The Use of the Bones of the Caudal Complex to Identify Juvenile Rockfish (Sebastes spp.)

By

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ABSTRACT

The bones of the caudal complex of different rockfish species (Sebastes spp.) were examined for the possibility of differentiating species. The shape of the neural arch and haemal spine of the preural centrum, the epurals, and the parhypural exhibited consistent variability between species to allow identifications of the different species. Many other subtle differences existed between the species.

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INTRODUCTION

The identification of juvenile fish is based mostly on external characteristics, such as pigmentation and meristics (Kendall 1991). Juvenile rockfish (Sebastes spp.) are some of the most difficult fish to identify to species. This difficulty is greatly increased if identification characteristics are indistinct or disintegrated, as when examining species found in predator stomachs. In these instances, only fragmentary pigmentation and meristics are present. Further identifiable attributes of these prey species need to be determined to enhance the correct classification of each species.

The use of hard structures (excluding fin rays) to separate species has been investigated (Messieh 1972; Litvinenko 1974; McKern et al. 1974; Postuma 1974; Neilson et al. 1985; Rybock et al. 1975; Laroche and Richardson 1980, 1981; Sanchez and Acha 1988; Laidig and Ralston 1991[2]). Since hard structures typically take longer to digest, any identifiable hard structures that could be used in separating species would greatly increase the chances of accurate identifications. Most studies have involved examining head spination or otolith characteristics. However, Sanchez and Acha (1988) examined the caudal complex to

[2] Laidig, T. E. and S. Ralston. 1991. Otolith characters as an aid in identifying larval rockfish (Sebastes spp.). Unpub. ms.

differentiate between species of rockfish, Litvinenko (1974) examined vertebrae for differences in juvenile Sebastes fasciatus and S. menitella, and Rybachuk (1974) used articular bones to identify species found in middens.

In this study, we compared the caudal complexes of different species of juvenile rockfish for use in identification. Caudal complexes were selected because they usually were one of the last elements to be digested and they possessed ample structures in which to examine consistent differences among species.

METHODS

Juvenile rockfish were collected from midwater trawl samples conducted off central California (Wyllie Echeverria et al. 1990). Rockfish were identified (using pigmentation and meristics) and placed in 10% Formalin[3]. After fixation (one to two weeks), the bones were stained, using a mixture of water and alizarin red S. We used a weak solution of potassium hydroxide to dissolve the muscle tissue surrounding the caudal complex and the last few vertebrae while leaving the cartilage intact. Once the bones were free of tissue, they were embedded within resin blocks. At least five specimens of each species were used for comparisons.

Juvenile rockfish were also removed from the stomachs of king salmon, Oncorhynchus tshawytscha. Samples were collected

[3] Use of tradename does not imply endorsement by NMFS.

from four sport fishing boats docked in Sausalito, California, from April 10 to June 13, 1989. Salmon were caught between Half Moon Bay and Bodega Bay, California, most from near the Farallon Islands. Rockfish were identified using pigmentation or meristics. Further preparation of these specimens was as above.

Terminology

A projection was considered an extrusive growth of the bone that created an irregular (non smooth) pattern on the bone edge (Fig. 1). A projection was called a spine if it was longer than wide. A notch was an indentation in the bone, and a deep notch was a depression that was longer than wide. The edge of the boneis the outline of the bone when viewed laterally.

Eleven species of rockfish were used in this study: brown rockfish, Sebastes auriculatus; yellowtail rockfish, S. flavidus; chilipepper, S. goodei; squarespot rockfish, S. hopkinsi; shortbelly rockfish, S. jordani; blue rockfish, S. mystinus; bocaccio, S. paucispinis; canary rockfish, S. pinniger; bank rockfish, S. rufus; stripetail rockfish, S. saxicola; and pygmy rockfish, S. wilsoni.

We examined differences in bones in the caudal fin complex (Fig. 1): epurals, parhypural, hypural plates, preural (penultimate) centrum, and urostyle. We considered only those attributes of each bone that were consistently present for comparisons. The longest axis of each bone in both the frontal and transverse planes were measured, and the dorsal/ventral plane and ratios were computed to standardize comparisons.

