SYSTEMATICS, VARIATION, DISTRIBUTION, AND BIOLOGY OF ROCKFISHES OF THE SUBGENUS *SEBASTOMUS* (PISCES, SCORPAENIDAE, *SEBASTES*)

BY
LO-CHAI CHEN

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CONTENTS

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ABSTRACT

Following Matsubara, *Sebastodes* is synonymized with *Sebastes*.

The form known as *S. helvomaculatits* found in southern California is distinguished from that species and described as *S. simulator*, n. sp. *S. rhodochloris* (Jordan and Gilbert) is synonymized with *S. helvomaculatus* Ayres, and the form called *S. rhodochloris* by Phillips is described as *S. ensifer*, n. sp. *S. eos* of authors is a complex and a new species, *S. rosenblatti*, is described. In addition, three other new species, *S. noting, S. lentiginossus* and *S. exsul*, are described. Full description is given to each of the seven remaining species of the subgenus *Sebastomus*. Forms occurring in the southern hemisphere are all referred to as *S. capensis*. On the basis of similarities in meristics, body configuration, and color patterns, relationships among species of *Sebastomus* are discussed.

Meristic numbers in species of *Sebastomus* are found to be constant ontogenetically and geographically. Vertebral counts tend to be higher in northern species of *Sebastes* than in southern ones. Variability of meristic numbers is discussed, using the coefficient of variation as a criterion.

Allometry and its significance in taxonomy is discussed. Morphometric characters in speciea of *Sebastomus* are found to vary geographically. Both slopes and intercepts of the allometric regressions are equally susceptible to variation. There seems to be a correlation between growth rate and body form within a population.

Distributional data for all eastern North Pacific species of *Sebastes* are presented, with 34 new range records. Species of *Sebastes* are concentrated in the area from 34 to 38°N. As many as 50 species may occur in the same latitudinal range. There seems to have been a barrier near the latitude of San Francisco. A hypothesis involving differentiation following crossing of this barrier can explain the observed pattern of species distribution.

Growth of *Sebastes umbrosus* is studied in detail, using otoliths for age determination. Growth data back-calculated from otolith measurements are compared with those from average lengths of age groups and the discrepancy is discussed. This species can attain an age of 17 but mortality seems to increase after age 7. A Bertalanffy curve describes growth of this species well. Lee's Phenomenon is demonstrated and is explained as result of size-dependent mortality. No compensatory growth is detected and there is no correlation between early and subsequent growth. Fish that grew fast in early years, however, continue to be larger. There is no difference in growth rate between sexes. Individuals from Tanner Bank seem to grow more slowly than those from La Jolla.

Growth data of *S. rosaoeus, S. ensifer, S. chlorostictus*, and *S. dallii* are also presented, and, along with those of *S. umbrosus* are compared with those of other species of *Sebastes*.

Individuals of small species of *Sebastomus* such as *umbrosus* and *ensifer* may reach sexual maturity at age 3, whereas those of large species such as *constellatus, chlorostictus*, and *rosenblatti* generally do not mature until 10 years old or older. Species of *Sebastomus* spawn from February to July. Young of the year have been found to settle to the bottom starting from October.

INTRODUCTION

THE GENUS *Sebastes*, known to scientists as rockfishes, and to laymen as "rockcods," is of great interest. It is extremely speeiose, its species show a high degree of congeneric sympatry, and it is very rich in variation in color pattern. Economically, it ranks number one in the sport catches of California and appears also in quantity in commercial landings.

Although a majority of the species of *Sebastes* have been known for almost a century, the systematics of these forms remains confused. The latest detailed account on American Pacific rockfishes was that of Phillips (1957). Evidence collected in recent years indicates that further study is definitely needed. Concentrating on fishes of one subgroup, the present study sinks one species and describes six new ones.

This study concentrates on species referable to the subgenus *Sebastomus*, and deals with systematics, variation, and zoogeography. Information on growth and life history are also presented.

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MATERIALS AND METHODS

Nearly 2,000 specimens of *Sebastes* have been examined in this study. Only those that contributed to the data of meristies, morphometrics, and distribution of the *Sebastomus* species are listed in the text. Abbreviations for the listed collections are: AB, Auke Bay Laboratory, U.S. Bureau of Commercial Fisheries; CAS, California Academy of Sciences; LACM, Los Angeles County Museum of Natural History; SIO, Scripps Institution of Oceanography—Fish Collection; SU, Division of Systematic Biology, Stanford University; UCLA, Department of Zoology, University of California, Los Angeles; UMMZ, University of Michigan, Museum of Zoology; USNM, U.S. National Museum. Most of the material used was collected by Scripps personnel.

Specimens were examined either fresh, thawed after a period of freezing, or preserved in alcohol. The effect of freezing or preservation on the shrinkage of the specimens was not determined. All measurements were made with a dial caliper to the nearest 0.1 mm for lengths less than 20 cm or with a meter-stick caliper to the nearest mm for lengths greater than 20 cm. After measuring and counting, sex, gonad condition, cranial spine pattern, and squamation were noted. For fresh or thawed specimens, color pattern was also noted and the specimen was weighed with a 200 g capacity, 0.1 g accuracy Welch balance for weights less than 200 g or with a 15 kg capacity, 25 g accuracy Chatillon autopsy scale for weights greater than 200 g. The otoliths were then removed.

Measurements were made with the mouth and gill covers closed and fins erected. The methods of measuring and counting employed are those of Hubbs and Lagler (1958), with the following exceptions:

Length of raker at angle of first gill-arch ("gill-raker length"): from the lower base to the tip of the raker at angle between upper and lower limbs.

Free distal part of fourth dorsal spine ("dorsal-fin incision"): from the tip of the spine to the beginning of the membrane posterior to the spine.

Length of the base of the spinous part of dorsal ("spinous-dorsal base"): anterior base of first dorsal spine to anterior base of the last dorsal spine.

Length of the base of the soft-rayed part of dorsal ("soft-dorsal base"): from anterior base of the last dorsal spine to the posterior base of the last dorsal ray.

Length of the base of the anal fin ("anal base"): from anterior base of first anal spine to posterior base of the last anal ray.

Preanal length: from tip of snout to anterior base of first anal spine.

Prepelvic length: from tip of snout to anterior base of pelvic spine.

Body depth: from anterior base of first dorsal spine to anterior base of pelvic spine.

Upper peduncle length: posterior base of the last dorsal ray to the structural base of the middle caudal ray.

Lower peduncle length: from posterior base of the last anal ray to the structural base of the middle caudal ray.

Lachrymal width: least distance from notch between lachrymal projections to the opposite edge of the lachrymal.

Length of intestine: posterior base of the posteriormost pyloric caecum to anus, with the intestine lying straight.

Lateral-line pore count: including those beyond the structural caudal base.

Vertebral count: the urocentrum, with the upturned urostyle, is counted as the last vertebra.

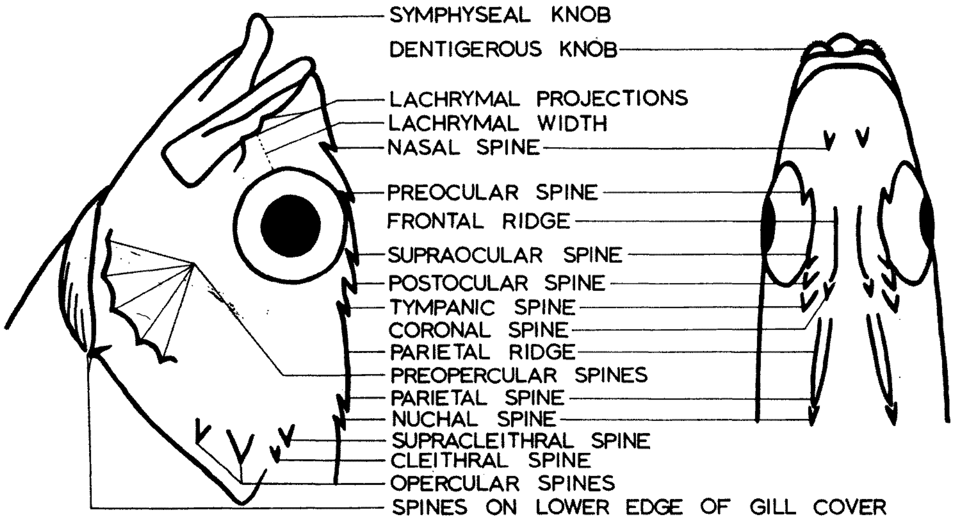

Fig. 1. Head of a rockfish, showing structures used in identification.

Terminology of the head structures follow those of Phillips (1957) (fig. 1), with one exception: the suborbital spines of Phillips are called "lachrymal projections" in this study.

In paired meristic structures, both left and right counts were taken, and the term "total count" refers to the sum of the left and the right counts. Vertebral counts were made on either skeletonized or cleared, alizarin-stained specimens. In estimating standard length from a total length, total length is multiplied by a factor of 0.82.

In the text, unless otherwise specified, body length refers to standard length. All statistical procedures follow the texts of Dixon and Massey (1957) and Snedecor (1956). Unless otherwise specified, differences are considered to be significant at the $P < .05$ level.

No separate description is given for the holotypes, but measurements and counts of the type specimens are presented in table 7.

TAXONOMY

GENUS *Sebastes* Cuvier, 1829

Sebastes Cuvier, 1829: 166 (type species *Perca norvegica* Müller, 1779 = *Perca marina* Linnaeus, 1758, by subsequent designation of Jordan and Gilbert, 1882b: 651).

Sebastodes Gill, 1861: 165 (orthotype, *Sebastes paucispinis* Ayres, 1854).

Sebastichthys Gill, 1862a: 278 (type species *Sebastes nigrocinctus* Ayres, 1859, by subsequent designation of Jordan and Gilbert, 1880b; 287).

Sebastomus Gill, 1864: 147 (orthotype, *Sebastes rosaceus* Girard, 1854).

Sebastosomus Gill, 1864: 147 (orthotype, *Sebastes melanops* Girard, 1854).

Acutomentum Eigenmann and Beeson, 1893: 669 (orthotype, *Sebastodes ovalis* Ayres, 1862).

Primospina Eigenmann and Beeson, 1893: 669 (orthotype, *Sebastichthys mystinus* Jordan and Gilbert, 1880).

Pteropodus Eigenmann and Beeson, 1893: 670 (orthotype, *Sebastichthys maliger* Jordan and Gilbert, 1880).

Auctospina Eigenmann and Beeson, 1893: 670 (orthotype, *Sebastes auriculatus* Girard, 1854).

Rosicola Jordan and Evermann, 1896: 429 (orthotype, *Sebastosomus pinniger* Gill, 1864).

Eosebastes Jordan and Evermann, 1896: 430 (orthotype, *Sebastichthys aurora* Gilbert, 1890).

Hispaniscus Jordan and Evermann, 1896: 431 (orthotype, *Sebastichthys rubrivinctus* Jordan and Gilbert, 1880).

Emmelas Jordan and Evermann, 1898: 1777 (orthotype, *Sebastes glaucus* Hilgendorf, 1880).

Zalopyr Jordan and Evermann, 1898: 1795 (orthotype, *Sebastodes aleutianus* Jordan and Evermann, 1898).

Rixator Jordan and Gilbert, 1920: 31 (orthotype, *Rixator porteousi* Jordan and Gilbert, 1920, fossil).

