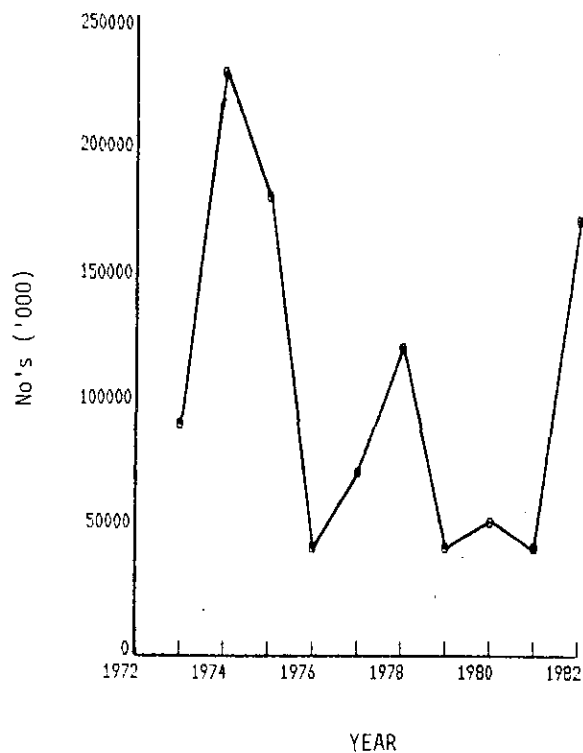


Figure 3a. Scotian Shelf silver hake research vessel surveys numbers.

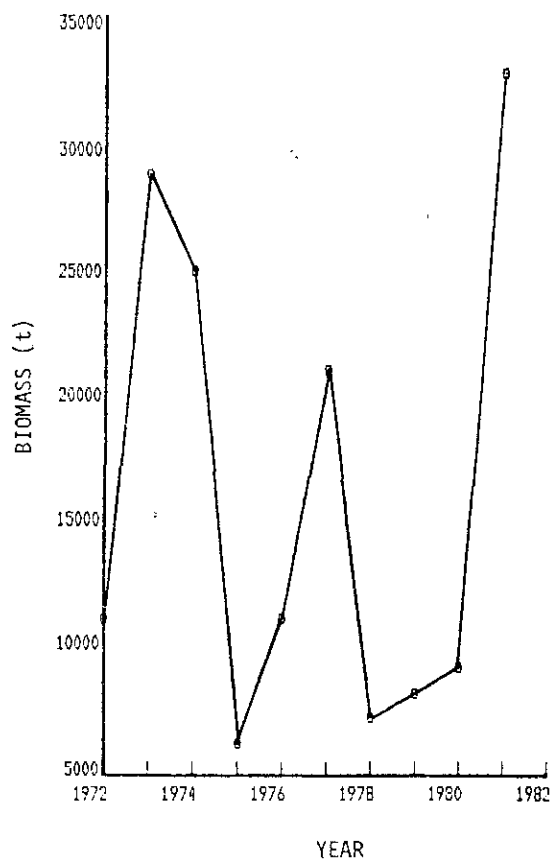


Figure 3b. Scotian Shelf silver hake research vessel survey 1+ biomass (t).

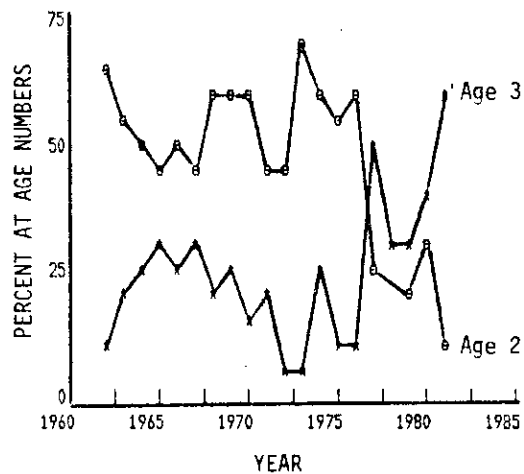


Figure 4. Percent at age numbers for age 2(0) and age 3(*) 4VWX silver hake (for commercial fishery).