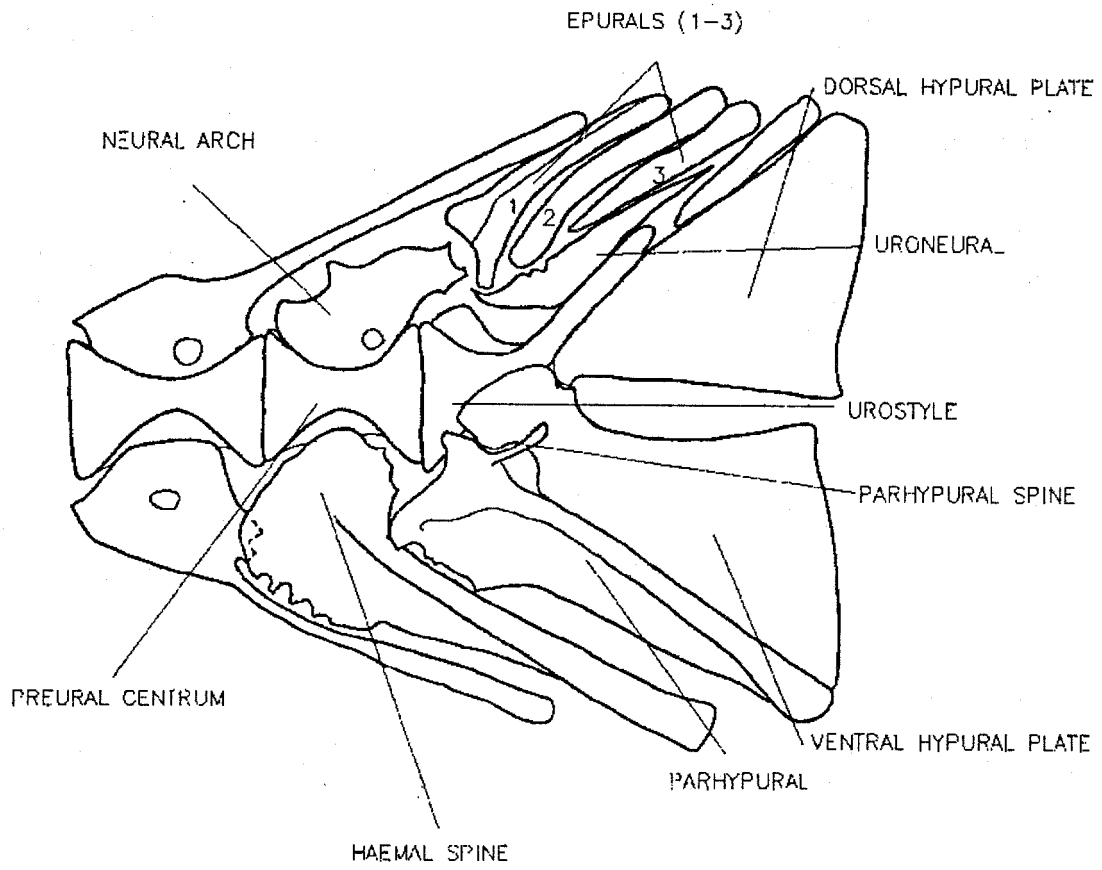
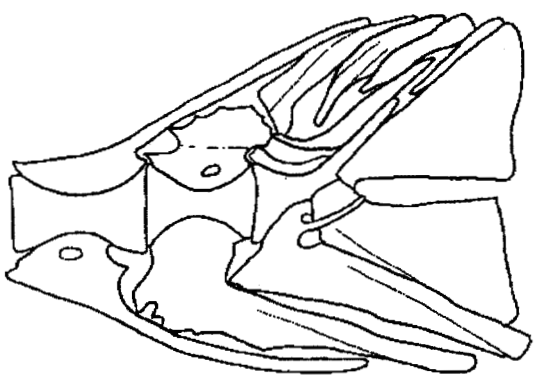


Figure 1. Caudal fin complex of Sebastes paucispinis displaying the different bones examined in this study.

