AGE AND GROWTH OF ORANGEMOUTH CORVINA IN THE SALTON SEA, CALIFORNIA

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Abstract: Age of 1,444 orangemouth corvina collected from the Salton Sea, California, from 1958 through 1968 were determined from their scales. Age groups 0 through IX were represented. The total length-anterior scale relationship is described by the formula L = 74.111 + 2.252S (r = 0.92). Growth was variable between year-classes and became more irregular with increasing age. The grand mean length attained at the end of each year of life for the combined year-classes best described the general growth of the species. Grand mean lengths for ages one through six are: 159, 363, 493, 601, 666, and 717 millimeters respectively. Annulus formation occurred from March to July, with younger corvina producing an annulus earlier in the year than older individuals. Growth occurred through spring and summer and apparently ceased by October or November. Females became heavier for their length as length increased; males showed the opposite relationship. The general weight-length relationship is described by the formula $W = 8.37 \times 10^{-6} L^{2.99}$.

INTRODUCTION

The purpose of this study was to gain knowledge of the age and growth of orangemouth corvina, *Cynoscion xanthulus*, in the Salton Sea, California, by the analysis of scale samples and related information collected by field personnel of the California Department of Fish and Game since the termination of the Salton Sea Research Project in 1957. The results are a necessary extension of work reported by Walker (1961) and completed recent Salton Sea ecological studies (Calhoun 1968, 1969).

The orangemouth corvina is the most important sport fish in the Salton Sea. It is a member of the family Sciaenidae and is endemic to the Pacific coast of Mexico (Jordan and Evermann 1898), including the Gulf of California. The species was first introduced into the Salton Sea in May, 1950, by the California Department of Fish and Game. Successful reproduction, as indicated by the discovery of young-of-the-year fish, was evident by 1952. Although the total number of orangemouth corvina released did not exceed 272 fish, the population rapidly increased to an estimated one million fish of catchable size in 1957. The population now numbers about three million and supports an average annual sport catch of about 500,000 fish, averaging 3 pounds each (Calhoun 1968, 1969).

In spite of the importance of orangemouth corvina to the ecology and economy of the Salton Sea, very little life-history work has been conducted on this species. The California Wildlife Conservation Board funded the Salton Sea Research Project, a study conducted under contract with the University of California at Los Angeles, from 1954 through 1957. Dr. Richard R. Whitney, in charge of project investigations on fishes, conducted a study of the life-history, age, and growth of the recently established orangemouth corvina and his results were reported by Walker (1961). Whitney's work was confined almost entirely to fish three years of age and younger because of the recency of establishment of the species in the Sea. His work, however, constitutes the only study reported in the literature to date on the life-history, age, and growth of this species.

For a physical description of the Salton Sea, California, see Walker (1961).

MATERIALS AND METHODS

This study was based primarily on the scale samples and weight-length data obtained from 1,444 Salton Sea orangemouth corvina collected in gill nets, seines, and by anglers from 1958 through 1968. Scale samples and associated data were collected by California Department of Fish and Game personnel during annual fishery investigations. Angler-caught