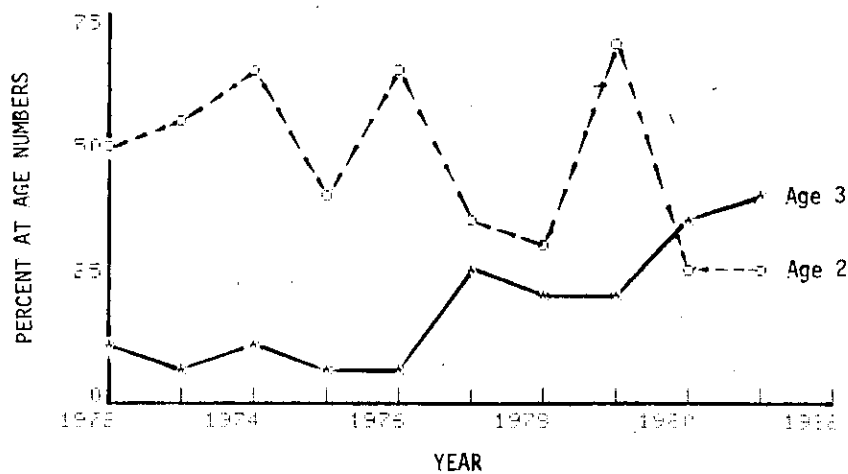


Figure 5. Percent at age (numbers) for research vessel survey age 2(0) and age 3(*) silver hake.

