STATUS OF THE HERRING RESOURCE IN THE EASTERN BERING SEA

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by V. Wespestad*

INTRODUCTION

Pacific herring have been commercially exploited on a continuous basis since 1960 when the Soviet Union began a fishery on the herring wintering grounds northwest of the Pribilof Islands. Japan entered the fishery in 1967 with a winter trawl fishery and a spring gillnet fishery for herring roe near the western Alaska coast. Catches generally increased through the early years of the fishery, except in 1965 and 1966 when the Soviet fleet reportedly failed to find herring concentrations. In 1970 the fishery peaked with a combined harvest of 146,000 mt (Figure 1). In the following years catches declined sharply due to a series of apparently weak year-classes. In 1976 catches began to rise slightly as herring abundance apparently began to increase, but in 1977 the U.S. established a quota of 21,000 mt in response to uncertainty about the status of the resource.

In 1977 the first large-scale U.S. herring fishery since the 1940's began operation in the nearshore waters of northern Bristol Bay. The U.S. fishery harvests herring for roe and the fishery has expanded from Bristol Bay to nearly all coastal spawning areas in response to increasing herring roe prices. Catches increased from over 2,000 mt in 1977 to 7,305 mt in 1978, 11,754 mt in 1979, and approximately 27,000 mt in 1980 (Table 1).

Since U.S. extended jurisdiction, several management measures have been enacted which have altered the foreign fishery and limited catches. Foreign catch quotas were established in 1977 (19,400 mt) and 1978-79 (8,600 mt each year). Since 1977, foreign herring fisheries were also prohibited east of

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168°W longitude. These measures have largely limited herring to an incidental catch in the pollock fishery and have reduced the Japanese gillnet fishery. In 1980 herring were declared a prohibited species for foreign fisheries in response to a ruling by the U.S. Court for the District of Alaska which found that the National Marine Fisheries Service violated the Procedures Act in amending the Bering Sea preliminary management plan to increase the optimum yield (OY) of herring for 1980. The total 1980 foreign catch through August 16, 1980 is 537.4 mt, including catches discarded after the herring prohibition. It is anticipated that total incidental catch for 1980 will range between 1-1.5 thousand mt.

STOCK CONDITION

Available data indicate that eastern Bering Sea herring stocks declined in abundance in the early 1970's. Age frequency and length frequency data indicate that recruitment to the fishery was very low in the late 1960's and early 1970's. Recently Naumenko (1979) presented relative abundance data on herring year-class strength from the 1947 to 1976 year-classes which show that most of the year-classes from the 1960's were of below average strength (Fig. 2). This data reinforces the suggestion that high levels of catch on weak stocks were the cause of the decline in catch.

Naumenko's data indicates that the 1972, 1974, and 1976 year-classes are of above average strength. Age samples collected by the Alaska Department of Fish and Game confirm that the 1974 year-class is a stronger than average year-class in the Bristol Bay area (Table 2). The 1972 year-class only appeared to be stronger than average in areas north of Bristol Bay based on 1978 and 1979 data. However, this year-class could have been above average in Bristol Bay but sampling procedures in 1976 and 1977 did not allow for

year-class comparisons and in 1978 sampling did not begin until after spawning commenced and a large portion of the 1972 year-class may have spawned and left the area prior to sampling. It is also possible that differential survival is occurring and that the 1972 and 1976 year-classes were only above average north of Bristol Bay.

The year-class data through 1979 shows that there were at least two stronger than average year-classes in Bristol Bay stocks (stocks which account for approximately 80-95% of the coastal spawning biomass), and in the smaller northern stocks there were three stronger than average year-classes. The improvement in stock condition is evident in relative abundance indices of spawning herring schools which have increased several-fold through 1979 in all areas (Table 3). Absolute biomass estimates for coastal areas in 1978 and 1979 were 187,210 - 334,723 mt and 260,317 - 640,380 mt, respectively (Barton and Steinhoff 1980). These estimates were based on estimates of total surface area of herring schools present on the days of peak abundance in each spawning area which were converted to biomass based on biomass per area information obtained from purse seine catches of schools of known surface area. Peak days, rather than a summation of all daily counts, were used to minimize possible multiple counting of schools. This may have led to conservative estimates since spawning occurs in several age specific waves, but sampling indicated that spawned fish do not immediately leave the grounds and significant amounts of mingling of pre and post spawning herring occurs.