RESULTS

We analyzed the caudal bones of four individuals of S. goodei and S. pinniger, five individuals of S. auriculatus, S. rufus, S. saxicola, and S. wilsoni, and six individuals of S. flavidus, S. hopkinsi, S. jordani, S. mystinus and S. paucispinis



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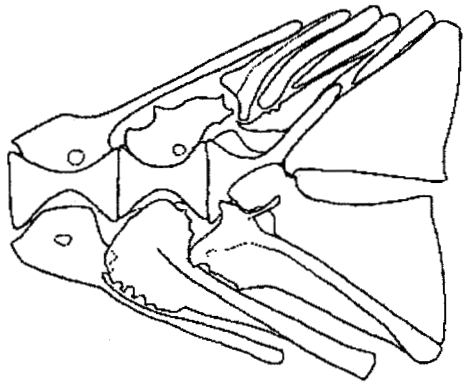

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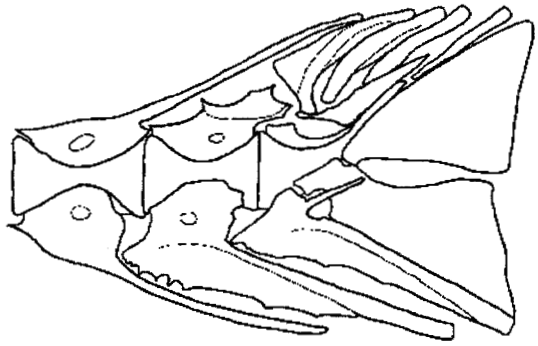

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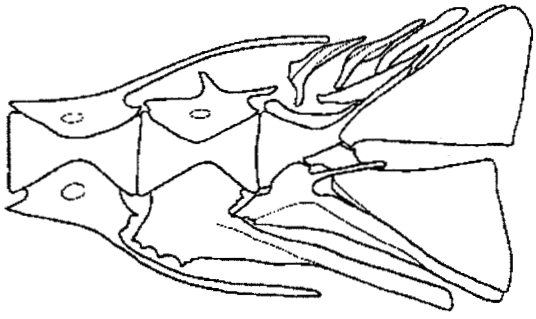

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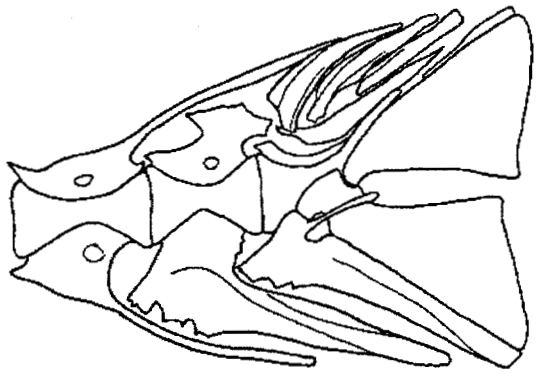

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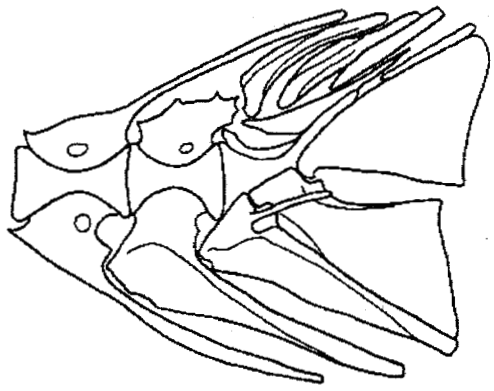