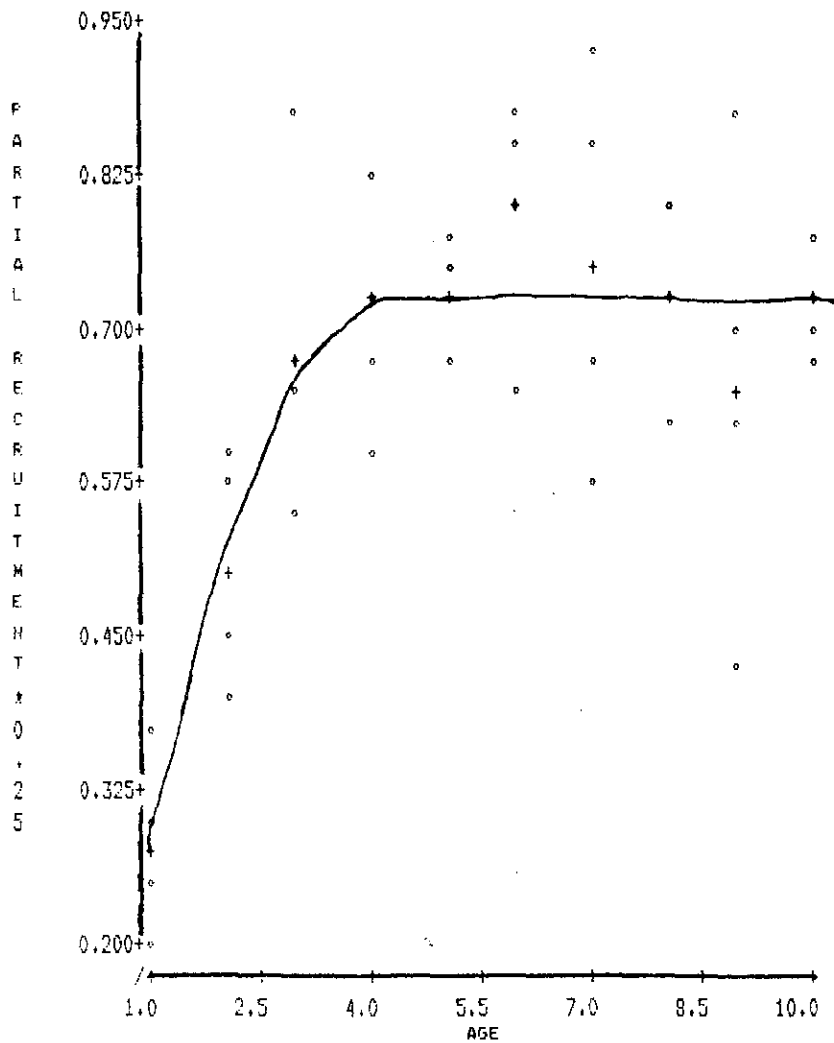


FIG. 6 : PLOT OF SILVER HAKE AVERAGE F S FROM 1977 - 1980
ASSUMING AN $M = 0.40$ AND $F = 0.2$

[illegible]

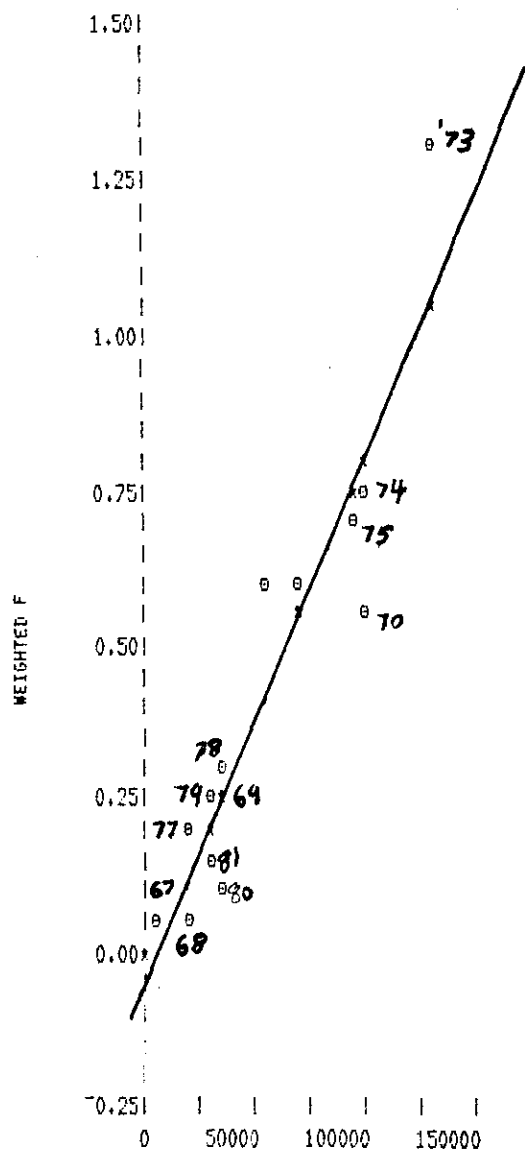


FIGURE 7. POP AGES 2 - 6 WEIGHTED F VS EFFORT (HRS.) FOR THE 4VMX SILVER HAKE STOCK, (R = 0.935).

TABLE , PREDICTED AND CALCULATED WEIGHTED F AND EFFORT (HRS.) FOR THE 4VMX SILVER HAKE STOCK,

YEAR	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
PRED F	0.025	0.110	0.257	0.665	0.821	0.539	1.061	0.827	0.772	0.417	0.120	0.265	0.183	0.235	0.193
WTD F	0.026	0.028	0.252	0.660	0.567	0.600	1.324	0.736	0.679	0.589	0.200	0.277	0.236	0.118	0.147
TERM F	0.027	0.024	0.210	0.575	0.449	0.418	1.406	0.453	0.679	0.392	0.225	0.412	0.685	0.296	0.200
DIR EFF	3818	19295	36033	82710	100624	68313	128061	101283	94997	54430	20382	37058	27574	33628	28745

TABLE , REGRESSION OF WEIGHTED F AGAINST EFFORT (HRS.) FOR THE 4VMX SILVER HAKE STOCK,

REGRESSION COEFFICIENT	8.741876046E-6
INTERCEPT	-0.05849026046
T-VALUE	9.47363052
STANDARD ERROR	9.227588122E-7
DEGREES OF FREEDOM	14
OBSERVATIONS	15
R ²	0.8734789188
R	0.934600941