In 1980 a significant change occurred in the spawning stocks in Bristol Bay while stocks to the north appeared to be equal in abundance or slightly improved relative to 1979. In Bristol Bay 98% of the herring present on the spawning grounds were ages 6, 7, and 8. Age 5 herring (1975 year-class) were present in low numbers, but this was anticipated since it had previously

been determined to be a weak year-class. Ages 3 and 4 were not found to occur above trace amounts. The relative abundance of age 3 herring is unknown, but Soviet prerecruit surveys indicated that the abundance of age 4 fish is above average and they should have been a significant proportion of the Bristol Bay spawning population in 1980.

All of the data available from spawning ground surveys in Bristol Bay, including reduced egg deposition, point toward a catastrophic decline in the stock. Preliminary estimates of the 1980 eastern Bering Sea spawning herring biomass were 76,200 mt - 137,300 mt based on previous years' estimates of school density. In 1980 additional density estimates were obtained which were near the low end of the range of the previously obtained estimates. No relationship could be discerned among the density estimates; therefore, an average density was used to obtain a final biomass estimate of 82,900 mt. All of the 1980 biomass estimates are considerably lower than previous years' estimates.

It is likely that there was not any significant change in the size of the Bristol Bay stock between 1979 and 1980; rather, the stock responded to the severe weather conditions prevalent over much of the spawning period. These conditions may have altered herring behavior and caused aerial surveys to be only marginally successful in 1980 with only a portion of the stock seen. This supposition is supported by data from the foreign fisheries that shows no change in the length frequency of herring collected by U.S. observers during the winter months for the past three seasons (Table 4). Had there been some reduction in the abundance of the younger ages one would expect to see a shift in the length frequency toward the larger lengths. However, it could also be possible that the younger herring harvested this past winter were from the unaffected northern stocks. At the current low trawl harvest levels this is possible if the northern stocks are on the winter grounds.

Another estimate of Bristol Bay herring abundance is obtained by using previous years' biomass estimates and by projecting them forward to the next year using instantaneous mortality and growth rates. To accomplish this the minimum biomass estimates of 172,625 mt in 1978 and 216,756 mt in 1979 were apportioned to age specific biomass using the age frequencies observed in Bristol Bay. The number of fish in each age was multiplied by average weight at age reported by Shaboneev (1964) to obtain a biomass distribution (Table 5). This biomass distribution was applied to the 1978 and 1979 minimum biomass estimates to obtain age specific biomass (Table 5). The estimated biomass at age was then projected to the following year using age specific mortality rates from Skud (1963) and growth rates calculated from Shaboneev's (1964) weight data in the formula:

$$B_t = B_o \, e^{(G-Zt)}$$

where B_o = Biomass at age in the base year

B_t = Projected biomass at age

G = Age specific instantaneous growth rate

Z = Age specific instantaneous mortality rate

e = Napier's number

t = 1 year.

Mortality rates were unavailable for ages 1 and 2, but the rates for ages 6 and 7 were utilized (Table 5). These rates may be too low but growth rates are also low and the overall rate of biomass change is very conservative relative to older ages.

In the projection from 1978 to 1979, biomass went from 172,625 mt to 148,561 mt, which was lower than the observed biomass of 216,756. However, recruitment into the spawning population was not included in the calculation. Recruitment appears to closely follow maturation as Barton and Steinhoff (1980) report 100% mature herring at age 4 and older, 95% for age 3, and 74%

for age 2. Barton et al. (1977) found in comparisons of offshore and onshore age compositions on the Alaska Peninsula that 100% of age 2, 85% of age 3, and 23% of age 4 occurred offshore during the spawning period. It is safe, therefore, to assume very few immature herring enter the spawning grounds.

Naumenko (1979) reported mean maturation rates based on 20 years of data from the winter fishery which correspond well with earlier reported maturation rates (Rumytsev and Darda 1970) and likely reflect the proportion of each age class appearing on the spawning grounds (Table 5). However, the rate of maturity is variable with year-class strength to some degree and in some cases according to Naumenko's data can vary by a factor of 5 in the younger ages. However, had the average maturation rates been used, the projected biomass estimate for 1979 would have been 176,027 mt, near the observed estimate of 216,756 mt.

