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BIOLOGICAL CHARACTERISTICS OF THE CATCH FROM THE 1986-87 PACIFIC HERRING, *CLUPEA HARENGUS PALLASI*, ROE FISHERY IN CALIFORNIA

By

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ABSTRACT

In Tomales Bay, 4-, 5-, and 6-yr-old herring, *Clupea harengus pallasi*, composed 85% by number of the 1986-87 season's catch. In San Francisco Bay, 2-, 3-, and 4-yr-old herring composed 88% of the roundhaul catch, and 4-, 5-, and 6-yr-old herring composed 86% by number of the gill net catch.

The age composition of both the Tomales Bay and San Francisco Bay gill net catch has shifted to primarily 4-, 5-, and 6-yr-old herring.

Recruitment of 2-yr-old herring into the San Francisco Bay roundhaul fishery was good, with the 1985 yr class composing 37% of the catch.

The mean length of herring in the San Francisco Bay roundhaul catch decreased to 174 mm BL, and the mean length of the gill net catch decreased to 194 mm BL. The mean length of the Tomales Bay catch also decreased to 197 mm BL.

Average weight at age of Tomales Bay herring is below average for the fourth consecutive year. In San Francisco Bay the average weight at age is above average, even though length at age declined slightly.

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INTRODUCTION

The Department began monitoring the age, size, and sex composition of the Pacific herring, Clupea harengus pallasi, roe fishery catch in Tomales and San Francisco Bays in 1973. Spratt (1981, 1982, 1983, 1984, 1985 and 1986a) reported on data collected by sampling the herring roe fishery from 1973 until 1986. This report complements previous data to provide a continuous seasonal series from 1973 through the 1986-87 season.

METHODS

Sampling

In the Tomales Bay area, herring were collected at Marshall. In San Francisco Bay, herring were collected at Sausalito and San Francisco. Up to four samples were taken 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 and laboratory procedures have remained unchanged since the fishery began in 1973 (Spratt 1981). A 1-kg (2.2-lb) sub-sample was randomly selected for processing. Every fish in the sub-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), and otoliths were read at least twice before final age determinations were made.

RESULTS

Tomales Bay

A total of 43 samples was collected this season and 381 individual fish were processed.

Age Composition

The Tomales Bay fishery was restricted to gill nets in 1977. From the 1977-78 season through the 1984-85 season, the catch was dominated by 5-, 6-, and 7-yr-old herring.

In the 1985-86 season, the age composition changed to predominantly 4-, 5-, and 6-yr-old herring (Spratt 1986a). This pattern continued this season, with 4-, 5-, and 6-yr-old herring composing 85% of the catch (Figure 1). The percent of 3-yr olds declined from 14% in the 1985-86 season to 4% this season. This is not consistent with the overall shift in the age composition of the catch to younger herring, and may be the first indication of a weak 1984 yr class.

The number of older herring (age 7 through 9) in the catch has been decreasing. From 1979-80 to 1984-85, age 7 through 9 herring averaged 30% by number of the Tomales Bay gill net catch, but in 1985-86 and 1986-87, these three age groups averaged only 8% of the catch by number.

Length Composition

The average length of herring in the Tomales Bay catch during the 1986-87 season declined slightly to 197 mm BL (Table 1), the smallest average length since 1977. The combined average length of 5-, 6-, and 7-yr-old herring (Table 2) actually decreased 4 mm BL from the 1985-86 season (Spratt 1986a). However, the reduced number of smaller 3- and 4-yr-old herring in the 86-87 catch compared with the 1985-86 season resulted in only a 1 mm BL decline in the overall mean length.

The timing of the fishery in relation to spawning may have influenced the age composition this season. No herring were caught from the largest spawning run of the season near the end of February (Spratt 1987). Late season spawning runs are composed of a higher percentage of younger herring.

Weight Composition

The mean weight at age of Tomales Bay herring declined in the 1985-86 season, after the dramatic increase following El Nino (Spratt 1985). This season the mean weight at age decreased again, and 3 out of the last 4 yr the average weight of the dominant age classes has been below the long-term mean (Table 3).

Sex Ratio

The female to male number and biomass (weight) ratios of the 1986-87 Tomales Bay catch were nearly equal (Table 4). The percent of females in the catch was 46% by number and 47% by weight. This is the first time that more males than females have been taken in the Tomales Bay gill net fishery.