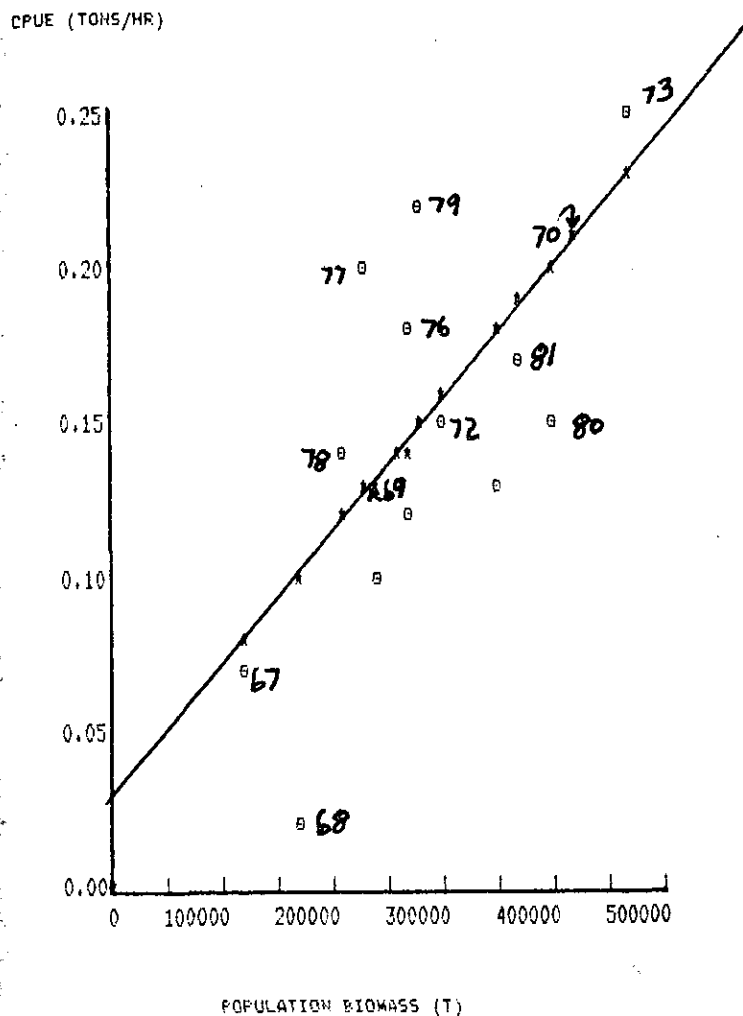


FIGURE 8, POPULATION BIOMASS AND CPUE FOR THE 4VMX SILVER HAKE STOCK,
($R = 0.691$);
SPANNING THE YEARS 1967 - 1981 ;

TABLE , REGRESSION OF YEARLY CPUE AGAINST YEARLY POPULATION BIOMASS FOR THE 4VMX SILVER HAKE STOCK,

YEAR	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
PRED CPUE	0.078	0.097	0.138	0.205	0.176	0.156	0.228	0.128	0.142	0.141	0.126	0.115	0.147	0.199	0.185
DIR, CPUE	0.073	0.020	0.138	0.213	0.131	0.150	0.250	0.098	0.125	0.179	0.200	0.140	0.225	0.147	0.174
BIOMASS	121130	165502	261440	418316	349634	302119	470808	238331	269958	268587	232803	207510	282757	404327	371177

TABLE , REGRESSION OF YEARLY CPUE AGAINST YEARLY POPULATION BIOMASS FOR THE 4VMX SILVER HAKE STOCK,

REGRESSION COEFFICIENT	4.281308989E-7
INTERCEPT	0.0261949363
T-VALUE	3.450071803
STANDARD ERROR	1.2409333E-7
DEGREES OF FREEDOM	14
OBSERVATIONS	15
R ²	0.4779744457
R	0.6913569597

APPENDIX I

Preliminary 1981 monthly observed catch rates for 4VWX Silver hake, Argentine and Squid.