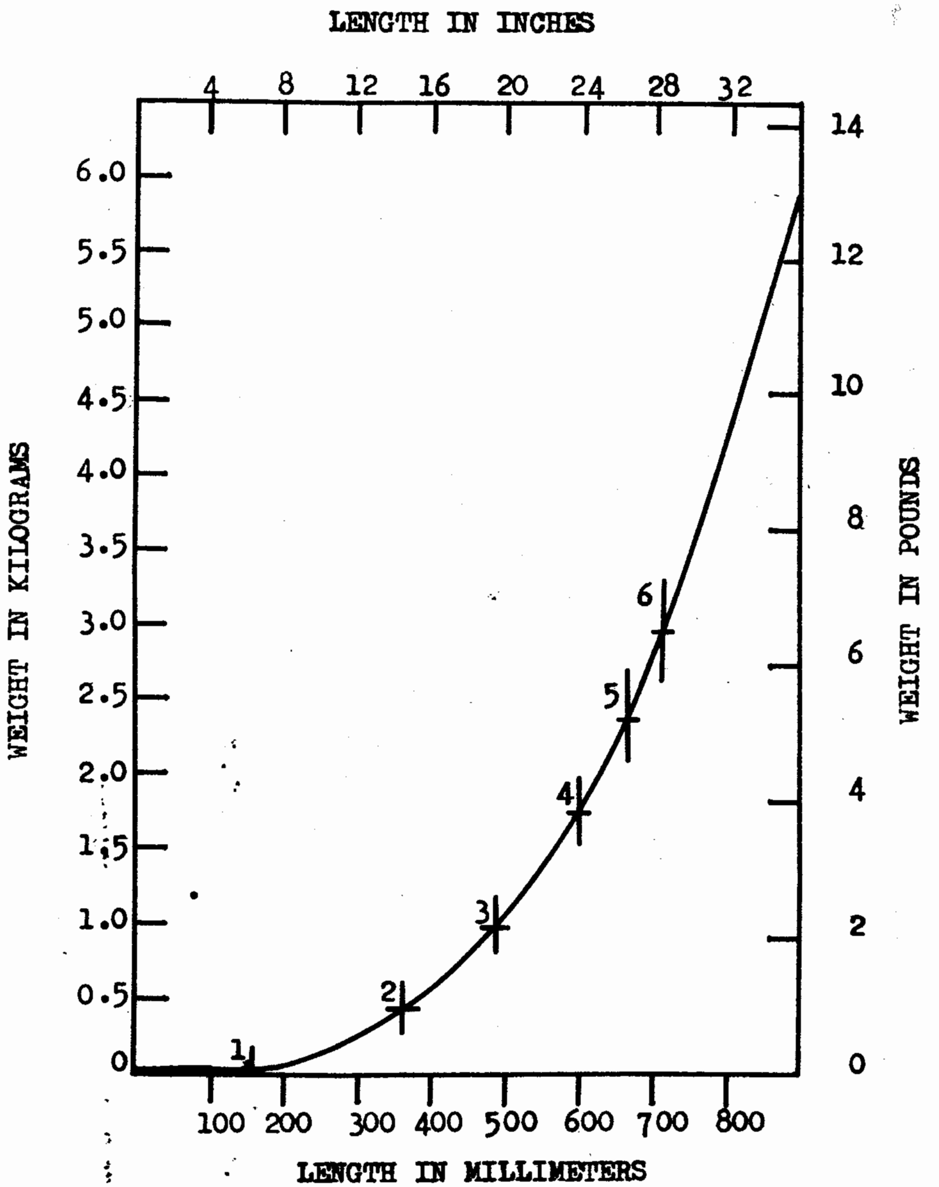

Figure 1. Weight-length curve and lengths at end of each year of life, ages 1 through 6 years, of orangemouth corvina from the Salton Sea, California.

fish were examined during periodic creel censuses.

The criteria used for distinguishing annuli on Salton Sea orangemouth corvina scales were basically those used by other investigators aging sciaenids (Taylor 1916; Nesbit 1954; Joseph 1962; Massmann 1963; Thomas 1968). These criteria generally apply to most species possessing ctenoid-type scales. Scale characteristics of orangemouth corvina are nearly identical in appearance with other species of Cynoscion and there is a very close similarity to other genera of sciaenids.

Scale samples were taken from the left side of the body below the origin of the dorsal fin and ventral to the lateral line. Fish were measured to the nearest millimeter total length. Weight was recorded to the nearest two grams, ounce, or 0.05 pound depending on available equipment. Ounces and pounds were later converted to grams. Sex was determined by dissection. Scale samples, length, weight, and sex data were obtained in the field.

A roller press described by Smith (1954) was used to produce scale impressions on cellulose acetate slides. The impressions were viewed at a magnification of 43X on an Eberback Reflex Micro-Projector. Fish ages were determined by counting annuli.

Annuli on fish over six years of age were very difficult to distinguish from accessory checks. As a result of a low confidence in age determination and a small sample size of fish over six years of age, these older fish were generally not used in the various phases of this study.

To determine fish length-scale relationships and for the back calculation of fish lengths in growth analyses, anterior distances from the focus to each annulus and to the margin of selected scales from each specimen were measured on the micro-projector screen. Measurements of anterior scale radius were employed to empirically determine relationships between fish length and scale growth. Such relationships were calculated by least squares regression analyses.

Back calculated fish lengths reported in this paper were determined by the modified proportionate formula $L_n = S_n\ (L-c)\ /\ S+c$ (Lagler, 1956); where L_n is length of fish when annulus "n" was formed, S_n is scale radius of annulus "n", L is length of fish at capture, S is total anterior scale radius, and c is length of fish at time of scale formation. Back calculation was accomplished by using the procedure introduced by Van Oosten (1953).

Weight-length relationships were determined by the formula $W = aL^b$, in which W is weight in grams, L is length in millimeters, and a and b are constants (Ricker, 1968). Weight-length equations were computed utilizing a computer program. Values for the constants a and b were obtained in the computer by logarithmically transforming the weights and lengths and fitting a straight line by least squares regression to the resulting variables.