Sebastimis Jordan, 1920: 571 (orthotype, *Rixator ineziae* Jordan and Gilbert, 1920, fossil).

Sebastoessus Jordan, 1920: 571 (nomen nudum).

Sebastoessus Jordan, 1921: 285 (orthotype, *Sebastoessus apostates* Jordan, 1921, fossil).

Sebastopyr Jordan and Evermann, 1927: 506 (orthotype *Sebastodes ruberrimus* Cramer, 1895).

Sebastocarus Jordan and Evermann, 1927: 507 (orthotype, *Sebastichthys serriceps* Jordan and Gilbert, 1880).

Diagnosis.—Body compressed; head, eye, and mouth large (maxillary generally extending to below eye). Preopercle with five diverging spines; opercle with two. Suborbital stay pointed posteriorly, not connected to preopercle; fourth and fifth suborbitals present. Dorsal spines generally XIII (XIV or XV in a few species); vertebrae generally 26–27 (28—31 in a few species); dorsal soft-rays 10–18; anal soft-rays 5–11; pectoral rays 14–21, upper first ray and rays of lower half of fin generally unbranched. Villiform teeth on mandibles, premaxillaries, vomer, and palatines. Scales ctenoid; no dermal flaps. Gas bladder well developed. Ovoviviparous (giving birth to yolk-sac larvae).

Discussion.—The earliest description of a Pacific species of *Sebastes* was that of Tilesius in 1813, and most Pacific species of the genus were described before 1900. In 1861 Gill erected a genus, *Sebastodes*, to separate the Pacific from the Atlantic species of *Sebastes*. Since then, the Pacific species have been repeatedly split, combined, and again split. At one time as many as 14 genera were recognized for the living Pacific American species of *Sebastes*. This subject has been reviewed by Phillips (1957). Up to this date, most American workers have retained all Pacific species in *Sebastodes*.

Pacific species of *Sebastes* differ from those of the Atlantic in usually having 13 dorsal spines and 26–27 vertebrae instead of 15 dorsal spines and 30–31 vertebrae. Most of the Pacific species can be assigned, though rather arbitrarily, to one of two groups: the extremes of one group have a smooth cranium and a broad and convex interorbital, whereas those of the other group have a ridged and spiny cranium and a narrow and concave interorbital. However, because of the existence of intermediate species, subgroupings within Pacific *Sebastes* have not been widely accepted (Eigenmann and Beeson, 1893, 1894; Cramer, 1895; Jordan and Evermann, 1898; Jordan, Evermann, and Clark, 1930; Hubbs and Schultz, 1933).

Matsubara (1943, 1955) found two Japanese species to have meristic characters intermediate between those of the Atlantic and those of the Pacific. He found *S. glaucus* and *S. owstoni* (Jordan and Thompson) to have 14 dorsal spines and, respectively, 29 (29–30) and 30 (28–31) vertebrae. On the basis of these findings, Matsubara held that the separation of *Sebastodes* from *Sebastes* is not justified. Another meristically intermediate species, *S. polyspinis* (Taranets and Moiseev), has 14 dorsal spines and 28 (28–29) vertebrae (Barsukov, 1964).

I have examined specimens of all three meristic intermediates and of two Atlantic species, *S. marinus* and S. mentella Travin. The meristic intermediates all have a smooth cranium and a broad and convex interorbital, and thus stand at one extreme of the Pacific *Sebastes* species; but in the Atlantic species the cranium is ridged and spiny and the interorbital is rather concave and narrow, placing them at the other extreme of the Pacific *Sebastes* species. The relationship between the meristic intermediates and the Atlantic *Sebastes* thus may not be closer than between many other Pacific and Atlantic species. As the dorsal spines and vertebrae of Pacific species grade from the number 13 and 26 to 14 and 30, toward that of the Atlantic species (15 and 30–31), and as all other morphological characters of Atlantic species are shared variously by one or another Pacific subgroup, it seems undesirable to separate these forms into genera. Similar hemoglobin electrophoretic patterns (Tsuyuki et al., 1968) also provide evidence of close relationship.

SUBGENUS Sebastomus Gill, 1864

Sebastomus Gill, 1864: 147 (type species *Sebastes rosaceus* Girard); Eigenmann and Beeson, 1893: 607; Eigenmann and Beeson, 1894: 390; Jordan and Evermann, 1898: 1772; Jordan, Evermann, and Clark, 1930: 367.

Description.—Base of skull straight; interorbital relatively narrow, moderately to strongly concave. Top of cranium with the following spines: nasal, preocular, supraocular, postocular, tympanic, and parietal; nuchal spines almost always absent except in *S. eos* in which they are usually present, coronal spines almost always absent; parietal ridges well developed, highly elevated; a conspicuous groove between frontal ridges; supracleithral, cleithral, and the two opercular spines rather strong; preopercular spines directed radially.

Body relatively deep; dorsal profile of body more convex than the ventral; predorsal profile rather steep; mouth moderately oblique. Dorsal spines increasing in length to fourth, then decreasing gradually to 12th spine, 13th spine longer than 12th; soft dorsal high; second anal spine much stronger and longer than third (its tip reaching or exceeding tip of anal soft-rays in smaller specimens of some species); origin of pectoral below second or third dorsal spine; 10th or 11th ray longest; pectoral extending behind tip of pelvic, to above anus or sometimes origin of anal in small, but not in large, specimens; tip of pelvic reaching anus in small, but not in large, specimens; origin of anal below insertion of first or second dorsal soft-ray, end of anal below insertion of third or fourth dorsal soft-ray from rear; rear profile of anal nearly vertical; caudal truncate.

Snout between and before nasal spines scaleless; mandibles, maxillaries, and branchiostegals with or without scales; head scaled elsewhere. Fin rays scaled; membranes scaled basally, most extensively on anal and caudal.

P_1 16–18 (15–20), 17 in most species; the formula, unbranched rays + branched rays+unbranched rays, generally is 1+8+8 when the total number is 17, 1+8+7 when the total is 16, and 1+9+8 or 1+8+9 when the total is 18; dorsal soft-rays 12–13 (11–14); anal soft-rays 6 (5–7); vertebrae 26 (25–27).

Color in life generally pink, orange, or red; body typically with six characteristic white blotches located as follows: at tip of opercle, at base of fourth dorsal spine, at base of eighth dorsal spine, below ninth dorsal spine just above lateral line, at base of last dorsal spine, and at base of last dorsal ray; the first three blotches are not present consistently; they are absent in some species, or fade with growth, to disappear in large fish.

Discussion.—*Sebastomus* was first proposed by Gill in 1864, when he split the then known Pacific species into four genera.

Eigenmann and Beeson (1893, 1894) placed the following species in *Sebastomus: miniatus, pinniger, levis, aereus, constellatus, umbrosus, rosaceus, rhodo-chloris, gillii, rupestris, eos, chlorostictus, ruber, rufus*, and *capensis*. Three of these species, *rufus, miniatus*, and *pinniger*, do not belong in the group, since they differ from other members in having a rather smooth cranium, a broad and convex interorbital, and a curved skull base. Jordan and Evermann (1898) removed these three species, as well as *S. levis* (Eigenmann and Eigenmann), from *Sebastomus*, and synonymized *S. aereus* with *S. umbrosus*. In 1927 they removed *S. ruberrimus (= S. ruber* Ayres) from *Sebastomus* because of the rugosity of the cranial ridges and spines in adults. Among the species then left in the *Sebastomus* group, *S. rupestris* (Gilbert) has been synonymized by Phillips (1957) with the distantly related *S. melanostomus* (Eigenmann and Eigenmann), and *S. rhodochloris* is synonymized with *S. helvomaculatus* in the present study. *S. gillii* (Eigenmann and Eigenmann) differs from the other species in having 7–8 rather than 6 anal soft-rays, in having 18–19 rather than 16–18 pectoral rays, and in lacking the characteristic white blotches; it differs as well in its overall general body configuration, particularly the strongly protruding lower jaw, the greatly upturned head, and the relatively weak anal spines. With the removal of *S. gillii* the subgenus *Sebastomus* forms a relatively compact group.

Among the species excluded from *Sebastomus, S. ruberrimus* may be the most closely related. Juveniles of this species, with intact cranial ridges and spines, resemble members of the group in many features of general body configuration. However, there are no white blotches on the body but, instead, two conspicuous longitudinal white stripes. The usual numbers of soft-rays in this species also differ somewhat from those of the species of *Sebastomus:* dorsal 15, anal 7, pectoral 19. Individuals of this species also grow rather rapidly, in a pattern different from that of the *Sebastomus* species so far as determined (see BIOLOGY section).

Species of *Sebastomus* occur along the Pacific coasts of North and South America, at Tristan da Cunha in the South Atlantic, and in South Africa, but are absent along the Asiatic coast of the Pacific. Following is a list of the North Pacific species of *Sebastomus:*

S. constellatus (Jordan and Gilbert)

S. rosaceus Girard

S. helvomaculatus Ayres

S. simulator, sp. nov.

S. ensifer, sp. nov.

S. notius, sp. nov.

S. umbrosus (Jordan and Gilbert)

S. lentiginosus, sp. nov.

S. exsul, sp. nov.

S. chlorostictus (Jordan and Gilbert)

S. rosenblatti, sp. nov.

S. eos (Eigenmann and Eigenmann)

For species from the southern hemisphere, see discussion of *Sebastes capensis* (pp.37–39).

KEY TO NORTH PACIFIC SPECIES REFERRED TO SUBGENUS *Sebastomus*

Morphometric characters used in the following key are for specimens longer than 11 cm (standard length). If questionable specimens are encountered, tables 2, 3, 4, 5, and 6 should be used as supplements.

1. Mandible naked or with patches of fine scales 2
Mandible more or less wholly scaled 6

2(1). Color red with small white dots over whole body; first 4–7 rakers on each limb of first gill-arch rudimentary and spinulated; (lachrymal width 1.0–1.5 in interorbital)
S. constellatus
Body without small white dots; gill-rakers rarely rudimentary or spinulated 3

3(2). Color pinkish-yellow on sides, greenish-yellow on back; pectoral rays usually 16; (lachrymal width 1.3–1.9 in interorbital; caudal-peduncle depth generally greater than 10.5 in standard length
S. helvomaculatus
Color not as above; pectoral rays usually 17 4

4(3). Color orange red to pink with round green spots on back, most conspicuous on top of head *S. chlorostictus*
No round green spots on body 5

5(4). Color plain red; lachrymal width 1.8–2.5 in interorbital; caudal-peduncle depth 10.6–12.4 in standard length; first anal soft-ray 2.1–2.8 in head *S. simulator*
Color orange-red; conspicuous purplish marks on back; lachrymal width 1.2–1.9 in interorbital; caudal-peduncle depth 8.9–11.4 in standard length, generally less than 10.5; first anal soft-ray 1.8–2.2 in head *S. rosaceus*

6(1). Lower jaw slightly projecting; symphyseal knob generally prominent and projecting downward and forward; no green vermiculations, frecklings, or dark scale margins on body; fourth dorsal spine 1.3–2.0 in second anal spine 7
Jaws subequal; symphyseal knob generally round and not much projecting; body with green markings, either vermiculations, frecklings, or dark scale margins; fourth dorsal spine in second anal spine generally less than 1.5 8