COUNTRY	DIRECTED SPECIES		M O N T H							TOTALS
			APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	
USSR	S. hake	Catch (T)	413.4	8751.3	4506.5	5459.0	188.9	-	-	19319.2
		Hrs.	306.3	6085.2	3704.9	4466.0	130.8	-	-	14693.3
		Days	25	348	268	217	10	-	-	868
		C/hr.	1.3	1.4	1.2	1.2	1.4	-	-	1.3
	Squid	Catch (T)	-	-	45.2	462.4	1.7	-	-	509.3
		Hrs.	-	-	63.2	446.2	10.5	-	-	519.9
		Days	-	-	8	38	1	-	-	47
		C/hr.	-	-	0.7	1.0	0.2	-	-	1.0
	Argentine	Catch (T)	-	-	-	-	-	-	-	-
		Hrs.	-	-	-	-	-	-	-	-
		Days	-	-	-	-	-	-	-	-
		C/hr.	-	-	-	-	-	-	-	-
JAPAN	S. Hake	Catch (T)	-	-	-	-	26.3	3.1	-	29.4
		Hrs.	-	-	-	-	52.0	14.3	-	66.3
		Days	-	-	-	-	7	2	-	9
		C/hr.	-	-	-	-	0.5	0.2	-	0.4
	Squid	Catch (T)	-	-	-	-	2259.4	1256.2	28.1	3543.6
		Hrs.	-	-	-	-	1539.7	2216.3	31.8	3787.8
		Days	-	-	-	-	155	93	3	251
		C/hr.	-	-	-	-	1.5	0.6	0.9	0.9
	Argentine	Catch (T)	-	-	-	-	16.4	2.6	-	19.0
		Hrs.	-	-	-	-	16.0	15.5	-	31.4
		Days	-	-	-	-	3	2	-	5
		C/hr.	-	-	-	-	1.0	0.2	-	0.6
CUBA	S. hake	Catch (T)	-	108.7	241.2	72.8	1.6	-	-	424.3
		Hrs.	-	236.8	562.1	117.5	23.1	-	-	939.4
		Days	-	15	42	9	2	-	-	68
		C/hr.	-	0.5	0.4	0.6	0.1	-	-	0.5
	Squid	Catch (T)	-	-	17.9	1524.7	51.4	-	-	1593.9
		Hrs.	-	-	43.3	721.0	100.7	-	-	865.0
		Days	-	-	4	74	11	-	-	89
		C/hr.	-	-	0.4	2.1	0.5	-	-	1.8
	Argentine	Catch (T)	-	-	-	-	-	-	-	-
		Hrs.	-	-	-	-	-	-	-	-
		Days	-	-	-	-	-	-	-	-
		C/hr.	-	-	-	-	-	-	-	-
PORTUGHAL	S. Hake	Catch (T)	160.8	632.8	665.2	-	-	-	-	1458.8
		Hrs.	203.0	806.1	919.0	-	-	-	-	1928.1
		Days	13	46	50	-	-	-	-	109
		C/hr.	0.8	0.8	0.7	-	-	-	-	0.8
	Squid	Catch (T)	-	-	-	-	-	-	-	-
		Hrs.	-	-	-	-	-	-	-	-
		Days	-	-	-	-	-	-	-	-
		C/hr.	-	-	-	-	-	-	-	-
	Argentine	Catch (T)	-	-	-	-	-	-	-	-
		Hrs.	-	-	-	-	-	-	-	-
		Days	-	-	-	-	-	-	-	-
		C/hr.	-	-	-	-	-	-	-	-

Preliminary 1981 monthly observed catch rates for 4VMX Silver hake, Argentine and Squid.