RESULTS AND DISCUSSION

The nature of the empirical relationship between total fish length and growth to the anterior scale radius was determined by plotting paired observations of fish length against scale radius. The resulting scatter diagram indicated a straight-line relationship. A least-squares regression equation was calculated. The equation $L = 74.111 + 2.252S$, where L is total fish length in millimeters and S is anterior scale radius (X43) in millimeters, best describes the relationship. The correlation coefficient is 0.92, and suggests that corvina scale growth is proportional to growth in total length.

The Y-intercept value of 74mm (2.9 inches) was not employed in the back calculation of fish lengths as representing the fish length at time of scale formation (the "c" value in the Lagler formula) because of the mathematical limitations inherent in a multiple age-group regression (Lagler 1956; Wallis and Roberts 1956; Ricker 1968). The value was excessive and unrealistic for use in the Lagler formula.

It was necessary to determine an acceptable estimate of fish length at time of scale formation in the absence of data from very small fish. A realistic and usable estimate was determined by calculating a fish length-scale radius relationship for 256 age zero fish over a length

Table 1. Length at end of each year of life by year of life by year class for Salton Sea, California, orangemouth corvina collected from 1958 through 1967. Lengths of fish over six years of age omitted (number of fish in parentheses).

Year Class	Mean total length at end of each year of life (mm) 1/ 1	2	3	4	5	6
1954	124	316	484	547	591	651
	(18)	(18)	(18)	(18)	(2)	(2)
1955	105	388	503	614	689	744
	(15)	(15)	(15)	(3)	(2)	(2)
1956	119	342	454	564	694	694
	(36)	(36)	(8)	(8)	(6)	(2)
1957	134	364	524	690	733	773
	(84)	(33)	(31)	(22)	(16)	(9)
1958	181	367	559	669	709	719
	(56)	(55)	(38)	(33)	(15)	(7)
1959	192	309	449	631	673	709
	(94)	(89)	(83)	(42)	(31)	(28)
1960	188	315	447	569	620	726
	(98)	(98)	(90)	(56)	(45)	(20)
1961	191	349	493	577	641	719
	(97)	(95)	(69)	(48)	(24)	(12)
1962	180	359	483	564	647	
	(153)	(125)	(101)	(48)	(33)	
1963	141	385	505	586		
	(208)	(141)	(99)	(91)		
1964	162	408	523			
	(193)	(179)	(164)			
1965	140	459				
	(182)	(124)				
1966	208					

	1	2	3	4	5	6
Grand mean length: 2/						
(mm)	159	363	493	601	666	717
(inches)	6.3	14.3	19.4	23.7	26.2	28.2
Length increment:						
(mm)	159	204	130	108	65	51
(inches)	6.3	8.0	5.1	4.3	2.5	2.0
Number of fish:	1317	1008	716	369	174	82

1/ $L_n = S_n(L-34.711)/S+34.711$

2/ Unweighted means

range of 60 to 360 mm. The relationship is a straight-line having the regression equation $L = 34.711 + 2.607S$. The correlation coefficient is 0.87. The intercept value of 35 mm (1.4 inches) more closely approximated the length of fish at time of scale formation as estimated from the cursory examination of a few small specimens.

Whitney, as reported by Walker (1961), calculated a length-scale relationship for 514 corvina collected during the early years of establishment of the species from 1954 through 1957. All but five of the fish, however, were less than 4 years old. The relationship of standard body length to scale length was $Y = 47.26 + 60.99X$, where Y is standard body length in millimeters and X is scale length in inches (X29).

Back calculated fish lengths were determined by the formula $L_n = S_n \ (L-34.711) / S + 34.711$. Lengths of orangemouth corvina at the end of each year of life for ages one through six years were back calculated for individual year classes (Table 1). General growth is described by the unweighted grand mean length for each year of life. The use of the unweighted grand mean length eliminates the effect of disproportionately large collections of fish of certain year-classes, a problem more associated with variation in collection effort than year-class strength. The grand mean lengths attained at the end of each year of life for ages one through six years are: 159 (6.3), 363 (14.3), 493 (19.4), 601 (23.7), 666 (26.2), and 717 mm (28.2 inches), respectively. I believe the grand mean length attained at the end of each year of life for the combined year-classes best described the general growth of Salton Sea orangemouth corvina for the 1958-1967 period.

Corvina grew rapidly during their first 2 years of life, with the growth increment of the second year (204 mm, 8.0 inches) exceeding that of the first year (159 mm, 6.3 inches). The accelerated growth during the second year was attributed to a shift in food habits from invertebrates to young-of-the-year croaker, Bairdiella icistius, generally occurring between the first and second years of life.

