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BIOLOGICAL CHARACTERISTICS OF THE CATCH
FROM 1984-85 PACIFIC HERRING
CLUPEA HARENGUS PALLASI, ROE FISHERY IN CALIFORNIA

by

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ABSTRACT

In Tomales Bay, 5-, 6-, and 7-yr-old herring, Clupea harengus pallasii, composed 75% by number of the 1984-85 season's catch. In San Francisco Bay, 2-, 3-, and 4-yr-old herring composed 82% by number of the round-haul catch, and 5-, 6-, and 7-yr-old herring composed 68% by number of the gill net catch.

The percent of 4-yr-old herring increased to a record high level in the San Francisco Bay gill net catch.

Recruitment of 2-yr-old herring into the San Francisco Bay roundhaul fishery was excellent, with 2-yr-old herring composing 41% of the catch.

The growth rate of herring improved in both Tomales and San Francisco Bays, after the period of poor growth during the recent El Niño, when the weight of herring averaged 20% below normal.

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INTRODUCTION

The Department began monitoring the age, size, and sex composition of the Pacific herring, Clupea harengus pallasii, roe fishery catch in Tomales and San Francisco Bays in 1973. Spratt (1981, 1982, 1983, and 1984b) reported on data collected by sampling the herring roe fishery from 1973 until 1984. This report compliments previous data to provide a continuous seasonal series from 1973 through the 1984-85 season.

METHODS

Sampling

In the Tomales Bay area, herring samples were collected at Marshall and Bodega Harbors. In San Francisco Bay, herring were collected at Sausalito and San Francisco. This season the sampling level was increased from three per day to four per day in each bay, when herring were available. A sample consisted of 2.3 kg (5 lb) collected after vessels unloaded.

All samples were processed in a fresh condition. Laboratory procedures have remained unchanged since the fishery began in 1973 (Spratt 1981). Every fish in the sample was weighed to the nearest 0.1 g, measured in millimeters body length (mm BL), and sex and maturity were determined. Body length was used as the unit of measurement because the fleshy caudal peduncle of herring makes the hypural plate difficult to locate. Body length was measured from the tip of the snout to the end of the silvery part of the body. Otoliths were removed for age determination and stored in gelatin capsules. Ages were assigned by the author using previously determined criteria (Spratt 1981). All otoliths were read twice before final age determinations were made.

RESULTS

Tomales Bay

A total of 38 samples was collected this season and 311 individual fish were processed.

Age Composition

The Tomales Bay fishery was restricted to gill nets in 1977, and since then, the catch has been dominated by 5-, 6-, and 7-yr-old herring.

In the 1984-85 season, 5-, 6-, and 7-yr-old herring composed 75% of the catch by number and 77% by weight (Figure 1), about average over the long run. The percent of 8- and 9-yr-old herring in the catch has stabilized during the past two seasons at 5% by number (Figure 1), the lowest level since the fishery was restricted to gill nets in 1977.

The percentage of 4-yr-old herring in the catch (13%) was about average, while the percentage of 3-yr-old herring in the catch was at its highest level (6%) since the 1977-78 season, when the fishery was restricted to gill nets.

Length Composition

The average length of herring in the Tomales Bay catch during the 1984-85 season increased to 202 mm BL (Table 1). The average length of 5-, 6-, and 7-yr-old herring (Table 2) all increased from the 1983-84 season (Spratt 1984b). This increase is encouraging, but the mean length of the catch remains depressed. This is due to the numbers of 3-yr-old herring in the catch and a residual effect of poor growth during 1983, from which the Tomales Bay herring population has not completely recovered.

The timing of the fishery also influenced the size and age composition of the catch this season. Most of our samples were taken late in the spawning season when the older age classes are less abundant.

Weight Composition

The mean weight at age of Tomales Bay herring declined dramatically in the 1983-84 season, when weight at age of all exploited year classes was below normal (Table 3). In the 1984-85 season, the mean weight of all age classes increased, but the average weight of the dominant age classes 5- through 7-yr olds remains below the 7-yr mean (Figure 2), and still exhibits the effect of poor growth in 1983.

Sex Ratio

The female to male number and biomass (weight) ratios of the 1984-85 Tomales Bay catch were equal (Table 4). These ratios (60% females) are within the range of expected values.

San Francisco Bay

A total of 55 samples was collected this season and 531 individual fish were processed.