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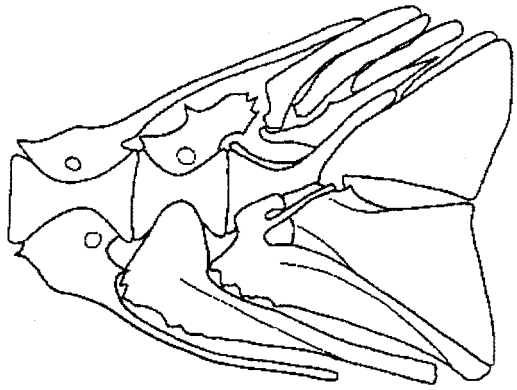
Figure 2. Caudal complex for each of the eleven species studied. A. Sebastes mystinus; B. Sebastes paucispinis; C. Sebastes goodei; D. Sebastes jordani; F. Sebastes hopkinsi; G. Sebastes saxicola.



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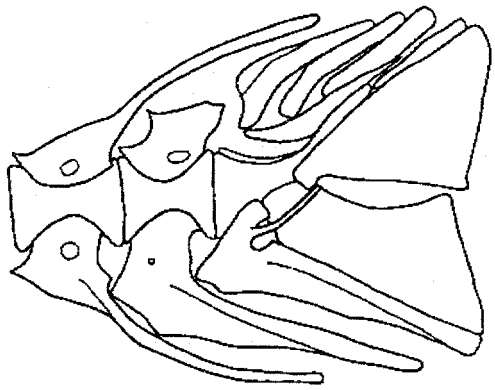

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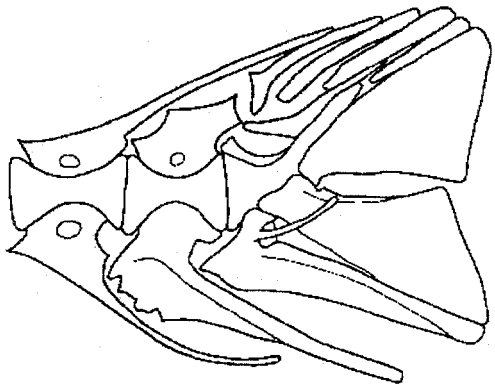

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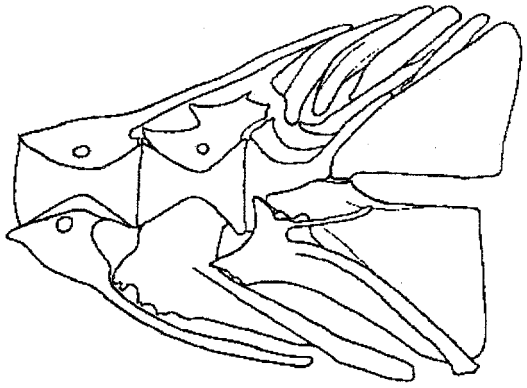

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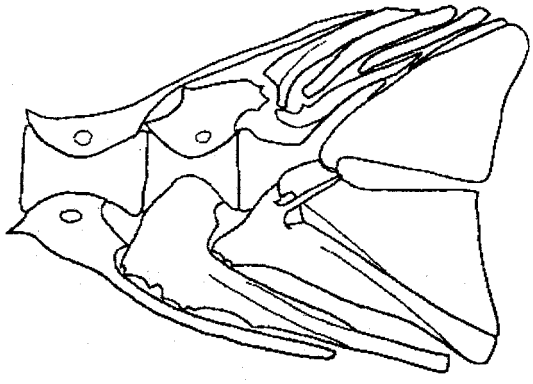

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Figure 2 (cont). Caudal complex for each of the eleven species studied. H. Sebastes auriculatus. I. Sebastes wilsoni. J. Sebastes pinniger. K. Sebastes rufus. L. Sebastes flavidus.

(Fig 2). The hypural plates, urostyle, and the vertebra anterior to the preural centrum were similar for each species and were not useful for discriminating between species.