San Francisco Bay

A total of 67 samples was collected this season and 710 individual herring were processed. In San Francisco Bay both the roundhaul and gill net catches are sampled, but sample data are analyzed separately.

Age Composition

The percent of 2-yr-old herring in the roundhaul catch is normally a good indicator of year class strength. This season recruitment of the 1985 yr class (2-yr olds) was above average, with 2-yr-old herring comprising 37% by number of the catch. The relative strength of 3-yr olds (33%) in the catch indicates that the 1984 yr class could be stronger than the 1985-86 sample data indicated. The 1985 yr class is the fourth consecutive strong year class to be recruited into the San Francisco Bay fishery.

The roundhaul fishery in San Francisco Bay was again confined to the latter half of the spawning season, when older herring are less available to the fishery. The first substantial roundhaul catches were made on January 19, after about 50% of the season's herring had already spawned. As a result there was only one 8-yr-old and no 9-yr-old herring in the samples, and the relative age composition of the roundhaul catch continues to be heavily weighted toward herring that are under 6 yrs old (Figure 1).

On February 10, 1987, a 1-yr-old herring (110 mm BL) was collected while sampling the roundhaul catch in San Francisco Bay. This is the first 1-yr-old herring that I have sampled from the roundhaul catch, although 1-yr-old herring have been taken in the bay (Reilly and Moore 1985).

The 1984-85 season is the first full season in which 2 1/8-in. minimum mesh was allowed in the San Francisco Bay gill net fishery. Since then, the age composition of the gill net catch has shifted to include more 4-yr-old herring and now the dominant age groups are 4-, 5-, and 6-yr olds. In the 1986-87 season 4- and 5-yr olds alone accounted for 70% of the catch by number and 69% by weight (Figure 1). The 1981 yr class (6-yr olds) is one of the weaker year classes in the fishery, but together 4-, 5-, and 6-yr-old herring comprise 86% and 87% of the gill net catch by number and weight, respectively.

Length Composition

The mean length of the San Francisco Bay roundhaul catch has ranged between 176 and 183 mm BL in 12 out of 14 seasons. The exceptions are the El Nino year of 1983-84 and the current season, when catch averaged 174 mm BL (Table 1). The mean length of 2-, 3-, and 4-yr-old herring decreased from 1 to 6 mm BL from the 1985-86 season (Spratt 1986a) (Table 5). These

are strong year classes and density-dependent factors may be affecting growth. In addition 6- through 9-yr-old herring comprised only 6% of the catch. Both of these factors contribute to the drop in overall average length of the catch.

The mean length of the gill net catch in San Francisco Bay is below 200 mm BL for the third time in three seasons (Table 1). The overall average length of the gill net catch has changed since the minimum mesh size was lowered from 2 1/4- to 2/18-in. mesh during 1984. This caused an increase in the number of 3- and 4-yr-old herring in the catch. However, this season the mean length of 4- and 5-yr-old herring decreased 6 and 3 mm BL, respectively. The low numbers of the weak 1981 yr class (6-yr-old) herring in the catch is also contributing to the lower mean length of the gill net 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 4- and 5-yr-old herring.

Samples from the roundhaul catch in the 1986-87 season indicate that the overall gain in weight of ages 2 through 6 was above average for the second consecutive year. However, only the older age groups were significantly above average (Table 7). Growth rates are density dependent; even so, the collective weight at age of the four strong entering year classes remains above average.

Sex Ratio

The sex and biomass (weight) ratios of the San Francisco Bay gill net and roundhaul fisheries were again similar this season. Females composed 60% of the gill net catch and 56% of the roundhaul catch by number

(Table 4). This season the percentage of females in the gill net catch increased to a near normal level, somewhat surprising considering the smaller mesh size now in use in the fishery. The high percentage of females in the roundhaul catch probably reflects the selectivity caused when boats release catches with low roe content or high percent of unripe fish.

DISCUSSION

Tomales Bay

Since 1977, the three dominant age groups in the Tomales Bay gill net catch have been 5-, 6-, and 7-yr-old herring comprising between 72% and 82% of the catch. In the 1985-86 season, the percentage of 5-, 6-, and 7-yr-old herring in the catch dropped to 55%. This was due to initial recruitment of the 1982 and 1983 yr classes as 3- and 4-yr olds. This season these 2 yr classes, which are still not fully recruited, comprised 58% of the catch as 4- and 5-yr olds.