7(6). Pectoral rays generally 17; orbit 6.7–8.3 in standard length; head 2.4–2.7 in standard length; color red to orange, with traces of green and red mottlings of deeper hue on back; fin membranes clear *S. ensifer*
Pectoral rays 18; orbit 8.4–8.7 in standard length; head 2.3–2.4 in standard length; color dull-yellow to orange with red vermiculations when alive, becoming generally red and vermiculations less conspicuous after death; pectoral and soft dorsal membranes dusky *S. notius*

8(6). Premaxillary tooth bands extended forward, to form conspicuous dentigerous knobs; body pink, freckled densely with green; (gill-raker 34–39) *S. lentiginosus*
No dentigerous knobs at anterior ends of premaxillaries; green marks, if present, in the form of vermiculations rather than of freckles 9

9(8). Orbit length in fourth dorsal spine less than 1.2; (body pink, with very fine green vermiculations on back; gill-rakers 32–37); (Gulf of California) *S. exsul*
Orbit length in fourth dorsal spine generally greater than 1.2; (not found in Gulf of California) 10

10(9). Gill-rakers 33–37; body pinkish-yellow or orange, partially dusky above lateral line; scales with conspicuous dark margins *S. umbrosus*
Gill-rakers less than 34, body pink, vermiculated with green on back (vermiculations often faded in large individuals); scales without conspicuous dark margins 11

11(10). Gill-rakers 26–30; first 4–7 rakers on each limb of first gill-arch rudimentary and spinulated; pectoral rays generally 18; usually no spines on lower edge of gill cover S. eos
Gill-rakers 29–33, rarely rudimentary or spinulated; pectoral rays generally 17; usually spines on lower edge of gill cover *S. rosenblatti*

Sebastes constellatus (Jordan and Gilbert, 1880)

Sebastichthys constellatus Jordan and Gilbert, 1880b: 295 (type localities: Santa Barbara Channel and San Francisco). Jordan and Gilbert, 1881a: 455 (distribution). Jordan and Gilbert, 1881b: 57 (distribution, size, spawning season). Jordan and Jouy, 1881: 8 (name only). Bean, 1882: 316 (reference to type description). Jordan, 1884: 265 (distribution). Jordan, 1887; 896 (name only). Goode, 1888: 266 (habit, size, distribution). Eigenmann and Eigenmann, 1889b: 128 (color, depth). Collins, 1892: 120 (San Francisco). Goode, 1903: 266 (habit, size, distribution). Jordan, 1905: 430 (color).

Sebastodes constellatus, Jordan and Gilbert, 1882b: 665 (description, size, range). Eigenmann, 1892: 165 (San Diego). Eigenmann and Eigenmann, 1892: 355 (range). Rathbun, 1894: 191 (Cortez Bank). Cramer, 1895: 589 (species analysis). Jordan and Evermann, 1896: 430 (range). Jordan and Evermann, 1898: 1806 (species analysis, description). Gilbert, 1899: 26 (Santa Catalina Island). Gill, 1903: Ixvi (name only). Starks and Morris, 1907: 210 (color, range). Cockerell, 1913: 170 (scale). Fowler, 1923: 299 (name only). Ulrey and Greeley, 1928: 37 (range). Ulrey, 1929: 8 (name only). Walford, 1931: 119, fig. 94 (color, distribution, size). Wales, 1932: 168 (Ranger Bank). Barnhart, 1936: 45–60, 155, fig. 182 (key, description, range, size). Phillips, 1939: 217 (Monterey). Roedel, 1948: 103, fig. 74 (characters, size, range). Follett, 1952: 417 (locality and meristie data). Roedel, 1953: 131, fig. 126 (characters, range, size). Cannon, 1953: 276 (fig., range, characters). Phillips, 1957: 124, fig. 51 (key, description, range, depth, size). Miller, 1959: 20 (fig., range, characters). Bailey et al., 1960: 38 (common name). Roedel, 1962: 30 (name only). Hitz, 1965: 53 (fig., characters, range, size, depth). Miller, Gotshall, and Nitsos, 1965: 26–27 (fig., characters, range, size, depth). Barrett, Joseph, and Moser, 1966: 489–494 (hemoglobin electrophoresis). Crozier, 1967: 181 (carotenoid composition of skin). Moser, 1967: 790–791, fig. 16 (larvae).

Sebastomus constellatus, Eigenmann and Beeson, 1893: 670 (relationships). Eigenmann, and Beeson, 1894: 394 (species analysis, synonymy). Eigenmann, 1894: 402 (range, depth). Jordan, Evermann, and Clark, 1930: 367 (name only).

Differential diagnosis.—This species differs from all its congeners in having characteristic small white dots over a red body. It may be distinguished from other species of *Sebastomus* in the following characters: interorbital conspicuously narrow, resulting in somewhat upward-looking eyes; lachrymal width in interorbital 1.0–1.5; head pointed and anterior part produced, caudal fin short (both of these features are obvious in configuration but are not readily measurable); rakers on first gill-arch 25–30; anterior 4–7 rakers in each limb rudimentary and spinulated.

Description.—D. XIII, 13 (12–14); A. III, 6 (5–7); P_1 17 (16–18); rakers on first gill-arch 25–30 (7–9 + 17–21); lateral-line pores 38–46; pyloric caeca 9–12.

Concavity of interorbital and elevation of cranial ridges and spines rather strong for a species of *Sebastomus*. Nuchal spines almost always absent; coronal spines absent; spines on lower edge of gill-cover more often absent than present; lachrymal projections blunt.

Symphyseal knob round, little projecting; jaws subequal; maxillary reaching to vertical from posterior edge of orbit. Head 2.3–2.5 and snout 9.1–10.6 in standard length. Orbit length 8.1–10.9 in standard length, 1.1–1.5 in length of fourth dorsal spine. Interorbital very narrow for a species of *Sebastomus* (lachrymal width 1.0–1.5 in interorbital). Body depth 2.7–3.5, predorsal length 2.5–2.8, and prepelvic length 2.3–2.7 in standard length. Caudal-peduncle depth 10.0–12.7 in standard length, 4.3–5.3 in head. First anal soft-ray 2.1–2.7 in head. Membrane of spinous dorsal moderately incised (free distal part of fourth spine 1.5–2.4 in spine length); fourth dorsal spine 1.0–1.5 in second anal spine, which does not reach to tips of anal soft-rays. Raker at angle of first gill-arch 6.8–10.4 in second anal spine. Rakers short; anteriormost 4–7 rakers on each limb of first arch rudimentary and spinulated, often fused into plates in large individuals.

Pectoral fin 1.4–1.6 and pelvic 1.9–2.3 in head. Upper jaw 0.9–1.0 in pelvic. Base of spinous part of dorsal 2.5–3.1, base of soft-rayed part of dorsal 4.6–5.6, and base of anal 7.2–8.6 in standard length.

Mandibles ordinarily scaleless, occasionally with some patches of scales; maxillaries scaled; branchiostegals scaleless.

Color in life red, lighter below, white ventrally. Top of head and back of body with dusky shading, becoming more conspicuous with age. Body always covered profusely with conspicuous small white dots. Fin rays and spinous dorsal membrane red, like body; other fin membranes golden-yellow. Gill-cavity lining white, with traces of golden and dusky; oral lining golden-red on roof, white ventrally, with dusky patches. Peritoneum silvery white.

In preserved condition, the dusky marks remain dark, body otherwise colorless.

Range.—The geographic range of this species was given by Phillips (1957) as Cedros Island (28°20N) to San Francisco (38°N). Dr. H. Goeffrey Moser has collected a specimen of this species at Thetis Bank, Baja California (24°57.1'N, 112°36.2'W), thus extending the range southward some three and half degrees of latitude.

Size.—The maximum total length was listed by Phillips (1968) as 16 inches [337 mm standard length]. The greatest standard length measured in the present study was 338 mm. Moser (1966, p. 493) reported standard lengths to 350 mm.

Depth.—Phillips (1957) gave 90 fathoms (162 m) as the greatest depth for S. *constellatus*. Specimens at SIO were taken between 30 and 190 m.

Material examined.—A total of 181 specimens from 48 mm to 338 mm. California:

Monterey: SIO 65–355,1 (277).

La Jolla: SIO 50–103, 2 (62–99); SIO 50–140, 1 (192); SIO 50–141, 1 (84); SIO 54–112, 3 (74–87); SIO 64–715, 1 (115); SIO 67–8, 1 (176); SIO 67–240, 1 (48); SIO 67–248, 1 (144); SIO 67–252, 2 (139–167); SIO 67–266, 1 (119); SIO 69–261,1(273).
Additional 56 specimens (109–310) discarded.

Forty Fathom Bank, off San Diego: SIO 61–3,1 (338).

Tanner Bank: SIO 67–223, 3 (164–294).
Additional 84 specimens (163–316) discarded.

Baja California: Cape Colnett: SIO 68–8,1 (200).
Guadalupe Island: SIO 65–54, 4 (280–312); SIO 65–57, 2 (280–310); SIO 65–58, 2 (304–316); SIO 65–59, 3 (227–287); SIO 65–74, 6 (264–294).
Thetis Bank: SIO 68–5,1 (278).

Sebastes rosaceus Girard, 1854

Sebastes rosaceus Girard, 1854: 146 (type locality: San Diego). Girard,1857: 14, pl. 21 (description). Girard, 1858: 78–79, pl. 21 (description). Girard, 1859: 50, pl. 21 (description). Günther, 1860: 98 (characters).

Sebastichthys rosaceits, Gill, 1862a: 278 (generic assignment). Jordan and Gilbert, 1880b: 296 (color). Jordan and Gilbert, 1881a: 455 (range). Jordan and Gilbert, 1881b: 57 (distribution, size). Jordan and Jouy, 1881: 8 (name only). Jordan, 1884: 265 (distribution). Jordan, 1887: 896 (name only). Goode, 1888: 266 (habit, size, distribution, San Francisco). Eigenmann and Eigenmann, 1889b: 129, 147 (color, depth). Collins, 1892: 120, pl. 2 (San Francisco, San Diego). Wilcox, 1902: 572 (fig.). Goode, 1903: 266 (habit, size, distribution). Jordan, 1905: 430 (color). Jordan, 1925: 641 (color).

Sebastomus rosaceus, Gill, 1864: 147 (characters). Eigenmann and Beeson, 1893: 668–671 (relationships). Eigenmann and Beeson, 1894: 375–407 (species analysis, synonymy). Eigenmann, 1894: 402 (range, depth). Jordan, Evermann, and Clark, 1930: 367 (name only).