Age Composition

In San Francisco Bay, both roundhaul and gill net fisheries were sampled. Recruitment, which can be quite variable, has stabilized the past two seasons. Recruitment of the 1983 yr class (2-yr olds) into the 1984-84 fishery was excellent (Spratt 1984b) when the 1983 yr class composed 47% of the 1983-84 season's roundhaul catch. In 1984-85, recruitment was again very good and the 1983 yr class (2-yr olds) composed 41% by number and 31% by weight of the 1984-85 roundhaul catch (Figure 1). The 1983 yr class appears to be strong, but the

roundhaul fishery in San Francisco Bay was again confined to the latter part of the spawning season when young herring are more available to the fishery. There were no 8- or 9-yr-old herring in the catch samples, but in 7 out of 12 seasons, 8- and 9-yr-old herring have composed 1% or less of the roundhaul catch.

The San Francisco Bay gill net catch is normally dominated by 5-, 6-, and 7-yr-old herring. This season 5-, 6-, and 7-yr-old herring composed 68% by number and 71% by weight of the gill net catch (Figure 1). Prior to this season, 2 1/4 in. mesh was the minimum mesh size allowed in the December gill net fishery. In the 1984-85 season, the minimum mesh restriction was lowered to 2 1/8 in. This had an impact on the overall age composition of the gill net fishery. The percent of 4-yr-old herring in the gill net catch increased to 21% by number, and the three predominant age classes this season were actually 4-, 5-, and 6-yr olds (Figure 1). Three-year-old herring also were present in unusually high numbers in the gill net catch.

Length Composition

The mean length of the San Francisco Bay roundhaul catch declined to an all-time low of 165 mm BL in the 1983-84 season due to the strong 1982 yr class and poor growth during 1983 (Spratt 1984b). The growth rate improved in 1984 and the mean length of the 1984-85 roundhaul catch increased to 176 mm BL (Table 1).

Herring age 2 through 6 normally comprise about 90% of the roundhaul catch and these five year classes have recovered from the effects of poor environmental conditions in 1983 (Figure 3), and the mean length of all age groups sampled returned to normal (Table 5).

The mean length of the gill net catch in San Francisco Bay dropped below 200 mm BL for the first time (Table 1). The average length at age (Table 6) of herring in the gill net catch was normal, but the change in mesh size from 2 1/4 in. to 2 1/8 in. caused an increase in the numbers of 3- and 4-yr-old herring resulting in the decline in overall mean length of the catch.

Weight Composition

The overall weight composition of the San Francisco Bay roundhaul and gill net catches (Figure 1) parallels that of the age composition. The roundhaul catch was dominated by 2- and 3-yr-old herring, while the gill net catch was composed mainly of 5- and 6-yr-old herring. The poor growth in 1983 had much more of an effect on the weight of individual herring than it did on the length. Samples from the roundhaul catch in the 1983-84 season indicated that all age classes were below normal weight (Table 7). In the 1984-85 season, San Francisco Bay herring exhibited a complete recovery from the period of poor growth in 1983 (Table 7 and Figure 3). Poor growth and the subsequent improvement was not evident in the gill net catch because gill nets are selective for large herring. However, the gill net catch was very poor in the 1983-84 season, indicating that there were not many large herring available during the season.

Sex Ratio

There was an unexpected change in the sex and biomass (weight) ratios in the San Francisco Bay fishery this season. Normally, females compose about 2/3 of the gill net catch and also compose about half of the roundhaul catch. This season the percentage of males in the gill net catch was 53% (Table 4) and the

percentage of females in the roundhaul catch was 65% (Table 4). This is a complete reversal from previous seasons and no explanation is apparent at this time.

DISCUSSION

Both the Tomales Bay and San Francisco Bay herring stocks were affected severely by the 1982-84 El Niño. The herring biomass in both bays declined in the 1983-84 season (Spratt 1984a) and the growth rate of individual herring was also depressed (Spratt 1984b). Oceanic conditions improved in 1984 and both populations responded favorably. The San Francisco Bay herring population increased 15% during 1984 and the Tomales Bay population recovered to a near normal level (Spratt 1985).

The overall age composition of the Tomales Bay herring catch changed very little from 1983 to 1985. Even when the biomass was at its lowest level in 1984, the age composition of the catch was composed of 5-, 6-, and 7-yr-old herring. The effect of the poor environmental conditions on Tomales Bay herring was uniform across all exploited age classes, causing poor growth, increased natural mortality exhibited by the decline in abundance from the recent peak in 1983, and movement of the stock away from its traditional spawning ground. This is substantiated by the return of herring in the 1984-85 season and the improvement in the growth characteristics of the stock.