A spawner-recruit relationship has never been demonstrated for Pacific herring. However, the strength of the entering year classes in the Tomales Bay herring fishery may be below normal in the near future, because of very low spawning escapement in the 1983-84 season and unusual spawning behavior in the 1985-86 season that could effect survival (Spratt 1986b). The initial recruitment (3%) of the 1984 yr class in the 1986-87 catch as 3-yr olds is poor compared to the 1983 yr class, which composed 13% of the 1985-86 catch as 3-yr olds. The 1986 yr class will not be fully recruited until the 1990-91 season as 5-yr olds.

Growth characteristics of Tomales Bay herring have also been below normal since 1983 (Table 3). The Tomales Bay herring population remains within the range of previous seasons' estimates (Spratt 1987), but

recruitment patterns and growth characteristics indicate the status of the population is changing.

San Francisco Bay

The age and size composition of the San Francisco Bay roundhaul catch changed little over the first 11 herring seasons. Only 2 yr classes have been weak (1977 and 1981), and the catch was dominated by 2- and 3-yr-old herring with a good representation of older herring in the catch.

The last three seasons there have been fewer herring over 5 yr old in the catch than at any other time. I believe this is a result of the 1982-83 El Nino which caused a significant reduction in the size of the herring population in San Francisco Bay. During the El Nino, herring that are now 6 through 9 yr old were 2 through 5 yr old. These 4 yr classes (1978, 1979, 1980, and 1981) experienced unusually high natural mortality when the San Francisco Bay herring population declined from nearly 100,000 tons in 1982 to 40,000 tons in 1984.

Since the El Nino, the San Francisco Bay population has been increasing due to four consecutive relatively strong year classes (1982, 1983, 1984, and 1985) and the population is now composed of relatively few older herring. In addition, gillnetters are now using smaller mesh nets in order to keep catch production up, which has caused a shift to younger herring in the gill net catch. Three-, 4- and 5-yr-old herring composed 77% of the 1986-87 gill net catch.

The age and length composition of the San Francisco Bay herring catch (roundhaul and gill net) should improve next season as these 4 year classes move through the fishery.

CONCLUSION

Three good year classes are maintaining the Tomales Bay herring fishery. However, there is reason to believe that the 1984 and 1986 yr classes could be weak. Therefore, with the prospect of poor recruitment coupled with below normal growth characteristics the past 3 yr, it is probable that the Tomales Bay population will remain below the long-term average level of 6,700 tons in the near future.

In San Francisco Bay four consecutive years of good recruitment coupled with recent good growth characteristics indicate the population is in excellent condition and may continue to increase in the near future.

Herring populations of Tomales and San Francisco Bays are exhibiting sustained opposite trends in abundance for the first time, with different growth and recruitment patterns. This is further evidence that the two bays may be genetically distinct.

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TABLE 1. Mean Length of Pacific Herring from Tomales and San Francisco Bay Roe Fisheries, 1972-73 through 1986-87 Seasons.

	Tomales Bay		San Francisco Bay			
			Gillnet		Roundhaul	
Season	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
1985-86	198	166-226	196	166-226	178	142-214
1986-87	197	174-236	194	168-222	174	110-214

Note. Tomales Bay has been restricted to gill nets only since 1977. The 1984-85 season was the first full season in which 2 1/8-in. mesh was allowed in the San Francisco Bay gillnet fishery.

TABLE 2. Length Frequency of the Tomales Bay Gillnet Catch in the 1986-87 Season.

	Age							
MM BL	2	3	4	5	6	7	8	9
236								1
234								
232								1
230						1		1
228								
226							1	1
224							2	1
222							3	
220					2	1	1	
218						1	1	1
216							2	
214						1	1	
212					4	5	1	
210					3	6		
208				1	5	1		
206				2	15	1		
204			1	3	19	3		
202				6	13	1		
200			1	10	17	1		
198		1	1	18	11			
196			3	33	14			
194			3	28				
192			4	27				
190			5	17				
188			12					
186			17	2				
184		1	20					
182		1	6					
180		3	4					
178		6						
176		1						
174		1						
N	-	14	77	147	103	22	12	6
Mean	-	180	187	195	203	210	220	228
St. dev.	-	5.7	4.7	3.9	4.9	6.5	4.4	6.3

TABLE 3. Mean Weight (g) at Age of Herring in the Tomales Bay Gillnet Catch by Season.