Sebastodes rosaceus, Jordan and Gilbert, 1882b: 666–667 (description, size). Eigenmann, 1892: 164 (San Diego). Eigenmann and Eigenmann, 1892: 355 (range). Rathbun, 1894: 159 (Cortez Bank). Cramer, 1895: 573–610, pl. 63 (species analysis, figure of skull). Jordan and Evermann, 1896: 430 (range). Gill, 1903: Ixvii (name only). Starks and Morris, 1907: 211 (range). Jordan and Evermann, 1898: 1808 (species analysis, description). Cockerell, 1913: 170 (scale). Gilbert, 1915: 336 (San Nicolas Island, 32–33 fathoms). Fowler, 1923: 299 (name only). Ulrey and Greeley, 1928: 39 (range). Ulrey, 1929: 8 (name only). Sehultz and DeLacy, 1936: 74 (range). Barnhart, 1936: 45–60, 155, fig. 183 (key, description, range, size). Sehultz, 1938: 475, 481 (range, diet, color, with color plate of *S. miniatus* labeled as *S. rosaceus*). Follett, 1952: 417 (locality, meristic data). Phillips, 1939: 217 (Monterey). Clothier, 1950: 66, pl. 17 (axial skeleton, vertebral number). Schultz, 1952: 87 (range, size, diet, with color plate of *S. miniatus* labeled as *S. rosaceus*). Roedel, 1953: 129, fig. 124 (characters, range, size). Cannon, 1953: 274 (fig., range, characters). Phillips, 1957: 116, fig. 47 (key, description, range, depth, size). Miller, 1959: 20 (fig., range, characters). Bailey et al., 1960: 38 (common name). Roedel, 1962: 30 (name only). Hitz, 1965: 57 (fig., characters, range, depth, size). Miller, Gotshall, and Nitsos, 1965: 26–27 (fig., characters, range, depth, size). Barrett, Joseph, and Moser, 1966: 489–494 (hemoglobin electrophoresis). Moser, 1967: 790–791, fig. 16 (larvae). Fitch, 1968: 17, 22 (otolith from Pleistocene bed).

Sebastodes rosaceus (Girard) &, Rathbun, 1894: 159 (Washington). Evermann and Goldsborough, 1907: 287 (Puget Sound). Hubbs, 1928: 13 (name only). Schultz, 1936: 168 (name in key).

Sebastodes ayresii Gilbert and Cramer (not Lockington, 1877), in Gilbert, 1896: 450–451 (type locality: Cortez bank). Jordan and Evermann, 1896: 430 (range). Jordan and Evermann, 1898: 1808–1809 (species analysis, description). Starks and Morris, 1907: 211 (name only). Fowler, 1923: 291 (name only). Ulrey and Greeley, 1928: 36 (range). Ulrey, 1929: 8 (name only). Barnhart, 1936: 45–60 (key, description, range, size).

Sebastomus ayresii, Jordan, Evermann, and Clark, 1930: 367 (name only).

Differential diagnosis.—*S. rosaceus* differs from all its congeners in having characteristic purplish marks, particularly around the white blotches. It resembles *S. helvomaculatus and S. simulator* in meristic counts as well as in a number of morphometric characters. It differs from those species in its much weaker and lower cranial ridges and spines and in its stouter caudal peduncle (its depth generally less than 10.5 in standard length in *S. rosaceus* but greater than 10.5 in both *S. helvomaculatus* and *S. simulator*). It can also be distinguished from *S. helvomaculatus* by usually having 17 instead of 16 pectoral rays, and from *S. simulator* by its narrower interorbital and longer anal soft-rays (lachrymal width in interorbital generally less than 1.6 in *S. rosaceus*, greater than 1.8 in *S. simulator*; first anal soft-ray in head generally less than 2.1 in *S. rosaceus*, greater than 2.2 in *S. simulator*).

Description.—D. XIII, 13 (11–14); A. Ill, 6 (5–7); P_1 17 (16–18); rakers on first gill-arch 29–34 (8–11 + 20–24); lateral-line pores 37–46; pyloric caeca 11–12 (9–14).

Concavity of interorbital and elevation of cranial ridges and spines rather weak for a species of *Sebastomus*. Nuchal spines almost always absent; coronal spines absent; spines on lower edge of gill-cover more often present than absent; lachrymal projections blunt.

Symphyseal knob round, little projecting; jaws subequal; maxillary reaching to vertical from posterior edge of pupil, or farther. Head 2.3–2.6 and snout 9.2–11.7 in standard length. Orbit length 7.2–9.4 in standard length, 1.1–1.5 in length of fourth dorsal spine. Interorbital narrow for a species of *Sebastomus* (lachrymal width 1.2–1.9 in interorbital, generally less than 1.6). Body depth 2.5–3.1, predorsal length 2.5–2.9, and prepelvic length 2.2–2.7 in standard length. Caudal-peduncle depth 8.9–11.4 in standard length, generally less than 10.5, 3.6–4.7 in head. First anal soft-ray 1.8–2.2 in head, generally less than 2.1. Membrane of spinous dorsal moderately incised (free distal part of fourth spine 1.8–2.5 in spine length); fourth dorsal spine 1.0–1.4 in second anal spine, which usually does not reach to tips of anal soft-rays. Baker at angle of first gill-arch 4.5–7.2 in second anal spine. Rakers moderately long, rarely rudimentary or spinulated.

Pectoral fin 1.2–1.5 and pelvic 1.6–2.1 in head. Upper jaw 1.0–1.2 in pelvic. Base of spinous part of dorsal 2.5–3.0, base of soft-rayed part of dorsal 4.3–5.3, and base of anal 6.2–8.1 in standard length.

Mandibles and maxillaries generally scaleless, occasionally with some patches of scales; branchiostegals scaleless.

Color in life orange-red, lighter below, white ventrally. Upper part of body with irregular patches of deep purple and trace of green; a wide band of purple across nape at about posterior half of parietal ridges; a patch of purple between anterior half of parietal ridges. White blotch at tip of gill-cover, at base of fourth dorsal spine, and at base of eighth dorsal spine often obscure; others surrounded by purple. Fin rays colored as body, fin membranes greenish-yellow. Mouth and gill-cavity linings white with trace of golden-yellow. Peritoneum grayish with fine black dots. Specimens from certain spots in the La Jolla Submarine Canyon, San Diego, are greenish-yellow instead of orange-red, and the purplish marks are less conspicuous.

In preserved condition, the purplish marks turn somewhat brownish, body otherwise colorless.

Discussion.—*S. rosaceus* was first described by Girard in 1854 and redescribed by him in 1858, but the first detailed description of *S. rosaceus* that certainly fits the present species is that of Jordan and Gilbert (1882b). Fowler (1923), apparently by lapsus, and Phillips (1957), Roedel (1962), Hitz (1965), and Fitch (1968), obviously following Hubbs and Follett's unpublished list of California fishes, referred to Jordan and Gilbert as the original authors. The original description was so crude and inaccurate that it cannot be assigned definitely to any of the presently known species of *Sebastes*. The length of the type specimen was given by Girard as 14 inches [292 mm standard length] which is considerably greater than the known maximum length (247 mm) of the present species. However, Gill (1864), who examined Girard's two specimens of *S. rosaceus* (including the type specimen?), claimed that they were identical with *S. helvomaculatus* of Ayres (presumably, however, he did not know the differences between *S. rosaceus* and *S. helvomaculatus*). The smoothness of the head as described and figured indicates that the type of *rosaceus* was not *helvomaculatus*, but does not exclude possible identity with *rosaceus, miniatus*, or some other species. In view of the uncertainties involved, it seems best to regard the type of *rosaceus* as representing the species currently so named.

The type specimen of Girard's *S. rosaceus* probably is no longer in existence; however, the second specimen of *S. rosaceus* which Girard secured (specimen numbered 344 in his 1858 paper) has been examined by Dr. Carl L. Hubbs (personal communication), who regarded it as an example of the present species.

The similarities between *S. rosaceus* and *S. helvomaculatus* have often led to misidentification. Thus Alverson and Welander (1952), Sunde and Lindsey (1958), Clemens and Wilby (1961), and Alverson, Pruter, and Ronholt (1964) called their specimens of *S. helvomaculatus S. rosaceus*. The questionable records of *S. rosaceus* from Washington (Rathbun, 1894; Evermann and Goldsborough, 1907; Hubbs, 1928; and Schultz, 1936) were likely based on specimens of *S. helvomaculatus*.

Range.—Phillips (1957) gave the geographic range of this species as Turtle Bay, Baja California (27°30'N), to Puget Sound. The Puget Sound record was probably based on the questionable reports of Rathbun (1894) and Evermann and Goldsborough (1907). This species has not been taken off Washington in recent years (Charles Hitz, personal communication). I have examined specimens from Monterey, California, and the species unquestionably occurs northward at least to San Francisco.

Size.—The maximum total length listed by Phillips for this species was 12 inches [247 mm standard length]. The largest specimen examined in the present study is 203 mm. Moser (1966, p. 483) reported standard lengths to 229 mm; Follett (1952), one of 238 mm.

Depth.—*S. rosaceus* has been taken most abundantly at depths of 40–50 m. Miller, Odemar, and Gotshall (1967) reported capturing it in waters shallower than 50 ft (15 m). Material at SIO is from slightly less than 30 m to 130–140 m.

Material examined.—A total of 338 specimens from 117 mm to 203 mm. California:

San Francisco: UMMZ 63504, 3[*]; UMMZ 92544, 4[*].

[*] Meristie data only, examined by Dr. Carl L. Hubbs.

Monterey: SIO 55–97, 2 (174–193); SU 2828, 5*; UMMZ 56338, 1*; UMMZ 56389, 1*; UMMZ 63505, 4*; UMMZ 92542, 2*; UMMZ 162178, 1*.

Morro Bay: LACM 30164–1, 1 (200); LACM 30165–1, 2 (172–176).

Santa Barbara: SIO 48–304, 1 (187).

Santa Cruz Island: SIO 68–208, 7 (153–197).

Catalina Island: SIO 68–258 & 260, 34 (142–186).

La Jolla: SIO 48–112, 2 (155–177); SIO 48–113, 1 (167); SIO 50–103, 4 (120–173); SIO 50–104, 1 (178); SIO 50–140, 1 (129); SIO 54–198, 1 (136); SIO 64–320, 1 (124); SIO 67–260, 1 (148); SIO 67–261, 3 (145–168); SIO 67–266, 4 (117–158); SIO 68–182, 3 (130–193).

Additional three specimens (154–173) discarded.

Tanner Bank: SIO 67–223, 39 (134–203); SIO 67–239, 4 (153–183); SIO 68–20, 1 (121).

Additional 204 specimens (131–191) discarded.

Baja California:

Guadalttpe Island: SIO 57–215, 1 (180).

Sebastes helvomaculatus Ayres, 1859

Sebastes helvomaculatus Ayres, 1859: 26 (type locality: San Francisco). Ayres, 1863*a*: 215 (name only). Ayres, 1863*b*: 396–397 (fig., description). Lockington, 1877: 79 (characters, synonymized with *S. rosaceus*). Lockington, 1879: 302 (color). Jordan and Evermann, 1898: 1808 (synonymized with *S. rosaceus*).

Sebastichthys helvomaculatus, Gill, 1862a: 278, and 1862b: 330 (*S. ocellatus* synonymized).

Sebastodes helvomaculatus, Phillips, 1957: 118–119, fig. 48 (key, description, range, depth, size). Bailey et al., 1960: 38 (common name). Roedel, 1962: 30 (name only). Heyamoto and Hitz, 1962: 847–848 (mouth of Columbia River, 275 fathoms). Alverson, Pruter, and Ronholt, 1964: 89–121 (depth). Westrheim, 1965: 232–233 (Gulf of Alaska, 59° 33'N, 142°34'W, 73 fathoms, 314 mm fork length). Barsukov and Lisovenko, 1965: 726–728 (57° 51N, 137° 16'W, 230 m, 5 C, 274 mm standard length, morphometric and meristie data). Miller, Gotshall, and Nitsos, 1965: 26–27 (fig., characters, range, depth, size). Hitz, 1965: 56 (fig., characters, range, depth, size). Tsuyuki et al., 1968: 2477–2501, figs. 2, 3 (electrophoretie studies, age, size).