The 1984 yr class could be weak, due to the low spawning escapement in 1984, but the 1984 yr class will not be recruited into the gill net fishery until the 1987-88 or 1988-89 season. We have no data on the strength of the 1982 or 1983 yr classes, but these two year classes exhibited good recruitment in San Francisco Bay, suggesting that recruitment may have been good in Tomales Bay also.

The age composition of the San Francisco Bay roundhaul herring catch has also changed little during the past 12 yr (Figure 4). In the 1983-84 and 1984-85 seasons, the late-season roundhaul fishery resulted in catch samples heavily weighted toward young herring. Nevertheless, the abundance of 2-yr-old herring both seasons indicated that the 1982 and 1983 yr classes are strong. Good recruitment occurred during the decline in overall biomass from the peak of 100 000 tons in the 1981-82 season, and follows the weak 1981 yr class. Preliminary data on the strength of the 1984 yr class in San Francisco Bay is encouraging. The 1984 yr class will be recruited as 2-yr-old herring next season. Therefore, three consecutive years of good recruitment are expected. I believe that this accurately reflects the recruitment pattern of the San Francisco Bay herring population, and that there are relatively fewer older herring in the population now than in recent years. The reduction in spawning biomass from 1982 occurred during a time when recruitment was relatively good, resulting in a population age structure that is heavily weighted toward newly recruited year classes. This age structure is expected to continue for at least one more season or until the 1982, 1983, and 1984 yr classes begin to enter the gill net fishery as 5-yr olds in the 1986-87 season.

CONCLUSION

The 1982-84 El Niño is the most severe environmental phenomenon of this century, and its lingering effects are still noticeable along California's coastline in 1985. Considering that California marks the southern limit of major herring concentrations, it is surprising that our stocks were not affected

to a greater degree. Both Tomales and San Francisco Bays' herring populations are now well below recent peak levels, but remain above recent low levels of abundance. They have also exhibited a dramatic improvement in growth rates in 1984 and excellent recruitment during the past 2 yr. California's herring stocks have responded to the decrease in abundance, since 1982, with an increase in productivity and growth. This is an indication that these stocks are in a healthy condition even though biomass levels may be depressed.

The Tomales Bay herring population is expected to exhibit normal variation next year and fluctuate within the range of previous season estimates. The San Francisco Bay herring biomass is expected to continue to increase in 1985 due to good recruitment in recent years and improved environmental conditions which are expected to result in better growth rates and normal natural mortality during 1985.

The improved condition of both stocks justifies a quota increase for the 1985-86 season, but the exploitation rate must be kept in the 15% to 16% range in order to promote further recovery of the stocks.

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TABLE 1. Mean Length of Pacific Herring from Tomales Bay and San Francisco Bay Roe Fisheries, 1972-73 through 1984-85 Seasons.

Season	Tomales Bay		San Francisco Bay			
	Gill net		Gill net		Roundhaul	
	Mean length mm BL	Size range	Mean length mm BL	Size range	Mean length mm BL	Size range
1972-73	186	150-234	-	-	-	-
1973-74	190	146-248	-	-	177	134-222
1974-75	189	142-236	-	-	178	132-226
1975-76	184	150-230	-	-	178	128-230
1976-77	169	140-216	212	192-236	181	142-228
1977-78	217	194-248	211	178-236	178	144-232
1978-79	No Samples		203	164-234	183	146-222
1979-80	214	196-236	208	184-230	180	148-220
1980-81	208	172-234	205	170-236	178	150-226
1981-82	211	176-236	201	160-228	177	148-226
1982-83	208	184-236	203	170-230	183	152-226
1983-84	199	174-242	205	182-232	165	132-208
1984-85	202	164-232	196	158-238	176	150-206

Note: Tomales Bay has been restricted to gill nets only since 1977, and in San Francisco Bay the gill net mesh size was lowered from 2 1/4 in. to 2 1/8 in. for the December fishery in the 1984-85 season.