Parhypural

Differences were observed in the length of the spine and the number and shape of the projections on the anterior edge. Sebastes jordani and S. hopkinsi had the longest spines (extending into the gap between the hypural plates) (Fig. 1); S. saxicola, S. mystinus, S. flavidus, S. pinniger, and S. wilsoni had intermediate length spines that extended to the dorsal edge of the ventral hypural plate; and S. auriculatus, S. goodei, S. paucispinis, and S. rufus had small spines. Sebastes wilsoni, S. saxicola, S. pinniger, and S mystinus had few projections on the anterior edge (at most three), and the remaining species typically had greater than three anterior projections.

Haemal spine of preural centrum

Sebastes wilsoni, S. pinniger, S. auriculatus,and S. rufus had no projections on the posterior surface. The anteriormost edge was smooth in S. saxicola and S. wilsoni, with only a few projections (Table 1). Sebastes mystinus, S. rufus, S. goodei, S. jordani, S. paucispinis, S. pinniger, and S. hopkinsi had deep notches between the numerous projections.

Haemal spine of the vertebra anterior to the preural centrum

Sebastes goodei, S. rufus, and S. hopkinsi had no projections on the posterior surface. The remaining species had at least one projection on the posterior surface.

Table 1. Counts and measurement ratio for the preural centrum, parhypural, and the preural centrum haemal spine. AnHaPr=number of preural centrum haemal spine anterior projections, AnPa=number of parhypural anterior projections, Hy=dorsal hypural length, Pr=preural centrum length, PrWi=Preural centrum width.

	Range AnHaPr	Ave AnHaPr	Range AnPa	Ave AnPa	Ave Pr/PrWi	Ave Hy/Pr
S. auriculatus	2-3	2.5	3-4	3.4	1.2	1.60
S. flavidus	5-7	6.2	2-4	3.0	1.2	2.44
S. goodei	4-8	5.5	2-4	3.0	1.5	1.78
S. hopkinsi	3-7	4.7	2-4	3.2	1.5	1.86
S. jordani	4-6	4.0	2-4	3.0	1.5	1.81
S. mystinus	3-5	4.0	2-3	2.3	1.3	1.88
S. paucispinis	4-5	4.3	3-5	3.7	1.3	1.68
S. pinniger	3-4	3.7	2-3	2.3	1.4	1.91
S. rufus	3-5	4.0	3-4	3.2	1.3	1.58
S. saxicola	1-5	3.0	2-3	2.6	1.4	1.89
S. wilsoni	1-3	1.8	0-2	1.0	1.0	1.74

Preural Centrum Neural Arch

The dorsal surface of this bone appears flat, with one anteriodorsal projection in S. jordani. Sebastes pinniger and S. wilsoni had four projections. All other species had greater than four projections. The most anterior projection was rounded in S. paucispinis. This bone was very diverse and each species had an individually shaped bone, but these differences are subtle and not easily described.

Epurals

Epural 1 was very wide in S. goodei. It was thinner in the remaining species, but varied among these species. This variability does allow for further separation based on the size of epural 1.

Uroneural

The uroneural had projections on the anteriodorsal edge in S. flavidus, S. paucispinis, and S. auriculatus. The remaining species had no projection.

DISCUSSION

The caudal complexes of the 11 rockfish studied differ substantially, allowing investigators an opportunity to separate these species. Of all the bones examined, the neural arch of the preural centrum had a characteristic shape for each species (Fig. 2). The other bones also contained attributes useful in identifying species. These differences in the caudal complex are combined in a key (Appendix I). This key used only one possible set of characteristics, and many other traits could be substituted, instead of the ones used.

The use of the bones of the caudal complex add another dimension to the ever-increasing science of fish identification. Pigmentation and meristics are still the most reliable features for identification, but, in the past few years, the use of different methods has increased; Sanchez and Acha (1988) studied the bones of the caudal complex to distinguish between two rockfish species, Seeb and Kendall (1991) used electrophoresis to separate rockfish species, Silberberg (1991) use the cleithrum to distinquish rockfish species, and Laidig and Ralston (1991)[2] found that otoliths contained plenty of information to differentiate rockfish species.