Sebastichthys rhodochloris Jordan and Gilbert, 1880*a*: 144–146 (type locality: Monterey). Jordan and Gilbert, 1881*a*: 455 (distribution). Jordan and Gilbert, 1881*b*: 57 (distribution). Jordan, and Jouy, 1881: 7 (name only). Bean, 1882: 314 (reference to original description). Jordan, 1884: 264 (distribution). Jordan, 1887: 896 (name only). Goode, 1888: 266, and 1903: 266 (habit, size, distribution).

Sebastodes rhodochloris, Jordan and Gilbert, 1882b: 667–668 (description, size, range). Eigenmann and Eigenmann, 1892: 355 (range). Cramer, 1895: 598–599 (species analysis). Jordan and Evermann, 1896: 431 (range). Jordan and Evermann, 1898: 1809–1810 (species analysis, description, size, range). Gill, 1903: lxvii (name only). Jordan, 1905: 430 (color). Jordan, 1925: 641 (color). Ulrey and Greeley, 1928: 38 (range). Ulrey, 1929: 8 (name only). Barnhart, 1936: 45–60 (key, description, range, size). Cannon, 1953: 214 (in part, description—condensed from type description as repeated by Jordan and Evermann, 1898: 1809, figured *S. ensifer*).

Sebastomus rhodochloris, Eigenmann and Beeson, 1893: 670 (relationships). Eigenmann and Beeson, 1894: 395 (species analysis, synonymy). Eigenmann, 1894: 402 (range, depth). Jordan, Evermann, and Clark, 1930: 367 (name only).

Sebastodes rosaceus (not of Girard), Alverson and Welander, 1952: 142 (name in key). Sunde and Lindsey, 1958: 1–6 (name in key). Clemens and Wilby, 1961: 267–268, fig. 162 (description). Alverson, Pruter, and Ronholt, 1964: 89–122 (depth).

Sebastes rosaceus (not of Girard), McAllister, 1960: 40 (name only).

* Meristic data only, examined by Dr. Carl L. Hubbs.

Differential diagnosis.—This species differs from all other *Sebastomus* species in usually having 16 pectoral rays instead of 17 or 18. It resembles *S. rosaceus*, and, more particularly, *S. simulator.* Compared with *S. rosaceus, S. helvomaculatus* has much stronger and higher cranial ridges and spines and a more concave interorbital. The caudal peduncle of *S. helvomaculatus* is slenderer than that of *S. rosaceus* (depth of caudal peduncle generally greater than 10.5 in standard length in *S. helvomaculatus* but less than 10.5 in *S. rosaceus*). In *S. helvomaculatus* the interorbital is narrower than in *S. simulator* (lachrymal width in interorbital generally less than 1.8 in *S. helvomaculatus* but greater than 1.8 in *S. simulator*). *S. helvomaculatus* is generally greenish-yellow, not uniformly red as in *S. simulator*, and lacks the purplish markings characteristic of *S. rosaceus*.

Description.—D. XIII, 13 (12–14); A. III, 6 (6–7); P_1 16 (15–17); rakers on first gill-arch 28–33 (8–11 + 20–23); lateral-line pores 35–45.

Concavity of interorbital and elevation of cranial ridges and spines very strong for a species of *Sebastomus*. Nuchal spines almost always absent; coronal spines absent; spines on lower edge of gill-cover more often absent than present; lachrymal projections occasionally sharp-tipped.

Symphyseal knob round, not much projecting; jaws subequal; maxillary reaching to vertical from posterior edge of pupil, or farther. Head 2.3–2.6 and snout 9.0–10.9 in standard length. Orbit length 7.3–8.8 in standard length; 1.0–1.4 in length of fourth dorsal spine. Interorbital very narrow for a species of *Sebastomus* (lachrymal width in interorbital 1.3–1.9, generally less than 1.8). Body depth 2.8–3.5, predorsal length 2.5–2.9, and prepelvic length 2.4–2.7 in standard length. Caudal-peduncle depth 9.8–12.4 in standard length, generally greater than 10.5; 4.0–5.1 in head. First anal soft-ray 1.8–2.5 in head, generally less than 2.3. Membrane of spinous dorsal moderately incised (free distal part of fourth spine 1.8–2.6 in spine length); fourth dorsal spine 1.2–1.6 in second anal spine, which sometimes reaches the tips of anal soft-rays. Raker at angle of first gill-arch 3.6–8.3 in second anal spine, generally less than 6.0. Rakers slender, never rudimentary or spinulated.

Pectoral fin 1.3–1.6 and pelvic 1.7–2.0 in head. Upper jaw 1.0–1.2 in pelvic. Base of spinous part of dorsal 2.6–3.3, base of soft-rayed part of dorsal 4.1–5.1, and base of anal 6.2–8.0 in standard length.

Mandibles generally scaleless, occasionally with some patches of fine scales; maxillaries scaled; branchiostegals scaleless.

Color in life greenish-yellow, mixed with pink; white ventrally; sometimes with olive-green vermiculations on upper part of body and top of head. Fin rays pink; fin membranes greenish-yellow to pink. Oral lining whitish, with trace of pink; gill-cavity lining dusky, particularly black dorsally on inside of gill-cover. Peritoneum grayish, with fine black dots. White blotches conspicuous, the one at base of 8th dorsal spine often missing, but there often is a small patch of white on lateral line below mid-soft-dorsal. One of the frozen specimens examined had a few irregular patches of light purple on the back somewhat like those of *S. rosaceus*.

Specimens in alcohol generally colorless; vermiculations, if present, becoming somewhat brownish.

Discussion.—In the original description of *Sebastes helvomaculatus*, Ayres (1859) characterized this fish as red and as having 17 pectoral rays. These two characters suggest *S. simulator.* However, the type locality, San Francisco, is too far north for *S. simulator*; and the species name, *helvomaculatus*, indicates presence of yellow marks on the body. Type specimens of *S. helvomaculatus* probably no longer exist. Shortly after describing the species, however, Ayres sent four specimens of *S. helvomaculatus* to the British Museum (BM 1863.10.9.7–10). Upon examining these specimens, it becomes clear that the original *S. helvomaculatus* was definitely of the northern form of the helvomaculatus—simulator complex.

In 1864, Gill synonymized *S. helvomaculatus* with *S. rosaceus* Girard. Probably influenced by Gill, Jordan and Gilbert (1880) regarded Ayres's *helvomaculatus* as identical with *S. rosaceus* and described the specimens of helvomaculatus they secured as *S. rhodochloris*. I have examined the eight syntypes of *S. rhodochloris* from USNM and am of the opinion that *S. rhodochloris* is identical with *S. helvomaculatus*. One of the syntypes (USNM 26967), 189 mm in standard length, is herein selected as the lectotype of *S. rhodochloris.*

Range.—*S. helvomaculatus* has the greatest geographic range among the *Sebastomus* species. I have examined specimens from as far northwest as Albatross Bank, Gulf of Alaska, 56° 23'8"N, 152° 21'O"W. The southernmost record of this species is from Coronado Bank, off San Diego, at about 32° 40'N (well within the range of *S. simulator*).

Size.—Phillips (1957) listed a maximum size of 13 inches total length [271 mm standard length] for this species. The largest specimen examined in the present study is 268 mm. Barsukov and Lisovenko (1965) reported a specimen of 274 mm. Westrheim (personal communication) has secured, from the Gulf of Alaska, specimens up to 37 cm fork length [30–31 cm standard length].

Depth.—This species is known from 133 m (73 fathoms, Westrheim, 1965) to 456 m (250 fathoms, Heyamoto and Hitz, 1962).

Material examined.—A total of 95 specimens from 108 mm to 268 mm. Gulf of Alaska: SIO 69–58, 4 (261–268); AB 67–63, 1 (241). Washington: SIO 61–210, 2 (208–220); SIO 67–23, 40 (108–252); SIO 68–401, 2 (176–182); SIO 68–403, 2 (121–170); SIO 68–404, 5 (154–226); SIO 68–405, 4 (152–218).

California:

Eureka: SIO 68–12, 2 (227–231).

San Francisco: BM 1863.10.9.7–10, 4 (179–203); UMMZ 63507, 3*.

Monterey: SIO 64–1087, 1 (219); SIO 64–1088, 1 (177); SIO 64–1089, 4 (212–249); SIO 64–1090, 1 (262); SIO 64–1091, 1 (243); SIO 64–1092, 1 (235); USNM 26967, 1 (189) (*S. rhodochloris lectotype*); USNM 203835, 7 (175–235) (*S. rhodochloris remaining syntypes*); BM 81.3.14.88, 1 (180); BM 91.5.19.38–40, 3 (169–193)*; UMMZ 92541, 1*; UMMZ 92540, 2*.

Ooronado Bank: SIO 56–5, 2 (200–214).

Sebastes simulator*, sp. nov.*

Sebastodes rhodochloris (not of Jordan and Gilbert), Starks and Morris, 1907: 211 (characters, Point Loma). Gilbert, 1915: 330 (in part, southern California, characters).

* Meristic data only, examined by Dr. Carl L. Hubbs.

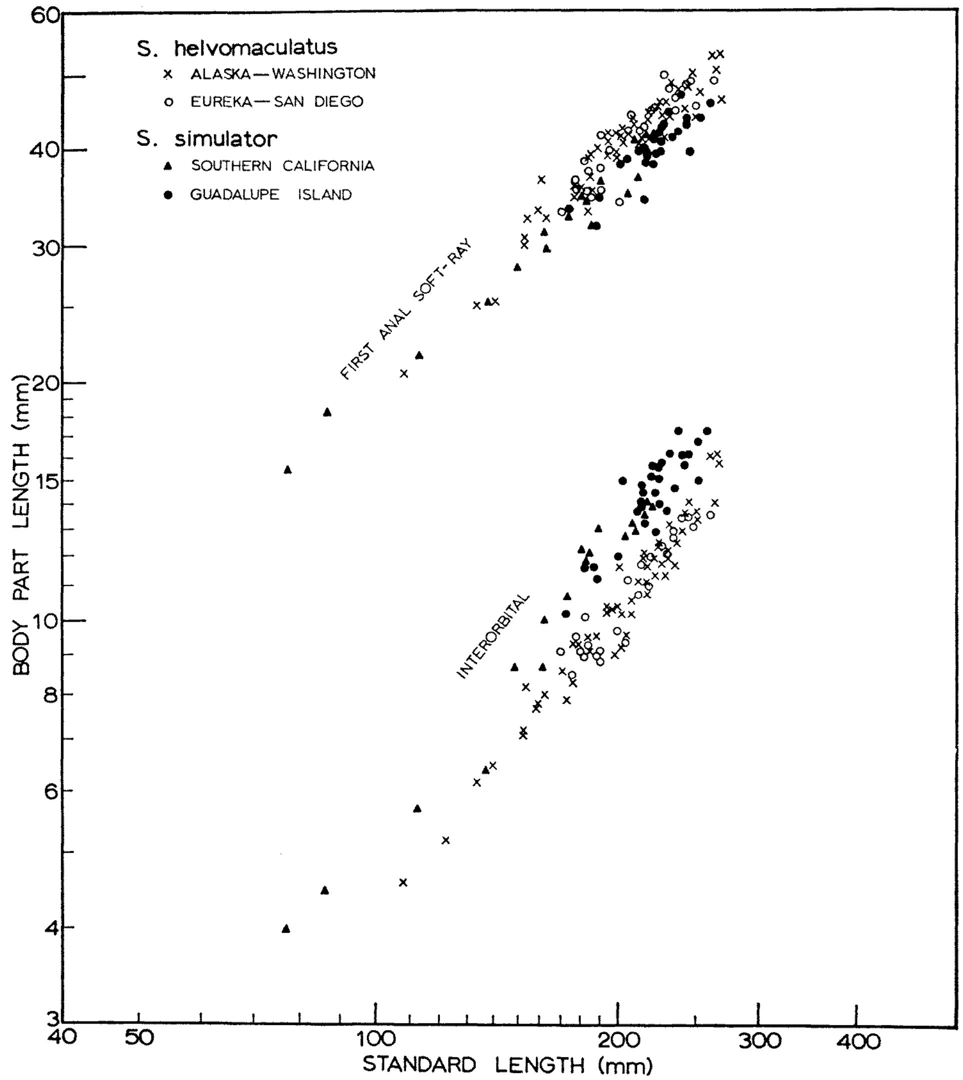

Fig. 2. Relation of the length of first anal soft-ray and of interorbital width to standard length for *S. helvomaculatus* and *S. simulator.*

TABLE 1 RATIO LACHRYMAL WIDTH IN INTERORBITAL WIDTH OF *S. helvomaculatus* AND *S. simulator*

	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5
S. helvomaculatus	6	18	35	15	9	1	2	..	..	..	..	..
S. simulator	..	1*	..	..	2	3	8	12	14	4	3	1

* This specimen has an extraordinarily wide lachrymal.