TABLE 2. Length Frequency of the Tomales Bay Gill Net Catch in the 1984-85 Season.

mm BL	Age								
	2	3	4	5	6	7	8	9	
232						1			
230							1		
228							2		
226							1		
224						2			
222					1		2	1	
220					1	5			
218				1	1	4	1		
216					3	6	3		
214					4	7			
212				1	5	7	2		
210		1	1	1	8	6	1		
208		1		2	12	2			
206		1	1	2	20	3			
204				4	13	1			
202				7	20	2			
200			1	6	9				
198			1	13	2				
196		1	3	20	4				
194		1	6	14	1				
192		1	6	10					
190			12	4					
188		1	4						
186			3						
184	1	2	3						
182		2							
180		5							
178		2							
176									
174									
172		1							
170									
168									
166									
164	1								
N	2	19	41	85	104	46	13	1	
Mean	174	187	191	197	205	213	220	221	
St. dev.	14	11	5	5	5	6	7	-	

TABLE 3. Mean Weight in Grams at Age of Herring in the Tomales Bay Gill Net Catch by Season.

Season	Age							
	2	3	4	5	6	7	8	9
1976-77	-	119	135	149	162	174	184	-
1977-78	-	-	142	139	155	157	165	184
1978-79	No Samples							
1979-80	-	-	130	135	137	145	188	-
1980-81	1	92	113	131	141	153	161	177
1981-82	-	83	116	121	147	158	160	181
1982-83	-	-	100	120	132	150	169	172
1983-84	-	-	91	106	114	131	141	150
1984-85	76	102	109	117	135	151	161	172

TABLE 4. Female to Male Sex and Biomass
(Weight Ratios of the Catch for
the 1984-85 Season by Area.

Tomales Bay		
Sex ratio		1:0.7
Biomass ratio		1:0.7

San Francisco Bay Gill Net		
Sex ratio		1:1.1
Biomass ratio		1:1.1

San Francisco Bay Roundhaul		
Sex ratio		1:0.5
Biomass ratio		1:0.5

TABLE 5. Length Frequency of the San Francisco Bay Roundhaul Catch in the 1984-85 Season.

mm BL	Age							
	2	3	4	5	6	7	8	9
206					1	1		
204						1		
202					1	1		
200				3	3			
198				1	2			
196				3	3			
194				2	1			
192		1	3	8	1			
190		1	3	2				
188		1	6	4				
186		2	8					
184		1	6					
182		1	5					
180	1	6	2					
178		11	1					
176	1	8						
174	1	5						
172	4	4						
170	7	7						
168	10	2						
166	11	2						
164	19	1						
162	6							
160	7							
158	8							
156	5							
154	2							
152	2							
150	1							
N	85	53	34	23	12	3	-	-
Mean	163	176	185	193	198	204	-	-
St. dev.	6	6	3	3	4	2	-	-

TABLE 6. Length Frequency of the San Francisco Bay Gill Net Catch in the 1984-85 Season.

mm BL	Age								
	2	3	4	5	6	7	8	9	
238									1
236									
234									
232									
230									
228									
226									
224							1		
222									
220							2	1	
218						1	1		
216							1	1	
214							3	1	
212							5	2	
210						1	9	3	
208							4	9	2
206							7	11	
204				1		9	10		
202				6		14		1	
200				7		14	1		
198				9		16			
196				15		7			
194			1	11		2			
192			6	19		1			
190			9	17					
188			10	7					
186			14						
184			15						
182		2	10						
180		3	3						
178		12							
176		1							
174									
172		1							
170									
168									
166									
164									
162									
160									
158	1								
N	1	19	68	92	76	49	14	2	
Mean	157	178	186	194	201	207	213	229	
St. dev.		2	3	4	4	3	6	13	

TABLE 7. Mean Weight in Grams at Age of Herring in the San Francisco Bay Roundhaul Catch by Season.

Season	Age							
	2	3	4	5	6	7	8	9
1973-74	57	73	95	109	128	133	153	-
1974-75	55	82	89	105	124	140	148	-
1975-76	57	77	108	122	142	155	180	-
1976-77	58	80	95	116	130	154	150	166
1977-78	66	85	106	114	111	132	161	168
1978-79	70	87	103	119	128	150	-	222
1979-80	68	79	102	119	132	153	147	154
1980-81	63	83	98	124	118	136	163	-
1981-82	61	82	98	113	124	132	-	-
1982-83	62	74	93	107	120	144	147	-
1983-84	46	58	75	91	103	109	98	-
1984-85	66	84	100	115	127	129	-	-