We studied only 11 out of the 69 species of rockfish occurring on the Pacific coast of North America (Anderson 1983). Because the caudal complexes are not described for the other 58 species, positive identifications of the examined species cannot be generated by examination of the caudal complex alone. The use of these bones for identifications can be used to separate species when analyses are augmented with partial pigmentation and meristic data.

ACKNOWLEDGEMENTS

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CITATIONS

Anderson, T. W.

1983 Identification and development of nearshore juvenile rockfishes (genus Sebastes) in central California kelp forests. M. A. thesis, California State Univ., Fresno, California, 216 p.

Kendall, A. W., Jr.

1991 Systematics and identification of larvae and juveniles of the genus Sebastes. Environ. Biol. Fishes 30:173-190.

Laroche, W. A., and S. L. Richardson

1980 Development and occurrence of larvae and juveniles of the rockfishes Sebastes flavidus and Sebastes melanops (Scorpaenidae) off Oregon. Fish. Bull., U. S. 77:901-923.

1981 Development and occurrence of larvae and juveniles of the rockfishes Sebastes entomelas and S. zacentrus (family Scorpaenidae) and occurrence off Oregon, with notes on head spines of S. mystinus, S. flavidus, and S. melanops. Fish. Bull., U. S. 79:231-258.

Litvinenko, N. N.

1974 Coloration and other morphological characters distinguishing juvenile Sebastes fasciatus from juvenile Sebastes menitella (Scorpaenidae). J. Ichthyol. 14:591-595.

McKern, J. L., H. F. Horton, and K. V. Koski

1974 Development of steelhead trout (Salmo gairdneri) otoliths and their use for age analysis and for separating summer from winter races and wild from hatchery stocks. J. Fish. Res. Baord Can. 31:1420-1426.

Messieh, S. N.

1972 Use of otoliths in identifying herring stocks in the southern Gulf of St. Lawrence and adjacent waters. J. Fish. Res. Board Can. 29:1113-1118.

Neilson, J. D., G. H. Geen, and B. Chan

1985 Variability in dimensions of salmonid otolith nuclei: Implications for stock identification and microstructure interpretation. Fish. Bull., U. S. 83:81-89.

Postuma, K. H.

1974 The nucleus of the herring otolith as a racial character. J. Cons. Int. Explor. Mer 35:121-129.

Rybachuk, V. K.

1974 Identification of the species of the genus Sebastes from a bone found by A. Ya. Taranets in middens of the Ilou tribe. J. Ichthyol. 14:798-799.

Rybock, J. T., H. F. Horton, and J. L. Fessler

1975 Use of otoliths to separate juvenile steelhead trout from juvenile rainbow trout. Fish. Bull., U. S. 73:654-659.

Sanchez, R. P., and E. M. Acha

1988 Development and occurrence of embryos, larvae and juveniles of Sebastes oculatus with reference to two southwest Atlantic Scorpaenids: Heliocolenus dactylopterus lahihhei and Pontinus rathbuni. Meeresforsch 32:107-133.

Seeb, L. W., and A. W. Kendall, Jr.

1991 Allozyme polymorphism permit the identification of larval and juvenile rockfishes of the genus Sebastes. Environ. Biol. Fishes 30:191-201.

Silberberg, K. R.

1991 Identification of juvenile rockfish (genus Sebastes) using the cleithrum. In Laidig, T. E., and P. B. Adams (eds.), Methods used to identify pelagic juvenile and larval rockfish (genus Sebastes) occurring along the coast of central California. U. S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFC. In Press. p. 19-30.

Wyllie Echeverria, T., W. H. Lenarz, and C. Reilly

1990. Survey of the abundances and distribution of pelagic young-of-the-year rockfishes, Sebastes, off central California. U. S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFC-147, 125 p.