Differential diagnosis.—This species differs from all other *Sebastomus* species in its uniformly red body: *S. helvomaculatus* is greenish-yellow and *S. rosaceus* has conspicuous purplish markings in life, in part surrounding the white blotches. *S. simulator* resembles *S. rosaceus*, and, more particularly, *S. helvomaculatus*. From those two species it can be separated by its broader interorbital (lachrymal width in interorbital 1.8–2.5 but generally less than 1.8 in both *S. rosaceus* and *S. helvomaculatus)*. It also differs from *S. helvomaculatus* in usually having 17 instead of 16 pectoral rays, and it differs from *S. rosaceus* in having strong and high cranial ridges and spines and a strongly concave interorbital.

The differences between *S. simulator* and *S. helvomaculatus* are consistent (fig. 2 and tables 1 and 9), and include, on the average, in addition to characters pointed out above, more gill-rakers (table 11) and fewer lateral-line scales (table 13), shorter anal soft-rays (fig. 2), shorter anal base, larger head, and deeper body.

Description.—D. XIII, 13 (12–14); A. III, 6 (5–6); P_1 17 (16–18); rakers on first gill-arch 28–33 (8–10 + 20–23); lateral-line pores 33–39.

Concavity of interorbital and elevation of cranial ridges and spines very strong for a species of *Sebastomus*. Nuchal spines more often absent than present; coronal spines absent; spines on lower edge of gill-cover more often absent than present; lachrymal projections occasionally sharp-tipped.

Symphyseal knob generally round, sometimes pointing downward. Jaws subequal; maxillary reaching to vertical from posterior edge of pupil, or farther. Head 2.2–2.4 and snout 8.6–11.3 in standard length. Orbit length 7.0–8.3 in standard length; 0.9–1.3 in length of fourth dorsal spine. Interorbital broad for a species of *Sebastomus* (lachrymal width 1.8–2.5 in interorbital). Body depth 2.6–3.1, predorsal length 2.5–2.9, and prepelvic length 2.2–2.6 in standard length. Caudal-peduncle depth 10.5–12.4 in standard length; 4.6–5.2 in head. First anal soft-ray 2.1–2.8 in head. Membrane of spinous dorsal moderately incised (free distal part of fourth spine 1.6–2.4 in spine length). Fourth dorsal spine 1.1–1.6 in second anal spine, which usually does not reach to tips of anal soft-rays. Raker at angle of first gill-arch 3.0–5.0 in second anal spine. Rakers slender; never rudimentary or spinulated.

Pectral fin 1.3–1.6 and pelvic 1.9–2.2 in head. Upper jaw 1.0–1.1 in pelvic. Base of spinous part of dorsal 2.6–3.0, base of soft-rayed part of dorsal 4.5–5.3, and base of anal 7.0–8.3 in standard length.

Mandibles usually partly scaled, sometimes scaleless; maxillaries scaled; brachio-stegals with or without scales.

Color in life uniformly red, occasionally with trace of dusky on back. Fins colored as body. Gill-cavity and mouth linings white, with traces of golden and red; dusky dorsally on inside of gill-cover. Peritoneum grayish, with fine black dots. White blotches conspicuous.

Color in alcohol white.

Discussion.—*S. simulator* is so similar to *S. helvomaculatus* that the two have been considered as conspecific. The separation of *S. simulator* from *S. helvomaculatus* in the present study is based on the geographic consistency in all of the observed differences. Specimens of this species complex from Gulf of Alaska to Monterey all have the characters assigned above to *S. helvomaculatus*, and all those from Point Conception to Guadalupe Island, with the exception of two from Coronado Bank, off San Diego, have the characters assigned to *S. simulator.* No specimens in the area from Monterey to Point Conception have been examined.

Range.—The northern geographic limit of this species is probably Point Conception. I have examined material of this species from Los Angeles, California, to Guadalupe Island, Baja California.

Size.—The largest specimen examined in the present study is 259 mm.

Depth.—*S. simulator* is a deep-water species, generally occurring at depths near 200 m. The material at SIO was taken between 100 and 450 m.

Derivation of name.—From the Latin *simulator*, meaning one who imitates, to denote its similarity to *S. helvomaculatus*.

Material examined.—A total of 53 specimens from 71 mm to 259 mm.

Holotype: SIO 68–137, 216 mm, adult female; from 21/2 miles SSW of Carlsbad, South of Oceanside, San Diego County, California; collected by hook and line from the bottom at a depth of 200 m, by Lee Barlow on 17 February 1968.

Paratypes:

California:

Los Angeles: SIO 65–2, 1 (208); LACM 22127, 1 (162); UCLA 48–19, 2 (148–182).

San Diego: SIO 51–339, 1 (204); SIO 56–5, 2 (189–210); SIO 62–471, 1 (173); SIO 65–126, 1 (184); SIO 67–26, 1 (220); SIO 69–57, 2 (137–161); UCLA 49–362, 1 (180).

San Clemente Island: SIO 65–447, 1 (216).

Baja California:

Off San Quintin: SIO 62–520, 2 (77–86).

Guadalupe Island: SIO 56–74, 1 (222); SIO 56–81, 3 (203–225); SIO 57–48, 1 (223); SIO 57–220, 1 (200); SIO 63–161, 5 (189–223); SIO 64–937, 3 (182–238); SIO 65–58, 1 (243); SIO 65–62, 1 (220); SIO 65–67, 2 (172–212); SIO 65–70, 2 (224–242); SIO 66–17, 3 (227–244); SIO 67–73, 1 (220); SIO 67–74, 5 (186–259).

Additional specimens examined:

Southern California: SU 2808, 1 (184)*.

San Diego: SU 9927, 1 (223)*; USNM 77042, 1*; USNM 77046, 2 (71–91)*.

Guadalupe Island: 1 (236) discarded.

***Sebastes ensifer**, sp. nov.*

Sebastodes rhodochloris (not of Jordan and Gilbert), Roedel, 1953: 129 (characters). Cannon, 1953: 274 (in part, *S. ensifer* figured; not the description—condensed from type description of *S. rhodochloris* as repeated by Jordan and Evermann, 1898: 1809). Phillips, 1957: 114–115, fig. 46 (key, description, range, depth, size). Miller, 1959: 20 (fig., range, characters). Bailey et al., 1960: 38 (common name). Roedel, 1962: 30 (name only). Fitch, 1964: 27 (fossil otolith). Miller, Gotshall, and Nitsos, 1965: 26–27 (fig., characters, range, size, depth). Hitz, 1965: 52 (fig., characters, range, size, depth). Barrett, Joseph, and Moser, 1966: 489–494 (hemoglobin electrophoresis). Moser, 1967: 790–791, fig. 16 (larvae).

Differential diagnosis.— *S. ensifer* can be distinguished from other species of *Sebastomus* by the following combination of characters: lower jaw slightly projecting;

* Meristic data only, examined by Dr. Carl L. Hubbs.

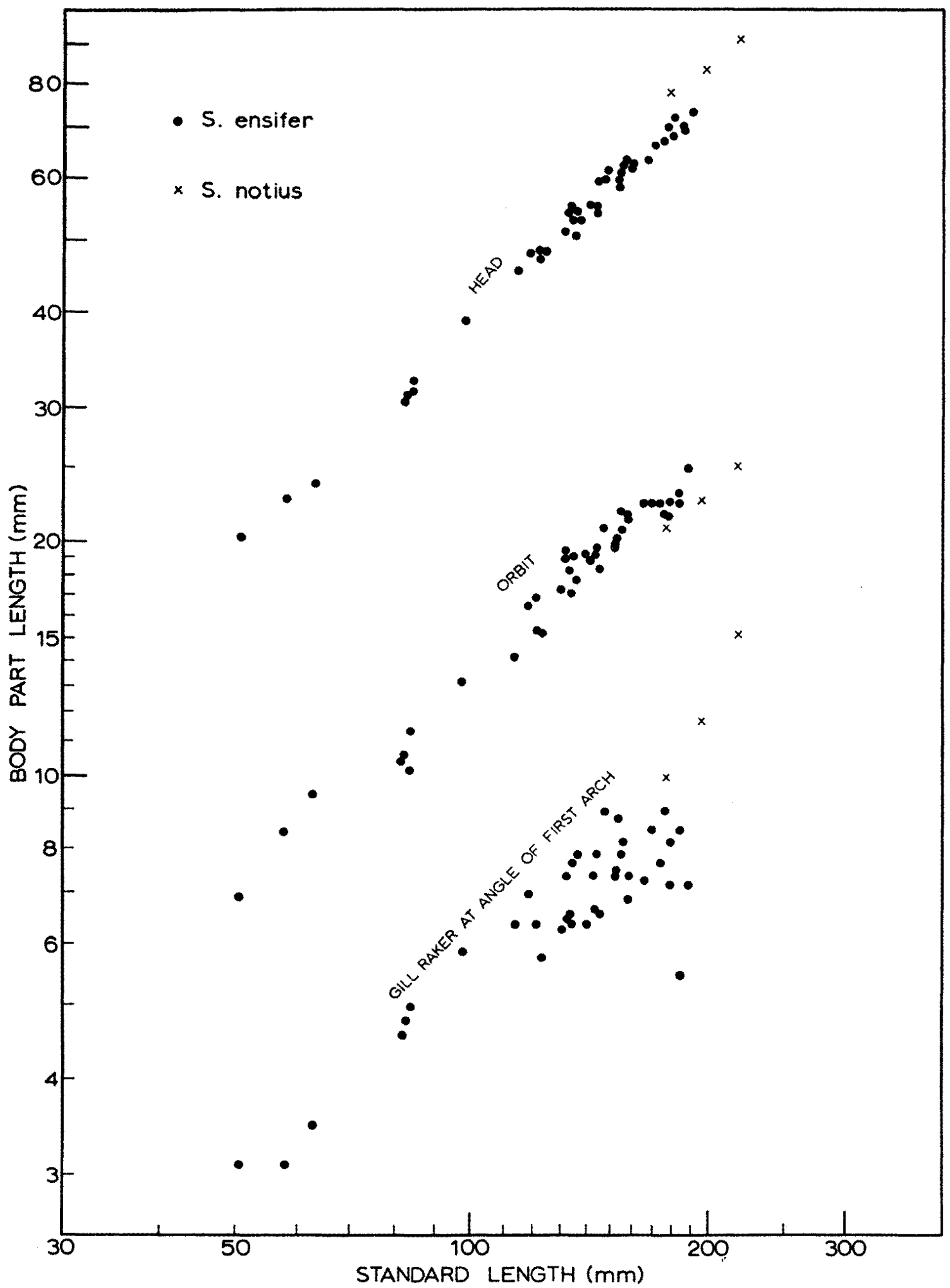

Fig. 3. Relation of head length, of orbit length, and of gill-raker length to standard length for *S. ensifer* and *S. notius*.

symphyseal knob prominent, projecting downward and often forward; mandibles sealed; body slender, dorsal fin low, second anal spine long; body red to orange, back mottled with red or purple of deeper hue and interlaced with greenish-yellow; gill-rakers slender and numerous, generally more than 35.