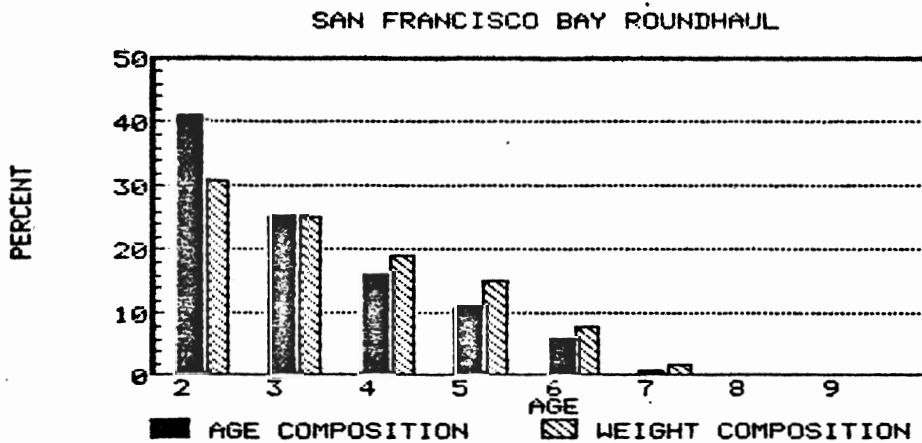
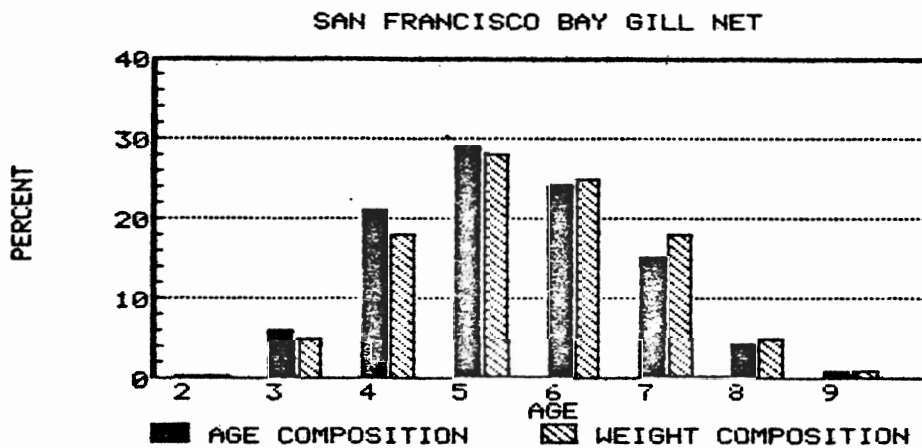
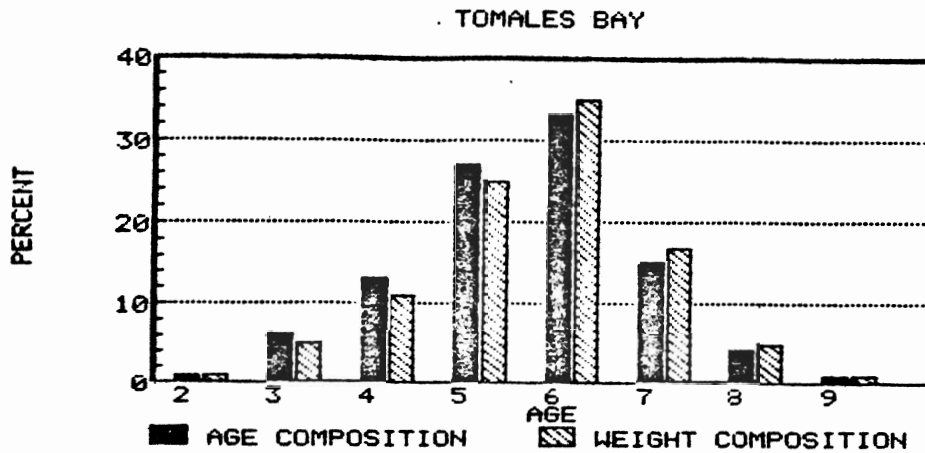


FIGURE 1. Age and weight composition of the 1984-85 Pacific herring roe fishery landings by area.