	Age								Unwted
Season	2	3	4	5	6	7	8	9	mean*
1979-80	-	-	130	135	137	145	188	-	148
1980-81	-	92	113	131	141	153	161	177	140
1981-82	-	83	116	121	147	158	160	172	134
1982-83	-	-	100	120	132	150	169	172	140
1983-84	-	-	91	106	114	131	141	150	117
1984-85	76	102	109	117	135	151	161	172	135
1985-86	73	94	106	121	137	150	148	162	132
1986-87	-	89	98	113	127	150	165	186	131
Unwted. mean	74	92	108	121	134	148	162	170	* 135

* Calculated from ages 4 through 8 only; they comprise over 95% of the samples.

TABLE 4. Female to Male Sex and Biomass (Weight) Ratios of the Catch for the 1986-87 Season by Area.

Tomales Bay	
Sex ratio	1:1.17
Biomass ratio	1:1.13
San Francisco Bay Gillnet	
Sex Ratio	1:0.6
Biomass ratio	1:0.6
San Francisco Bay Roundhaul	
Sex ratio	1:0.9
Biomass ratio	1:0.7

TABLE 5. Length Frequency of the San Francisco Bay Gillnet Catch in the 1986-87 Season.

	Age							
MM BL	2	3	4	5	6	7	8	9
222							1	
220								
218						1		
216						1	2	1
214								
212					3	1	2	
210					3	4	1	
208				1	4	2		
206				2	8	2		
204				2	5			
202			1	8	9	1		
200				7	11	1		
198			1	21	1			
196			2	29	2			
194			4	16	1			
192			10	12				
190		1	13	9				
188			15	4				
186		3	21	1				
184		3	23					
182		3	6					
180		9	2					
178		1						
176		2						
174								
172								
170								
168	1							
N	1	22	98	112	47	13	6	1
Mean	168	182	187	196	204	209	215	216
St. dev.	-	3.4	4.0	4.1	4.3	4.9	4.3	-

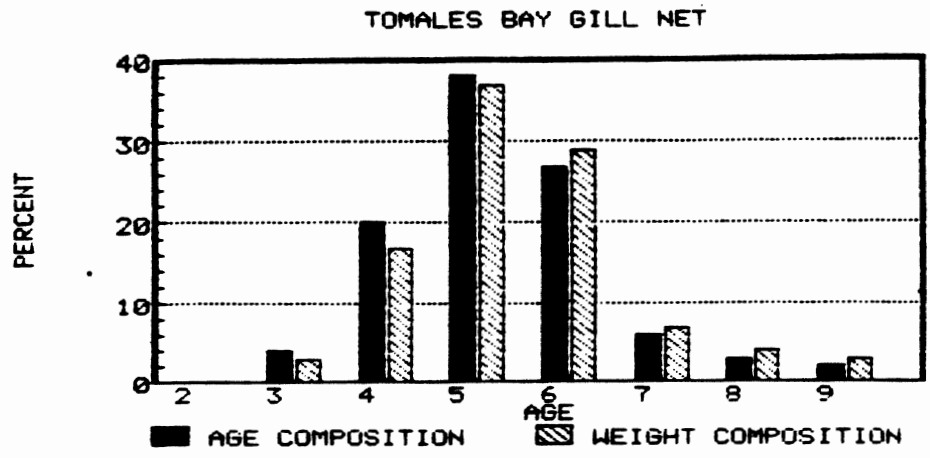
TABLE 6. Length Frequency of the San Francisco Bay Bounchaul Catch in the 1986-87 Season.