The projection of 1979 estimated biomass to 1980 results in an estimate of 161,837 mt without recruitment and 168,398 mt with recruitment. Including an estimated 20,600 mt biomass from stocks north of Bristol Bay results in a total eastern Bering Sea spawning stock biomass estimate of 182,437 - 188,998 mt. Overall, the trend has been toward increasing herring abundance in recent years; however, in 1980 there appears to have been a decrease in the abundance of Bristol Bay stocks which accounts for most of the eastern Bering Sea spawning biomass. Unfortunately the data available are not adequate to determine whether the decline is real or apparent. At present, biomass is estimated to be between 76,200 mt to 188,998 mt and preliminary ABC for the 1981 herring fishing year (April, 1981 - March, 1982) to be 6,572 - 32,240 mt.

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TABLE 1. HERRING CATCHES (MT) BY NATION IN THE EASTERN BERING SEA BY FISHING AND CALENDAR YEAR FOR 1959-80.

FISHING YEAR (JULY-JUNE)	TRAWL FISHERY USSR	TRAWL FISHERY JAPAN	GILLNET FISHERY JAPAN	U.S. FISHERY	TOTAL CATCH FISHING YEAR	CALENDAR YEAR	CALENDAR YEAR CATCH
1959-60	10,000	A/	--	--	10,000	1960	10,403
1960-61	9,800	A/	--	--	9,800	1961	10,572
1961-62	24,450	A/	--	--	24,450	1962	24,763
1962-63	47,060	A/	--	--	47,060	1963	47,060
1963-64	38,950	A/	--	18	38,968	1964	39,830
1964-65	10,000	1,362	--	0	11,362	1965	10,896
1965-66	5,000	3,117	--	0	8,117	1966	8,385
1966-67	A/	2,831	30	122	A/	1967	A/
1967-68	9,800	9,486	818	83	20,187	1968	60,705
1968-69	75,379	50,857	1,949	45	128,230	1969	129,482
1969-70	92,228	23,901	1,585	32	117,746	1970	145,579
1970-71	60,126	24,236	4,603	18	88,983	1971	46,148
1971-72	67,546	13,143	472	88	81,250	1972	60,546
1972-73	39,999	346	1,878	78	42,301	1973	36,352
1973-74	16,810	219	3,337	114	20,480	1974	25,549
1974-75	15,039	2,663	736	51	18,489	1975	16,066
1975-76	9,518	3,119	2,668	8	14,922	1976	30,635
1976-77	18,097	13,413	551	2,550	32,061	1977	21,287
1977-78	8,340	2,703	0	7,305	18,348	1978	16,288
1978-79	6,133	1,804	155	11,754	20,135	1979	19,055
1979-80 C/	2,151	1,009	0	26,700	27,221		

A/ NOT AVAILABLE.
B/ INCOMPLETE.
C/ PRELIMINARY
DATA SOURCES:

USSR 1960-1964: FISHING SEASON (NOVEMBER-APRIL) FROM SHABONEEV (1965) AND RUMYANTSEV AND DARDA (1970) 1964-1966: U.S. FISH AND WILDLIFE SERVICE FOREIGN FISHERY SURVEILLANCE REPORTS, ALASKA REGION 1968-1976 FURNISHED BY THE USSR UNDER PROVISIONS OF U.S.-USSR FISHERIES AGREEMENTS 1977-80; DATA PROVIDED BY THE USSR UNDER PROVISIONS OF P.L. 94-265

JAPAN 1960-1963: FORRESTER ET AL., 1978; 1964-1976: FISHERIES AGENCY OF JAPAN 1977-80: DATA PROVIDED BY JAPAN UNDER PROVISIONS OF P.L. 94-265.

U.S. ALASKA DEPARTMENT OF FISH AND GAME, EXCLUDES SUBSISTENCE CATCHES.

Table 2.--Age distribution in percent of herring in 1978 and 1979 in coastal spawning grounds (from figures presented by Barton and Steinhoff 1980).