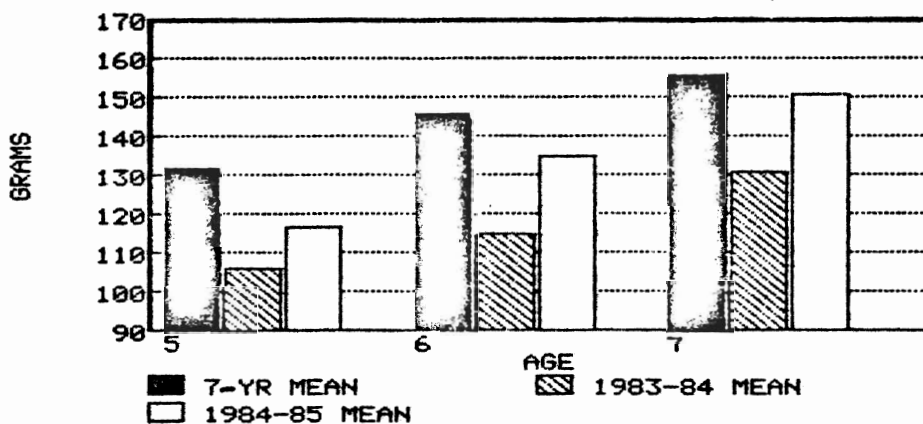


FIGURE 2. Comparison of 7-yr mean weight at age for the dominant age classes of herring in Tomales Bay with data from the 1983-84 and 1984-85 seasons.

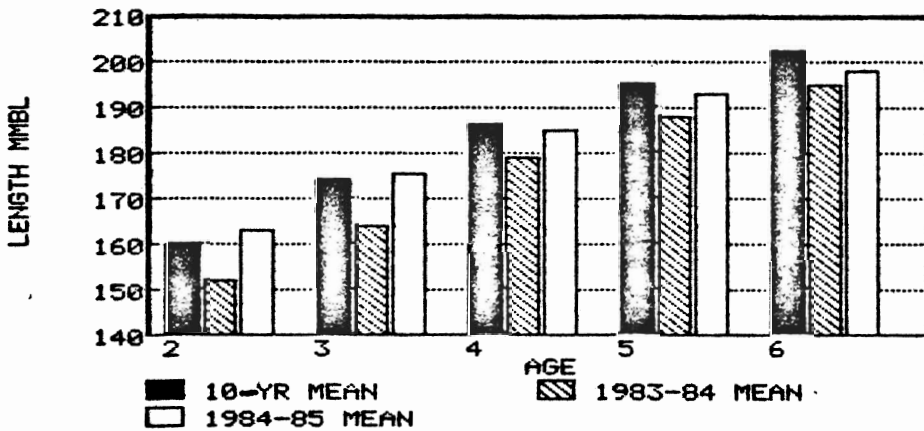
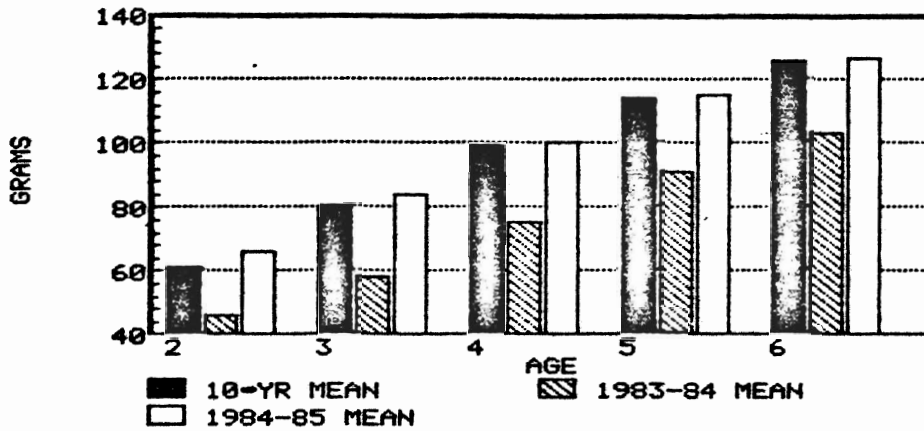
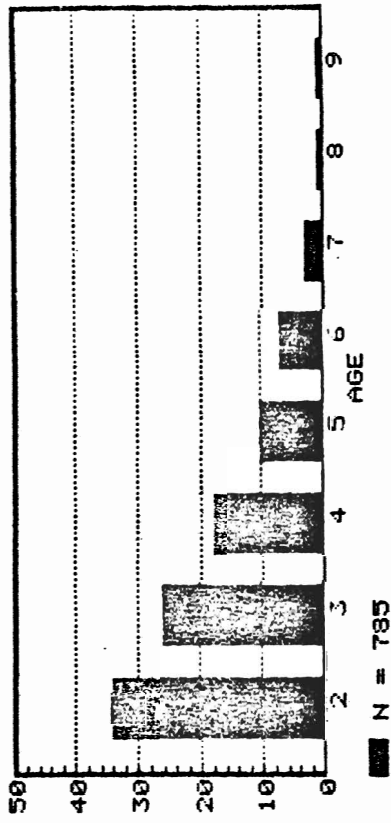
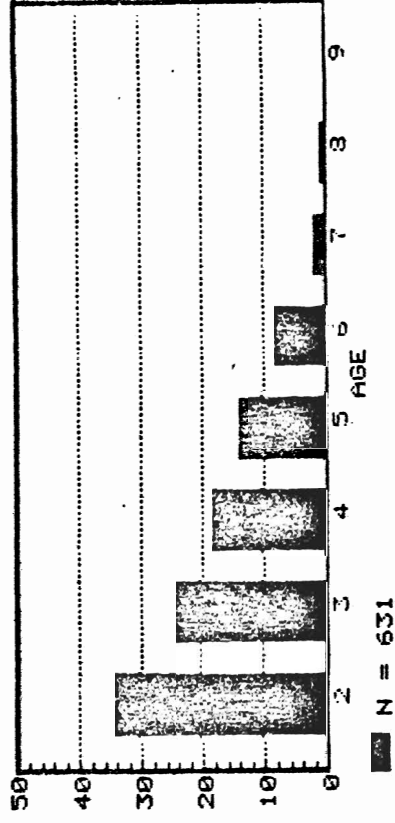