S. ensifer resembles *S. notius* but differs from it in having traces of greenish-yellow on the back, in lacking red vermiculations, and in usually having 17 instead of 18 pectoral rays. As shown in figure 3, *S. ensifer* also has a smaller head and larger eyes, as well as shorter gill-rakers than *S. notius*. In *S. ensifer*, head 2.4–2.7 and orbit 6.7–8.3 in standard length, and gill-raker at angle of first arch 3.6–5.0 in second anal spine; in *S. notius* these ratios are, respectively, 2.3–2.4, 8.5–8.7, and 2.4–3.5.

Description.—D XIII, 13 (12–14); A. III, 6 (5–7); P_1 17 (16–18); rakers on first gill-arch 34–40 (10–12 + 24–28); lateral-line pores 34–44; pyloric caeca 10–11.

Concavity of interorbital and elevation of cranial ridges and spines rather weak for a species of *Sebastomus*. Nuchal spines almost always absent; coronal spines absent; spines on lower edge of gill-cover more often absent than present; lachrymal projections sometimes sharp-tipped.

Symphyseal knob prominent, projecting downward and often forward; lower jaw slightly projecting; maxillary reaching to vertical from posterior edge of pupil. Head 2.4–2.7 and snout 10.0–13.3 in standard length. Orbit length 6.7–8.3 in standard length, 0.9–1.2 in length of fourth dorsal spine. Interorbital broad for a species of *Sebastomus*; width of lachrymal narrow, 1.9–2.7 in interorbital, generally greater than 2.1. Body depth 2.8–3.5, predorsal 2.6–3.0, and prepelvie length 2.5–2.7 in standard length. Caudal-peduncle depth 10.1–12.8 in standard length, 4.1–5.0 in head. First anal soft-ray 1.9–2.3 in head. Membrane of spinous dorsal moderately incised (free distal part of fourth spine 1.7–2.2 in spine length). Fourth dorsal spine 1.4–2.0 in second anal spine, which often reaches to tips of anal soft-rays. Raker at angle of first gill-arch 3.6–5.0 in second anal spine. Rakers slender, never rudimentary or spinulated.

Pectoral fin 1.2–1.4 and pelvic 1.7–2.0 in head. Upper jaw 1.1–1.3 in pelvic. Base of spinous part of dorsal 2.6–3.2, base of soft-rayed part of dorsal 4.4–5.2, and base of anal 6.8–7.9 in standard length.

Mandibles, maxillaries, and branchiostegals all finely scaled.

Color in life orange-red, lighter below, white ventrally. Upper part of body and top of head mottled with red or purple of deeper hue (slightly approaching the purplish marks in *S. rosaceus*), interlaced with greenish-yellow. White blotch at tip of gill-cover, at base of fourth dorsal spine, and at base of eighth dorsal spine often obscure. Fin rays red, like body. Dorsal and caudal membranes greenish-yellow; other fin membranes light pink. Mouth and gill-cavity linings pink to white, with trace of golden; dusky dorsally on inside of gill-cover. Peritoneum blackish, or grayish with fine black dots.

Color in alcohol white.

Discussion.—For a number of years, the species name *rhodochloris* of Jordan and Gilbert has been assigned to the present species (see SYNONYMY). Jordan and Gilbert, however, described *S. rhodochloris* as having high and sharp cranial ridges and spines and a very narrow interorbital space, as well as reticulating green streaks on body. These features do not fit the present species. Furthermore, an examination of the syntypes of *S. rhodochloris* (USNM 26967, USNM 203835) renders it clear that *S. rhodochloris* is a synonym of *S. helvomaculatus* Ayres, and that the present species has never been named.

Range.—Phillips (1957) delimited the geographic range of this species (as *S. rhodochloris*) as San Francisco to Guadalupe Island. I have examined specimens from Monterey to Ranger Bank (28°25–31'N, 115°32'W), slightly south of Guadalupe Island.

Size.—Phillips (1957) gave the maximum size for his *S. rhodochloris* [= *S. ensifer*] as 12 inches total length [25 cm standard length], apparently on the basis of the original description of *S. rhodochloris*. The largest specimen of *S. ensifer* examined in the present study measures only 190 mm. Individuals of this species probably do not commonly exceed 20 cm.

Depth.—Material of *S. ensifer* at SIO was taken between 70 m and 230m.

Derivation of name.—From the Latin *ensifer*, meaning sword-bearing, in reference to the unusually long second anal spine of this species.

Material examined.—A total of 41 specimens from 51 mm to 190 mm.

Holotype: SIO 67–295, 190 mm, adult female, from Scripps Submarine Canyon off La Jolla, California, collected by hook and line with squid bait from the bottom at a depth of 100 m, by Lo-chai Chen on 20 November 1967.

Paratypes:

Monterey: SIO 55–97, 2 (177–180).

Santa Barbara Island: UCLA 54–382, 1 (82).

Los Angeles: CAS 26585, 1 (122); LACM 3420, 1 (147); LACM 3421, 1 (133); LACM 22127, 1 (156).

Lausen Sea Mount: SIO 67–224, 5 (135–171).

San Clemente Island: UCLA 56–262, 1 (159); SIO 68–21, 3 (58–98).

La Jolla: UCLA 49–346, 1 (145); SIO 64–321, 1 (154); SIO 67–9, 1 (140); SIO 67–143, 2 (157–185); SIO 67–226, 1 (186); SIO 67–295, 1 (175); SIO 69–29, 1 (154).

Coronado Bank: SIO 65–106, 3 (119–133); SIO 65–113, 2 (124–149); SIO 65–149, 3 (122–180).

Coronado Island: SIO 62–690, 1 (124); UCLA 49–416, 2 (51–83).

Cortez Bank: SIO 63–239, 2 (84–114).

Northern Baja California, mainland: SIO 61–502, 1 (63).

Guadalupe Island: SIO 57–47, 1 (109).

Ranger Bank: SIO 68–6, 1 (144).

Sebastes notius, *sp. nov.*

Differential diagnosis.—*S. notius* is conspicuous in having red vermiculations when alive. In preserved condition, it can be distinguished from other species of *Sebastomus* by the following combination of characters: lower jaw projecting; symphyseal knob prominent, pointing downward and forward; mandibles scaled; rakers on first gill-arch 35 or more; pectoral rays 18.

S. notius resembles *S. ensifer* most closely but differs from it in having red vermiculations when alive, in having dusky pectoral and soft-dorsal membranes, in lacking greenish-yellow on back, and in having 18 instead of 17 pectoral rays. As shown in figure 3, compared with *S. ensifer, S. notius* also has a larger head (length 2.3–2.4 rather than 2.4–2.7 in standard length), smaller eyes (orbit length 8.5–8.7 rather than 6.7–8.3 in standard length), and longer gill-rakers (length of raker at angle of first gill-arch 2.4–3.5 rather than 3.6–5.0 in second anal spine).

Description.—D. XIII, 13; A. III, 6; P_1 18; rakers on first gill-arch 35–38 (10–12 + 25–26); lateral-line pores 33–40.

Concavity of interorbital and elevation of cranial ridges and spines rather weak for a species of *Sebastomus*. Nuchal spines present or absent; coronal spines absent; spines on lower edge of gill-cover absent; lachrymal projections sharp-tipped.

Symphyseal knob prominent, pointing downward and forward; lower jaw projecting; maxillary reaching to vertical from posterior edge of orbit. Head 2.3–2.4 and snout 9.5–11.0 in standard length. Orbit length 8.5–8.7 in standard length, 1.16–1.24 in length of fourth dorsal spine. Interorbital broad for a species of *Sebastomus* (lachrymal width 2.2–2.5 in interorbital). Body depth 2.7–3.0, predorsal length 2.8–2.9, and prepelvic length 2.3–2.5 in standard length. Caudal-peduncle depth 10.9–11.5 in standard length, 4.7–4.8 in head. First anal soft-ray 2.2–2.3 in head. Membrane of spinous dorsal moderately incised; free distal part of fourth spine 1.8–2.0 in spine length. Fourth dorsal spine 0.94–0.98 in second anal spine, which does not reach to tips of anal soft-rays. Raker at angle of first gill-arch 2.4–3.5 in second anal spine. Rakers slender, never rudimentary or spinulated.

Pectoral fin 1.43–1.45 and pelvic 1.9–2.0 in head. Upper jaw 1.1–1.2 in pelvic. Base of spinous part of dorsal 2.8, base of soft-rayed part of dorsal 4.5–4.7, base of anal 6.8–7.2 in standard length.

Mandibles, maxillaries, and branchiostegals all finely scaled.

Color in life dull yellow to orange, conspicuously vermiculated with red on back and on top of head; becoming generally red and less conspicuously vermiculated after death. Fin membranes golden, with trace of black on pectoral and soft dorsal. The three anterior white blotches obscure or absent. Gill-cavity and mouth linings whitish, with traces of golden and dusky. Peritoneum blackish, or grayish with fine black dots.

Color in alcohol white, fin membranes with trace of dusky.

Range.—*S. notius* is known only from Guadalupe Island, 29°N, and Uncle Sam Bank, 25°35’N.

Size.—The largest specimen of *S. notius* examined is the holotype, 219 mm in standard length.

Depth.—This is probably a rather deep-water species. The holotype was taken at 240 m and the paratypes between 165 and 250 m.

Derivation of name.—The Greek, *notius*, meaning of the south, is a reference to the southern localities where the species has been taken.

Material examined.—A total of three specimens from 179 mm to 219 mm.

Holotype: SIO 67–75, 219 mm, adult male, from Guadalupe Island, 29°09.4’N, 117°16.0’W, collected by hook and line with squid bait from the bottom at depth 240 m, by Robert Wisner and Lo-chai Chen on 1 May 1967.

Paratypes: Uncle Sam Bank, Baja California, 25°35.3’N, 113°21.3’W, SIO 64–29, 2 (179–198).

Sebastes umbrosus (Jordan and Gilbert, 1882)

Sebastichthys umbrosus Jordan and Gilbert, 1882*a*: 410–411 (type locality: Santa Rosa Is., California). Jordan, 1884: 265 (distribution). Jordan, 1887: 896 (name only). Goode, 1888: 266 and 1903: 266 (habit, size, distribution).