	Bristol Bay		Security-Goodnews		Nelson Island		Cape Romanzof		Norton Sound	
Age	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979
1	18	1	2	0	0	0	0	1	0	0
2	4	6	5	1	0	2	1	2	1	1
3	5	19	7	12	4	9	4	9	5	19
4	33	5	46	5	57	3	33	3	32	7
5	29	43	25	41	17	57	7	46	8	55
6	9	14	12	9	17	5	52	5	47	5
7	2	10	1	27	2	22	1	32	2	8
8+	1	2	2	5	3	2	2	2	5	5
N	2224	5246	1096	1490	738	1643	644	2376	1423	527

TABLE 3. RELATIVE ABUNDANCE INDICES OF SPAWNING HERRING (STANDARDIZED TO 1976) IN MAJOR SPAWNING AREAS OF THE EASTERN BERING SEA. A/

	1968	1972	1974	1975	1976	1977	1978	1979	1980
BRISTOL BAY	--	--	---	---	1.0	2.1	10.3	33.1	3.7
GOODNEWS BAY/ SECURITY COVE	--	---	---	9.5	1.0	20.9	48.7	664.1	40.7
NELSON ISLAND	--	--	--	0.5	1.0	1.0	3.2	3.2	C/
NORTON SOUND: ST. MICHAELS TO UNALAKLEET	20.8	8.4	2.9	0.0 B/	1.0	---	5.3	22.2	33.4

A/ RELATIVE ABUNDANCE INDICES ARE CORRECTED SCHOOL COUNTS WEIGHTED BY SURFACE AREA OBTAINED FROM AERIAL SURVEYS.

B/ MINIMAL SURVEY EFFORT.

C/ POOR SURVEY CONDITIONS

Table 4.--Length frequency distribution of herring harvested by Japan and the USSR during Oct-Mar, 1977-78-1979 in numbers.

Standard length[a/] (cm)	77-78		78-79		79-80	
	Japan	USSR	Japan	USSR	Japan	USSR
15	8		1			
16	15	1	10			
17	8	8	33		2	1
18	1	83	51		3	7
19	30	230	35		4	39
20	104	303	32	5	49	127
21	150	356	37	33	116	241
22	556	579	172	101	106	401
23	638	376	401	158	174	345
24	638	266	485	106	145	303
25	895	214	410	99	173	313
26	635	142	344	60	37	312
27	176	39	170	18	89	264
28	36	10	52	5	16	131
29	29	9	21	5	3	44
30	5	12	2	9	1	8
31	4	1	1	1	1	1
32						
33	2					
34	2					
TOTAL	3932	2629	2257	600	919	2537
mean length	24.1	22.2	24.1	23.8	23.6	22.4
mode	25	22	24	23	23, 25	22

a/ Fork length measured in 1977, 1979, and 1980, converted to standard length using $SL_{mm} = -2.1885 \times 0.922\ FL_{mm}$

Table 5.--Projection of 1978 and 1979 Bristol Bay herring biomass estimates to 1979 and 1980 by age based on observed age distribution and available weight, mortality, and recruitment data.

Age	Age Distribution (numbers) 1978	1979	Mean Wt. (gm)	Sample Biomass Distribution (gm) 1978	1979	Sample Biomass Distribution (%) 1978	1979 **
1	395	28	18	7,110	504	3	0
2	79	327	37	2,923	12,099	1	T
3	111	1,013	96	10,656	97,248	4	1.0
4	734	262	115	84,410	30,130	31	1.0
5	644	2,276	159	102,396	361,884	38	49.2
6	194	714	224	43,456	159,936	16	25.6
7	45	525	256	11,520	134,400	4	19.9
8+	22	101	301	6,622	30,401	2	3.3
TOTAL	2,224	5,246		269,093	826,602		

Age	Estimated Biomass Distribution (mt) 1978	1979	Rates M[a/]	G	R	Projected Biomass Without Recruitment 1979	1980	With Recruitment[b/] 1979	1980
1	5,179	0	.72	.72	0				
2	1,726	0	.59	.95	.059	5,179	0	*	*
3	6,905	2,168	.20	.18	.427	2,473	T	17,905	T
4	53,514	2,168	.33	.32	.832	6,768	2,125	13,188	4,141
5	65,598	106,644	.46	.34	.956	52,982	2,146	60,878	2,466
6	27,620	55,490	.59	.13	.998	58,180	94,585	60,736	98,740
7	6,905	43,134	.72	.16	1.000	17,436	35,030	17,471	35,100
8	3,453	7,153	.85	.08	1.000	3,944	24,639	3,944	24,639
9+						1,599	3,312	1,599	3,312
TOTAL	172,625	216,756				148,561	161,837	176,027	168,398

a/ Fishing mortality not included, F_{max} 1979-80 estimated as 0.07 or less than 0.01/age

b/ Formula with recruitment is: $B_t = \frac{B_o}{R_o} \left(e^{G-Z} \right) \cdot R_t$