Figure 3. Comparison of 10-yr mean weight and length at age for the dominant age classes of herring in the San Francisco Bay roundhaul fishery with data from the 1983-84 and 1984 seasons.

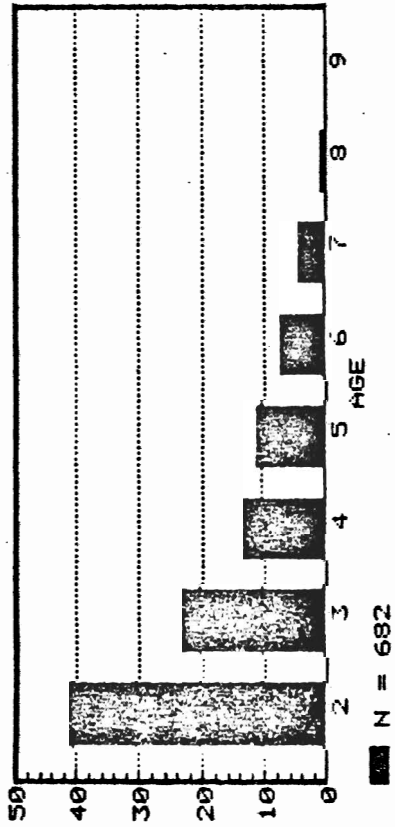
1979-80 TO 1981-82



1982-83 TO 1984-85



1973-74 TO 1975-76



1976-77 TO 1977-79

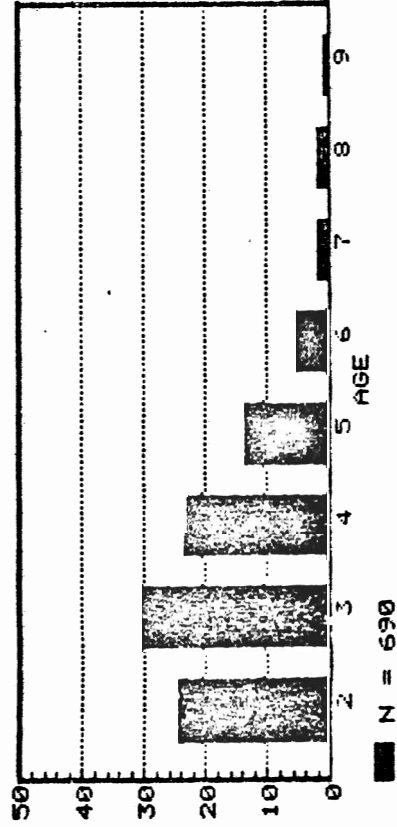


FIGURE 4. Variation in the age composition of the San Francisco Bay herring catch by three yr groups from 1973 to 1985.