Appendix I ---- Key to the Caudal Complex

1a The parhypural spine extends into the gap between the hypural plates 2
1b The parhypural spine does not extend into the gap between the hypural plates 3

2a The preural centrum neural arch has two major projections, one pointing dorsally and one pointing posteriorly; the dorsal surface of the neural arch appears flat ..... Sebastes jordani
2b The preural centrum neural arch has no major spines or if one, it points anteriorly; the dorsal surface does not appear flat. ..... Sebastes hopkinsi

3a The anteriormost edge of the preural centrum haemal spine has two or less anterior projections 4
3b The anteriormost edge of the preural centrum haemal spine has six or more anterior projections 6
3c The anteriormost edge of the preural centrum haemal spine has more than two and less than six anterior projections 7

4a Sharp anterior projections on the parhypural; not less than 3 of these anterior projections; parhypural spine does not extend to dorsal edge of the ventral hypural plates .... Sebastes auriculatus
4b No sharp anterior projections on the parhypural; often less than 3 of these anterior projections; parhypural spine extends to dorsal edge of ventral hypural plate 5

5a The length of the preural centrum is approximately equal to the width of the anterior end of the preural centrum .... Sebastes wilsoni
5b The length of the preural centrum is larger than the width of the anterior end of the preural centrum .... Sebastes saxicola

6a The ratio of the dorsal hypural to the preural centrum is greater than 2:1 ..... Sebastes flavidus
6b The ratio of the dorsal hypural to the preural centrum is 2:1 or less 2

7a The posterior edge of the haemal spine of the vertebra anterior to the preural centrum has no sharp projections ... 8
7b The posterior edge of the haemal spine of the vertebra anterior to the preural centrum has sharp projections 10

8a The parhypural spine extends into the gap between the hypural plates ..... Sebastes hopkinsi
8b The parhypural spine does not extend into the gap between the hypural plates 9

9a Bumps along the anterioventral edge of the parhypural; epural 1 very wide ..... Sebastes goodei
9b Anterioventral edge of the parhypural smooth; epural 1 width of medium length ..... Sebastes rufus

10a No sharp anterior projections on the parhypural; often less than three of these anterior projections; parhypural spine extends to dorsal edge of ventral hypural plate 11
10b Sharp anterior projections on the parhypural; not less than 3 of these anterior projections; parhypural spine does not extend to dorsal edge of the ventral hypural plates 13

11a Neural arch of preural centrum with one posteriorly pointing projection; four total projections occurring on the preural centrum neural arch; ventral edge of uroneural smooth 12
11b Neural arch of preural centrum with more than one posteriorly pointing projection; greater than four total projections occurring on the preural centrum neural arch; ventral edge of uroneural with bumps ..... Sebastes saxicola

12a The anterior edge of the haemal spine of the preural centrum with deep notches between sharp projections .... Sebastes pinniger
12b The anterior edge of the haemal spine of the preural centrum without deep notches or sharp projections .. Sebastes wilsoni

13a The preural centrum neural arch has two major spines, one pointing dorsally and one pointing posteriorly; the dorsal surface of the neural arch appears flat .... Sebastes jordani
13b The preural centrum neural arch not as above 14

14a The anterior edge of preural centrum neural arch rounded; parhypural spine short ..... Sebastes paucispinis
14b The anterior edge of preural centrum neural arch pointed; parhypural spine long 15

15a Anterior/ventral edge of uroneural with projections; anterior edge of the preural centrum haemal spine without deep notches 16
15b Anterior/ventral edge of uroneural without projections; anterior edge of the preural centrum haemal spine with deep notches .....Sebastes mystinus

16a Ratio of the lengths of the dorsal hypural to the preural centrum is greater than two; ventral end of epural 2 thin; urostyle sometimes without dorsal projection; anterior end of parhypural develops into a sharp point .... Sebastes flavidus
16b Ratio of the lengths of the dorsal hypural to the preural centrum is less than two; ventral end of epural 2 thick; urostyle always has dorsal projection; the anterior end of the parhypural is not sharp and has a more gradual slope than above ..... Sebastes auriculatus

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METHODS USED TO IDENTIFY PELAGIC JUVENILE ROCKFISH (GENUS *SEBASTES*) OCCURRING ALONG THE COAST OF CENTRAL CALIFORNIA

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