* Undefined

** Revised age distribution by Alaska Dept. Fish and Game, Sept. 1980.

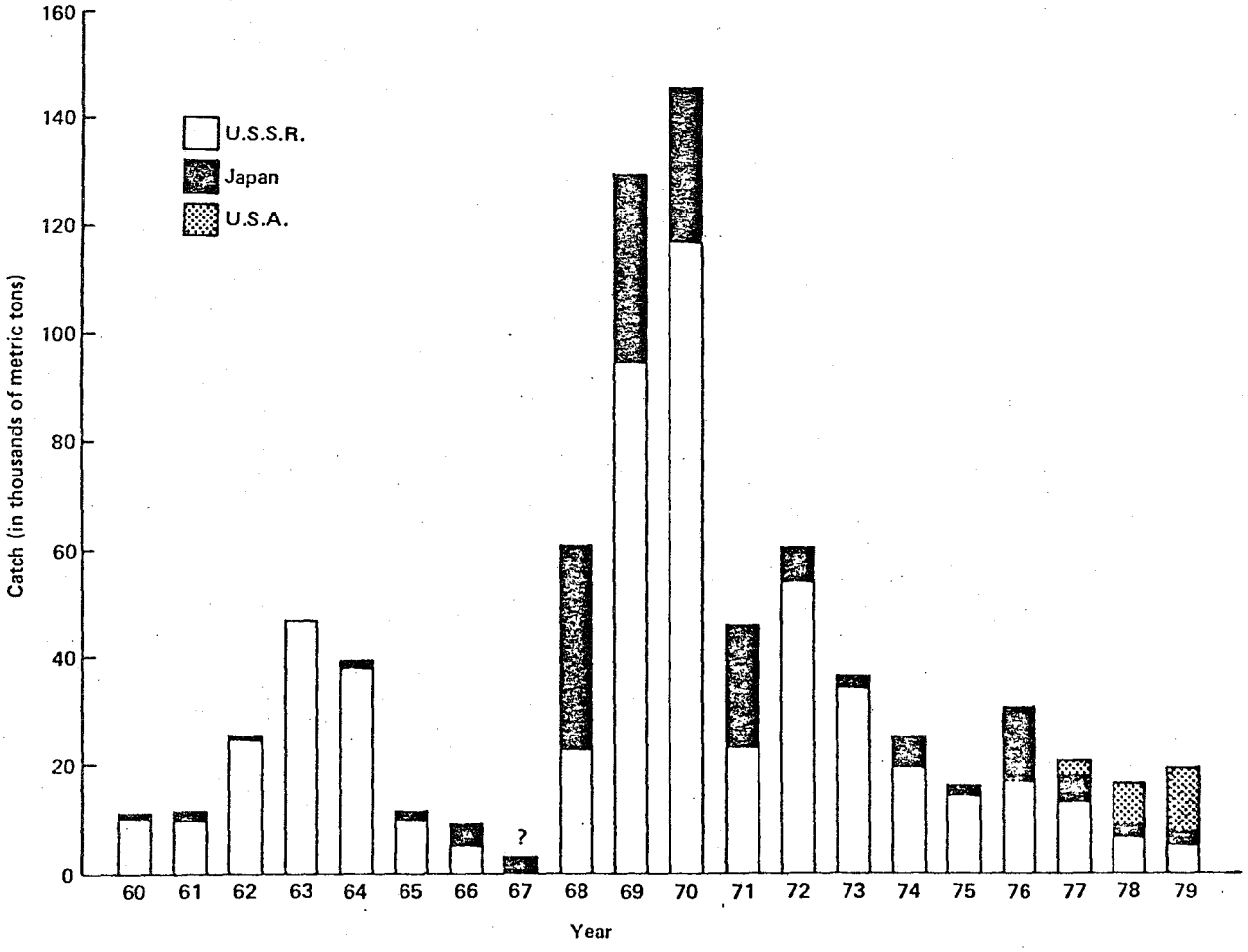

Figure 1. Eastern Bering Sea all-nation herring catch 1960-79.