Growth was variable between individual year-classes and became more irregular with increasing age. The 1957, 1958, 1961, and 1964 year-classes generally exhibited good growth histories, whereas the 1956, 1959, and 1960 year-classes were generally poor. Although corvina of the 1959 and 1960 year-classes exceptionally large at the end of their first year of life, growth beyond the first year was poor. Reasons why some year-classes exhibited better growth than others are obscure and probably complex.

Growth tended to be faster and lengths at corresponding ages were greater for the grouped 1954 through 1958 year-classes than for the grouped 1959 through 1963 year classes. The one major exception was yearling corvina which averaged 45 mm (1.8 inches) greater in length for the latter 5-year period than for the former period.

The percentages of orangemouth corvina showing new growth on the scales, and, therefore, identifiable annuli, for the combined 1958 through 1967 collections was determined for monthly intervals. New seasonal growth (= annuli) was first identified on seven percent of the fish collected in March. Subsequently, the percentage of fish with new growth increased to 36 percent in April and May, 88 percent in June, and 100 percent in July. Thereafter, all fish samples revealed new seasonal growth (= annuli).

In general, the percentage of fish with completed annuli (as indicated by new growth) in a single month's collection decreased as age increased. In June, for example, all age group I and 95 percent of the age group II fish have begun new growth, but only 70 percent of the age group VI and 33 percent of the age group VII and older fish had begun new growth. The data suggest that the younger corvina produce an annulus earlier in the year than the older fish. Younger fish apparently complete their scale annuli by mid or late May while older fish may not complete their annuli until July.

The younger corvina may be more responsive to seasonal changes in the environment, particularly increasing water temperatures, and thus terminate their period of winter dormancy earlier in the year than older fish. It is possible, however, that the resumption of seasonal activity may be more rapidly reflected in the scale growth of younger, smaller fish than older, larger individuals.

Table 2. Weight-length equations of Salton Sea, California, orangemouth corvina by sex, year of capture, and combined 1962 through 1968 collections.

Sex or Year	Number of Fish	Weight-length Equations ($W = aL^b$)[1./]
Male	69	$W = 3.01 \times 10^{-5} L^{2.79}$
Female	53	$W = 3.91 \times 10^{-6} L^{3.11}$
1962	70	$W = 2.41 \times 10^{-5} L^{2.82}$
1963	61	$W = 7.32 \times 10^{-6} L^{3.01}$
1964	89	$W = 2.82 \times 10^{-5} L^{2.79}$
1965	125	$W = 1.85 \times 10^{-5} L^{2.86}$
1966	119	$W = 8.77 \times 10^{-6} L^{2.99}$
1967	522	$W = 4.74 \times 10^{-6} L^{3.08}$
1968	24	$W = 4.07 \times 10^{-6} L^{3.12}$
1962-1968	1,010	$W = 8.37 \times 10^{-6} L^{2.99}$

1./ weight in grams, length in millimeters

In general, rapid scale (= fish) growth occurred following the time of annulus formation in the spring and continued through the summer. Seasonal growth apparently ceases in the fall months of October and November when water temperatures sharply decline. The scale margin at this time approximates the annulus of the following year. Whitney, (Walker 1961) also recognized a winter cessation in corvina growth. As noted above, older fish tend to form the annulus later in the year than younger corvina and, therefore, exhibit a progressively shorter growing season with increasing age.

Whitney, as reported by Walker (1961), initially identified the weight-length relationship of Salton Sea orangemouth corvina as being curvilinear, but no attempt was made to quantitatively define the relationship. For this study, a weight-length relationship was calculated for males, females, annual collections, and the combined 1962-1968 collections (Table 2). Weight data from collections prior to 1962 were inadequate for meaningful evaluation.

The weight-length relationship for male and female corvina is $W = 3.01 \times 10^{-5} L^{2.79}$ and $W = 3.91 \times 10^{-6} L^{3.11}$, respectively. Females became heavier for their length as length increased; males showed the opposite relationship. Females under 550 mm (21.7 inches) in length weighted less than males of comparable length; females 550 mm and over weighed more than males of comparable length.

The weight-length relationship for 1,010 corvina collected from 1962 through 1968 is $W = 8.37 \times 10^{-6} L^{2.99}$. The relationship is nearly isometric for the species. Although the nature of the relationship varied from year to year, the trend during the period 1964 through 1968 was toward allometric growth--where fish become heavier for their lengths as length increases.

Age, length, and weight characteristics of orangemouth corvina as determined in this study were combined to describe the general growth of the species in the Salton Sea between 1958 and 1968 (Figure 1). Mean length and weight for corvina at the end of each year of life for ages one through six were: 159 and 33, 363 and 385, 493 and 960, 601 and 1740, 666 and 2370, and 716 mm and 2950 grams, respectively.

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