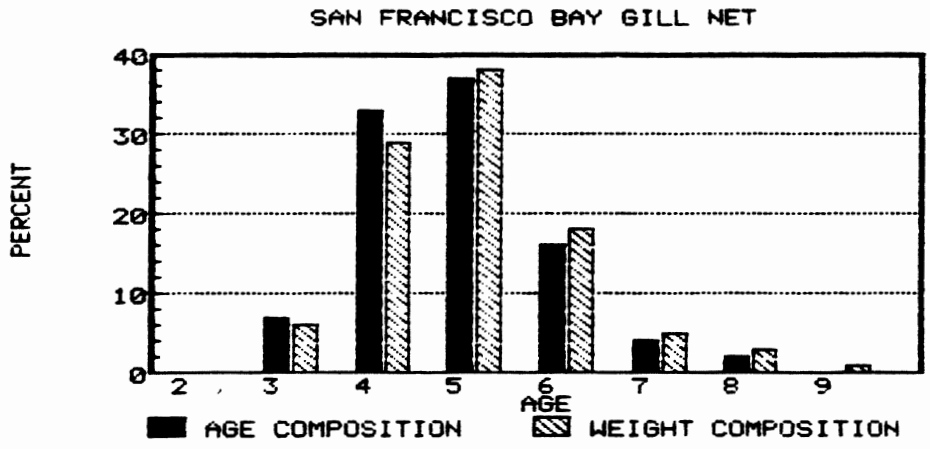
	Age							
MM BL	2	3	4	5	6	7	8	9
214						2		
212						1		
210				1	1		1	
208					2	1		
206				2	2			
204				1	2	1		
202			1	5	3	1		
200			1	3	4			
198			1	6	2	1		
196			1	8	1			
194			2	5	1			
192			3	5				
190			2	4				
188			5					
186			8					
184		1	5					
182		5	8					
180		7	10					
178		10	3					
176		19						
174	1	24	1					
172	3	23						
170	10	27	2					
168	24	10						
166	20	7						
164	15	1						
162	21	2						
160	11	1						
158	12							
156	6							
154	3							
152	5							
150	4							
148	1							
146	1							
144	2							
142	5							
140								
138	1							
<138	1							
N	152	137	54	4	18	7	1	-
Mean	161	173	185	197	202	207	210	-
St. dev.	8.0	4.4	6.7	4.8	4.4	6.3	-	-

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

	Age								
Season	2	3	4	5	6	7	8	9	Unwted. mean*
1973-74	57	73	95	109	128	133	153	---	92
1974-75	55	82	89	105	124	140	149	---	91
1975-76	57	77	108	122	142	155	179	---	101
1976-77	58	80	95	116	130	153	149	160	96
1977-78	66	85	106	114	111	132	161	168	96
1978-79	70	87	103	119	128	150	---	---	101
1979-80	68	87	102	119	132	150	---	---	100
1980-81	63	82	98	124	118	137	163	---	97
1981-82	61	82	98	113	124	133	---	---	96
1982-83	62	74	93	107	120	144	147	---	91
1983-84	46	58	75	91	103	109	---	---	75
1984-85	66	84	100	115	127	129	---	---	98
1985-86	64	87	101	118	134	131	184	---	101
1986-87	62	76	97	124	142	152	---	---	100
14 yr Unwted. mean	61	80	97	114	126	139	161	164	95 *

* Calculated from ages 4 through 8 only; they comprise over 95% of the samples.





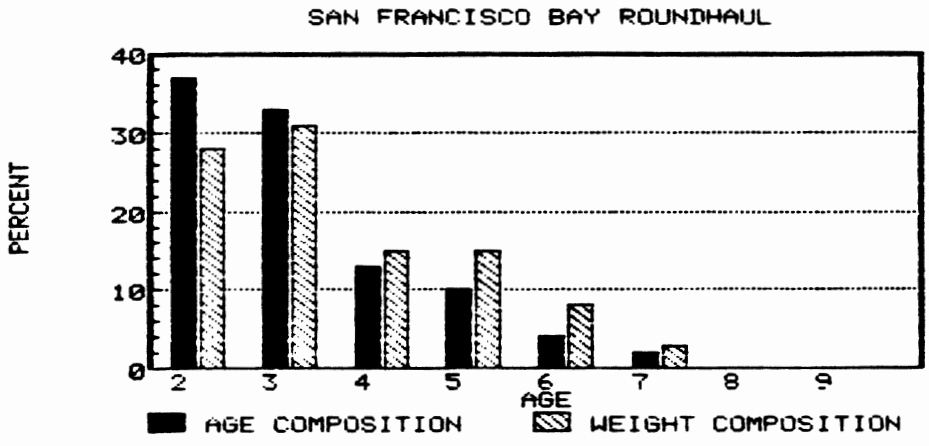


FIGURE 1. Age and weight composition of the 1986-87 Pacific herring roe fishery landings by area.