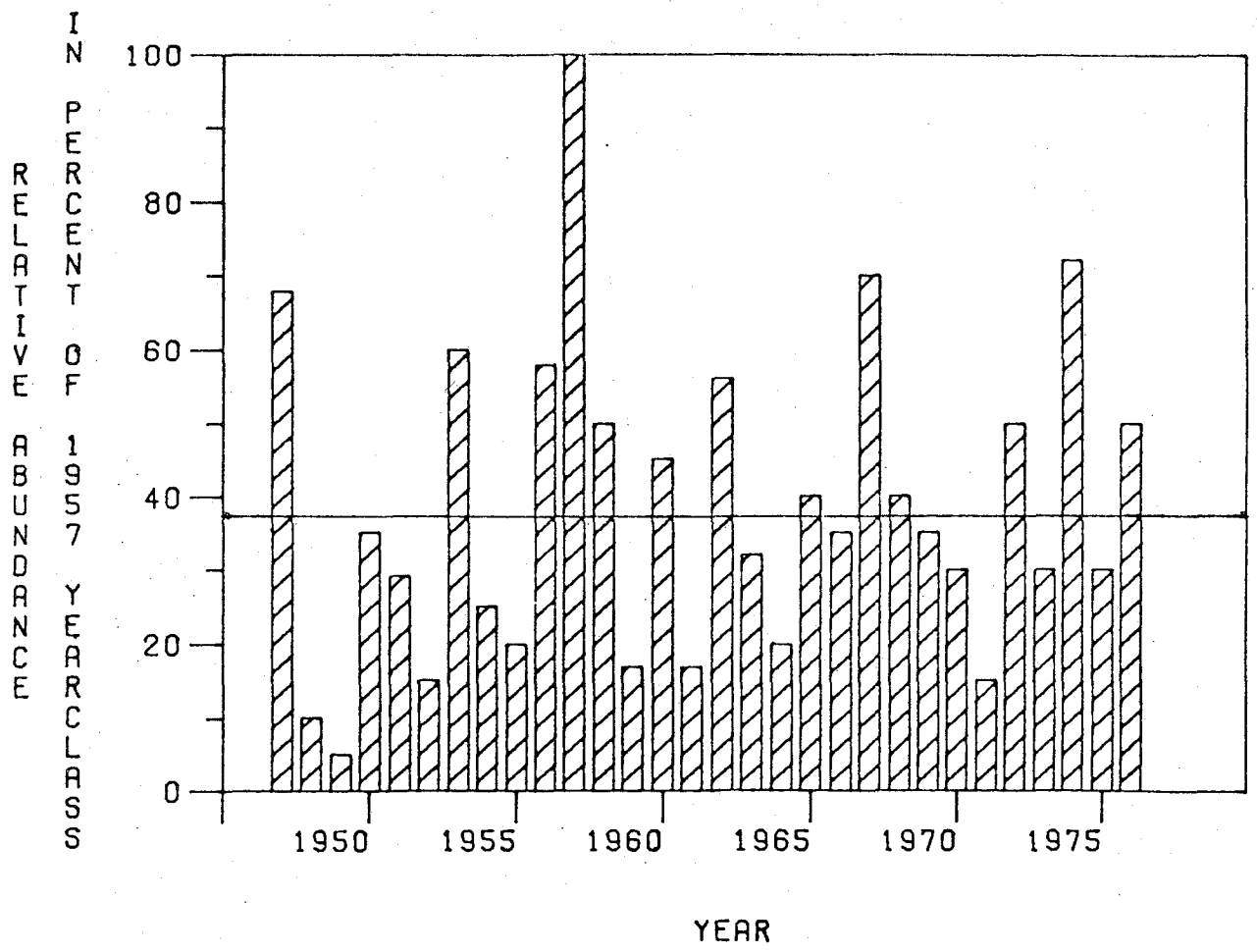

FIG. 2 Abundance of Pacific herring year-classes in the eastern Bering Sea relative to the 1957 year-class. (From Naumenko 1979.)