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MORPHOLOGY AND GROWTH OF A PUGHEADED BROWN ROCKFISH, SEBASTES AURICULATUS

During a population study on brown rockfish, *Sebastes auriculatus,* in San Francisco Bay, a pugheaded brown rockfish (Figure 1) was caught four separate times. The study, which included the taking of morphometric, tagging, and growth data, provided an opportunity to statistically test certain characteristics of the pugheaded fish against normal brown rockfish. The morphometric comparisons describe the effects of the pugheaded condition on growth of other parts of the body. Tagging data show the effects of pugheadedness on overall growth. This is the only instance known to us of a direct measurement of growth of a pugheaded fish. These data can be used to answer the question: Is this fish handicapped by its pugheadedness and, if so, how much?

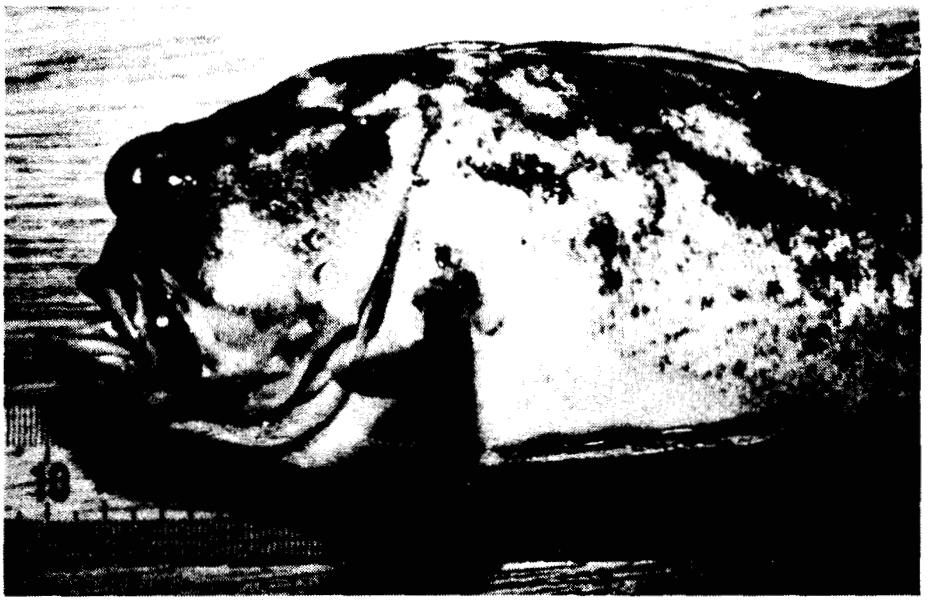

FIGURE 1. A pugheaded brown rockfish, *Sebastes auriculatus,* caught in San Francisco Bay near Tiburon, California.

Morphometrics of over 100 normal fish were regressed against total length (tip of lower jaw to the maximum length of the caudal fin). Measurement definitions were the same as those used by Phillips (1957). These regressions were used to estimate morphometrics for an "average" fish with a total length of 240 mm. The morphometrics of the pugheaded fish were compared with those of the "average" fish using *t*-tests.

The three morphometrics associated with pugheadedness—head, snout, and upper jaw lengths—were significantly smaller ($P > 0.05$) than the expected values (Table 1). The least depth of the caudal peduncle is significantly larger than expected normally. However, regression of the caudal peduncle against other parts of the body indicate that this is the result of random variations in the data. No other body parts differ significantly from those expected.

TABLE 1. Morphometrics and *t*-Test Statistics for Pugheaded and "Average" Brown Rockfish, *Sebastes auriculatus*.

Measurements	Pugheaded fish (mm)	Estimated "average" fish (mm)	t-test value	Degrees of freedom
Head length	63.5	71.5	−2.31*	109
Body depth at ventral fin	68.6	67.2	0.24	79
Body depth at anal fin	53.4	52.1	0.33	103
Length of anal fin base	29.2	29.8	−0.20	115
Length of snout	13.2	17.5	−1.73*	109
Width of orbit	16.2	17.1	−0.46	114
Width of interorbital space	12.9	12.8	0.11	106
Length of upper jaw	30.0	34.6	−2.38*	107
Width of base of pectoral fin	20.4	19.2	0.99	111
Longest pectoral fin ray	49.9	52.5	−0.78	110
Longest pelvic fin ray	37.8	41.7	−1.14	108
Length of pelvic spine	27.6	26.8	0.35	107
Length of first anal spine	15.2	14.0	0.69	107
Length of second anal spine	30.1	28.0	0.64	90
Length of third anal spine	27.1	25.9	0.48	107
Longest anal fin ray	35.7	37.5	−0.80	107
Longest dorsal fin spine	37.3	33.9	0.66	76
Longest dorsal fin ray	31.4	33.2	−0.71	94
Least depth of caudal peduncle	22.0	19.5	1.74*	77
Posterior of anus to origin of anal fin	10.4	11.2	−0.31	56

* Significant at the 95% probability level.