COUNTRY	DIRECTED SPECIES	M O N T H								TOTALS	
		APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER			
POLAND	S.Hake	Catch (T)	-	-	-	-	-	0.02	-	0.02	
		Hrs.	-	-	-	-	-	4.5	-	4.5	
		Days	-	-	-	-	-	1	-	1	
		C/hr	-	-	-	-	-	0.004	-	0.004	
	Squid	Catch (T)	-	-	-	59.8	486.4	24.9	-	571.1	
		Hrs.	-	-	-	43	130.1	45.1	-	218.5	
		Days	-	-	-	3	14	7	-	24	
		C/hr	-	-	-	1.4	3.7	0.6	-	2.6	
	ITALY	S. hake	Catch (T)	116.4	162.3	176.8	-	-	-	-	455.5
			Hrs.	143.9	250.3	365.3	-	-	-	-	759.5
			Days	14	21	23	-	-	-	-	58
			C/hr.	0.8	0.7	0.5	-	-	-	-	0.6
Squid		Catch (T)	-	-	5.5	-	-	-	-	5.5	
		Hrs.	-	-	25.2	-	-	-	-	25.2	
		Days	-	-	2	-	-	-	-	2	
		C/hr.	-	-	0.2	-	-	-	-	0.2	
Argentine		Catch (T)	-	-	-	-	-	-	-	-	
		Hrs.	-	-	-	-	-	-	-	-	
		Days	-	-	-	-	-	-	-	-	
		C/hr.	-	-	-	-	-	-	-	-	
GRAND TOTALS for all areas from April-October for all countries for Silver Hake, Squid & Argentine.											
S. Hake	Catch (t)	690.6	9655.1	5589.7	5531.8	216.8	3.1	-	21687.12		
	Hrs.	653.2	7378.4	5551.3	4583.5	205.9	18.8	-	18391.1		
	Days	52	430	383	226	19	3	-	1113		
	C/hr	1.1	1.3	1.0	1.2	1.1	0.2	-	1.2		
Squid	Catch (t)	-	-	68.6	2046.9	2798.9	1281.1	28.1	6223.6		
	Hrs.	-	-	131.7	1210.2	1781.0	2261.4	31.4	5416.1		
	Days	-	-	14	115	181	100	3	413		
	C/hr	-	-	0.5	1.7	1.6	0.6	0.9	1.2		
Argentine	Catch (t)	-	-	-	-	16.4	2.6	-	19.0		
	Hrs.	-	-	-	-	16.0	15.5	-	31.5		
	Days	-	-	-	-	3	2	-	5		
	C/hr	-	-	-	-	1.0	0.2	-	0.6		

APPENDIX II

July 1981 Groundfish minimum estimates (Nos. '000) for Scotian Shelf Silver Hake.

Strata/Sex	1	2	3	4	5	6	7	8	9	10	11	12	13+	UK	TOTAL
43-52															
Male	0	40	40	97	0	44	0	0	0	0	0	0	0	0	221
Female	0	72	170	431	132	119	42	100	0	0	0	0	0	50	1116
TOTAL	0	112	210	528	132	163	42	100	0	0	0	0	0	50	1337
53-66															
Male	5975	19450	19029	9509	3102	451	57	0	0	0	0	0	0	256	57829
Female	6808	20776	45345	17502	4372	1845	1292	162	181	0	187	0	0	73	98543
TOTAL	12783	59676	64374	27011	7474	2296	1349	162	181	0	187	0	0	329	156372
70-85															
Male	2009	1792	598	277	143	0	40	0	25	40	0	0	0	0	4924
Female	1565	1779	3348	1522	700	211	40	174	48	0	0	0	0	0	9387
TOTAL	3574	3571	3946	1799	843	211	80	174	73	40	0	0	0	0	14311
90-95															
Male	19	0	0	0	0	0	0	0	0	0	0	0	0	0	19
Female	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	19	0	0	0	0	0	0	0	0	0	0	0	0	0	19
YEARLY TOTAL															
MALE	8003	21282	19667	9883	3245	495	97	0	25	40	0	0	0	256	62993
FEMALE	8373	22627	48863	19455	5204	2175	1374	436	229	0	187	0	0	123	109046
TOTAL	16376	43909	68530	29338	8449	2670	1471	436	254	40	187	0	0	379	172039