Body parts other than those directly stunted by the pugheadedness grew in normal proportion to each other. The orbit and interorbital space were not significantly different from normal, indicating that the pugheadedness and exophthalmic condition (bulging eye) are the results of a shortened snout and upper jaw and are not independent conditions.

During a period of 15 months, the pugheaded brown rockfish was caught four times (Table 2). The fish was double-tagged with Floy [1] T-bar tags at the first capture date. The fish has been deposited in the fish collection at the California Academy of Sciences (CAS 46146). The daily growth rates for both the pugheaded and normal fish were calculated for all of the six possible time periods (Table 3). Only those fishes caught during the same time interval as the pugheaded fish, and with total lengths between 150 and 260 mm, were used to calculate the normal daily growth of the population. The *t*-tests were used to compare the daily growth rate of the pugheaded fish with the average growth rate of normal fish in the population.

TABLE 2. Capture Dates and Total Lengths of a Pugheaded Brown Rockfish, *Sebastes auriculatus*, from Tiburon, California.

Capture date	Total length (mm)
10 December 1976	173
7 June 1977	198
2 December 1977	232
18 April 1978	240

[1] Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

TABLE 3. Growth Periods and Daily Growth Rates for Pugheaded and Normal Brown Rockfish, *Sebastes auriculatus.*

Growth period number	*Date start*	*Date stop*	*Daily growth for pugheaded fish (mm)*	*Daily growth for normal fish (mm)*	*t-test value*	*Degrees of freedom*
1	10 Dec 1976	7 Jun 1977	0.1117	0.1927	−9.10*	20
2	10 Dec 1976	2 Dec 1977	0.1657	0.1495	1.55	4
3	10 Dec 1976	18 Apr 1978	0.1359	—	—	—
4	7 Jun 1977	2 Dec 1977	0.1932	0.1768	1.34	12
5	7 Jun 1977	18 Apr 1978	0.1342	0.1460	−1.28	6
6	2 Dec 1977	18 Apr 1978	0.0588	0.1517	−8.85*	32

* Significant at the 99% probability level.

The *t*-tests indicate that there were two periods (one and six) when the pugheaded fish's daily growth rates were significantly less than the average growth rates of the population (Table 3). The differential in growth between the pugheaded and normal fishes averaged −2.4, 0.5, and −2.8 mm per month during period 1 (December 1976 to June 1977), period 4 (June 1977 to December 1977), and period 6 (December 1977 to April 1978). Although the pugheaded individual grew more slowly than normal brown rockfish during the winter, its growth rate was the same during other times of the year.

The winter quarter (January, February, and March) is a period of limited food resources and stress for brown rockfish in San Francisco Bay, as demonstrated by major reductions in their fat reserves (unpublished data). The period of population stress and the period of growth reduction coincide, indicating that the pugheaded brown rockfish is not as efficient as normal fish when the population is under stress.

The possibility that pugheadedness reduces the ability of an individual to compete has been investigated for other species (Mansueti 1960, Leggett 1969). The growth rate of a pugheaded striped bass, *Morone saxatilis,* was compared to that of normal individuals by Mansueti (1960). He found the pugheaded individual to be relatively fit, but smaller than its normal counterparts at each age group. A similar comparison was made of a pugheaded Atlantic salmon, *Salmo salar,* by Leggett (1969) who found little indication (only a reduced length-weight ratio) that the pugheaded individual was unable to compete with normal fish in its population. Both of these studies and our data suggest that while a pugheaded fish may be relatively fit, pugheadedness limits the fish's growth. The reduced growth rate of the pugheaded brown rockfish and the timing of the reduction of fat reserves in the population suggests to us that the fish is relatively fit during periods of food abundance, but during periods of population stress and increased intraspecific competition, the pugheaded fish's fitness is lowered probably through reduced feeding efficiency.

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