Sebastodes umbrosus, Jordan and Gilbert, 1882*b:* 950 (distribution). Eigenmann and Eigenmann, 1892: 355 (range). Cramer, 1895: 598 (species analysis). Jordan and Evermann, 1896: 430 (range). Jordan and Evermann, 1898: 1807 (key, species analysis, description). Gill, 1903: lxvii (name only). Starks and Morris, 1907: 210 (Pt. Loma). Ulrey and Greeley, 1928: 40 (range). Ulrey, 1929: 8 (name only). Barnhart, 1936: 45–60 (key, description, range, size). Roedel, 1953: 131 (color, size). Cannon, 1953: 274 (fig., range, characters). Phillips, 1957: 112–113, fig. 45 (key, description, range, depth, size). Bailey et al., 1960: 39 (common name). Roedel, 1962: 31 (name only). Miller, Gotshall, and Nitsos, 1965: 16–17 (fig., characters, range, depth, size). Hitz, 1965: 58 (fig., characters, range, depth, size). Crozier, 1967: 179–184 (carotenoid and color).

Sebastomus umbrosus, Eigenmann and Beeson, 1893: 670 (relationships). Eigenmann and Beeson, 1894: 394–395 (species analysis, synonymy). Eigenmann, 1894: 402 (range). Jordan, Evermann, and Clark, 1930: 367 (name only).

Sebastodes aereus Eigenmann and Eigenmann, 1890: 20–21 (type locality: Coronado Is.). Eigenmann, 1892: 165 (San Diego).

Sebastomus aereus, Eigenmann and Beeson, 1893: 670 (relationships). Eigenmann and Beeson, 1894: 394 (species analysis, synonymy). Eigenmann, 1894: 402 (range, depth).

Differential diagnosis.—*S. umbrosus* differs from other species of *Sebastes* in having dark scale-margins, resulting in a honeycomblike pattern, especially noticeable on the lower sides.

The combination of scaled mandibles, subequal jaws, absent dentigerous knobs, orbit length in fourth dorsal spine greater than 1.2, and 33–37 gill-rakers further differentiates *S. umbrosus* from all other known species of *Sebastomus*.

Description.—D. XIII, 12 (11–13); A. III, 6 (5–7); P_1 17 (15–18); rakers on first gill-arch 33–38 (9–12 + 23–27); lateral-line pores 34–44; pyloric caeca 10–11 (9–13).

Concavity of interorbital and elevation of cranial ridges and spines moderately strong for a species of *Sebastomus*. Nuchal spines generally absent; coronal spines absent; spines on lower edge of gill-cover almost always present; lachrymal projections sharp-tipped, forming definite spines in extreme cases.

Symphyseal knob round, little projecting; jaws subequal; maxillary reaching to vertical from posterior edge of pupil, or farther. Head 2.3–2.7 and snout 9.4–11.9 in standard length. Orbit length 7.3–9.5 in standard length, 1.2–1.7 in length of fourth dorsal spine. Interorbital broad for a species of *Sebastomus* (lachrymal width 1.8–2.4 in interorbital). Body depth 2.4–3.0, predorsal length 2.6–3.1, and prepelvic length 2.3–2.8 in standard length. Caudal-peduncle depth 9.3–11.5 in standard length, 3.6–4.6 in head. First anal soft-ray 1.7–2.3 in head. Membrane of spinous dorsal moderately incised (free distal part of fourth spine 1.6–2.5 in spine length). Fourth dorsal spine 1.0–1.3 in second anal spine, which does not reach to tips of anal soft-rays. Raker at angle of first gill-arch 3.4–6.5 in second anal spine. Rakers slender, never rudimentary or spinulated.

Pectoral fin 1.2–1.6 and pelvic 1.6–2.0 in head. Upper jaw 1.0–1.3 in pelvic. Base of spinous part of dorsal 2.3–3.0, base of soft-rayed part of dorsal 4.1–5.3, and base of anal 6.3–8.3 in standard length.

Mandibles, maxillaries, and branchiostegals all finely scaled.

Color in life pinkish-yellow or light orange, pink to white ventrally; back normally with dusky patches which break up occasionally and appear somewhat frecklelike. Scales on body with conspicuous dark olive-green margins, resulting in a somewhat honeycomblike color pattern. Dorsal, caudal, anal, and pelvic fins often with conspicuously white margins, which become pink and inconspicuous after death. Fin rays orange to pink, like body; fin membranes olive-green, with trace of pink. Head dusky. Gill-cavity lining white and golden, with dusky patches. Oral lining pinkish dorsally, dusky with olive-green on side, whitish ventrally; tongue pinkish. Peritoneum black. All six white blotches remain conspicuous throughout life.

In preserved condition, all dusky marks and scale margins become black.

Range.—Phillips (1957) gave the geographic range of *S. umbrosus* as Point Conception, California, to Guadalupe Island, Baja California. Mr. Robert Lea (personal communication) of the California Department of Fish and Game secured a specimen of this species 51 miles WSW of Point San Juanico, Baja California (25°48'N), extending the range of this species southward about three degrees of latitude.

Size.—Phillips (1957) gave 18 inches total length [30 cm standard length] as the maximum size for this species. This size record may have been an error, as individuals of this species usually do not get much larger than 20 cm. The largest specimen examined in the present study is 231 mm.

Depth.—This is a shallow water species, most often found at depths between 30 m and 70 m. Material at SIO was taken between slightly less than 30 m and 120m.

Material examined.—A total of 318 specimens from 31 mm to 231 mm.

California:

La Jolla: SIO 67–8, 1 (120); SIO 67–241, 1 (31); SIO 67–242, 2 (33–81); SIO 67–243, 1 (37); SIO 67–244, 2 (38–75); SIO 67–245, 1 (74); SIO 67–246, 4 (37–86); SIO 67–247, 1 (40); SIO 67–248, 1 (133); SIO 67–249, 1 (140); SIO 67–251, 2 (125–226); SIO 67–252, 5 (104–151); SIO 67–255, 1 (126); SIO 67–259, 2 (114–163); SIO 67–260, 1 (160); SIO 67–261, 1 (121); SIO 67–265, 2 (115–216); SIO 67–266, 3 (104–231); SIO 67–268, 1 (202); SIO 68–25, 2 (133–195); SIO 68–150, 1 (150); SIO 69–261, 1 (163).

Additional 239 specimens (104–226) discarded.

Tanner Bank: SIO 63–240, 2 (195–197); SIO 64–999, 6 (176–196); SIO 65–6, 4 (173–194); SIO 67–223, 9 (144–188).

Additional 11 specimens (138–215) discarded.

Baja California:

Guadalupe Island: SIO 55–45, 3 (152–210); SIO 60–25, 1 (182); SIO 63–161, 1 (200).

Sebastes lentiginosus*, sp. nov.*

Differential diagnosis.—*S. lentiginosus* is conspicuous in having, at the front of the premaxillaries, a pair of dentigerous knobs which are otherwise seen among the many species of the eastern Pacific only in *S. diploproa* and *S. phillipsi*.

This species resembles *S. umbrosus* in having rather well pigmented scale margins, but differs in having characteristic freckling, which somewhat resembles the green marks in *S. chlorostictus, S. rosenblatti*, and *S. eos*. The frecklings, however, definitely are not round spots as in *S. chlorostictus* and they are much finer and denser than the markings of *S. rosenblatti and S. eos*. The high gill-raker counts (generally more than 35) of *S. lentiginosus* distinguish it immediately from those three species.

Description.—D. XIII, 12 (12–13); A. III, 6 (6–7); P_1 17 (16–18); rakers on first gill-arch 34–39 (9–12 + 24–27); lateral-line pores 33–41.

Concavity of interorbital and elevation of cranial ridges and spines moderately strong for a species of *Sebastomus*. Nuchal and coronal spines absent; spines on lower edge of gill-cover usually present; lachrymal projections sharp-tipped.

Symphyseal knob prominent, pointing downward; jaws subequal; premaxillary tooth bands projecting forward, forming a pair of conspicuous dentigerous knobs. Maxillary reaching to vertical from posterior edge of pupil. Head 2.3–2.6 and snout 9.9–12.6 in standard length. Orbit length 6.9–8.7 in standard length, 1.1–1.5 in length of fourth dorsal spine. Interorbital broad for a species of *Sebastomus* (lachrymal width 1.8–2.5 in interorbital, generally greater than 2.0). Body depth 2.6–3.2, predorsal length 2.6–3.0, and prepelvic length 2.4–2.6 in standard length. Caudal-peduncle depth 10.7–12.3 in standard length, 4.3–5.0 in head. First anal soft-ray 2.0–2.3 in head. Membrane of spinous dorsal moderately incised (free distal part of fourth spine 1.6–2.1 in spine length). Fourth dorsal spine 1.2–1.5 in second anal spine, which is long, often reaching to tips of anal soft-rays. Raker at angle of first gill-arch 3.4–5.4 in second anal spine. Rakers slender, never rudimentary or spinulated.

Pectoral fin 1.2–1.5 and pelvic 1.7–1.9 in head. Upper jaw 1.16–1.26 in pelvic. Base of spinous part of dorsal 2.4–2.9, base of soft-rayed part of dorsal 4.5–5.2, and base of anal 6.4–7.7 in standard length.

Mandibles, maxillaries, and branchiostegals all finely scaled.

Color in life pinkish, white ventrally; body freckled densely with dark olive-green above lateral line, on top of head, and on basal part of dorsal. Marks developed as freckling rather than distinct spots as in *S. chlorostictus* or vermiculations as in *S. rosenblatti* and *S. eos*. Fin rays pinkish; membranes greenish-yellow but olive-green on proximal part of caudal. Scale margins olive-green, lighter than the freckling. Gill-cavity and mouth linings whitish, with trace of golden and dusky. Peritoneum black.

In preserved condition, all olive-green marks and scale margins black; body otherwise colorless.

Range.—The known geographic range of *S. lentiginosus* is rather limited, covering not much more than one latitudinal degree in southern California. I have examined materials from Catalina Island, Los Angeles, La Jolla, Coronado Island, San Clemente Island, Tanner Bank, and Cortez Bank.

Size.—The largest specimen of *S. lentiginosus* examined is 190 mm.

Depth.—The specimens of *S. lentiginosus* at Scripps Institution were taken between 40 m and 160–170 m.

Derivation of name.—From the Latin, *lentiginosus*, meaning full of freckles, in reference to the olive-green freckling.

Material examined.—A total of 20 specimens from 79 mm to 190 mm.

Holotype: SIO 65–6, 190 mm, adult female, from Tanner Bank, off San Diego, California, 32°42’N, 119°08’W, collected by hook and line with squid bait from the bottom at depth 33–60 m, by Richard H. Rosenblatt and party on 15 January 1965.

Paratypes:

Catalina Island: SIO 68–258, 1 (169).

Los Angeles: LACM 9084–1, 1 (138).

San Clemente Island: SIO 65–446, 1 (168).

La Jolla: SIO 48–196, 1 (166); SIO 48–198, 1 (147); SIO 50–103, 1 (79); SIO 54–198, 1 (154); SIO 67–9, 1 (160); SIO 68–392, 1 (171); UCLA 49–354, 1 (163).

Coronado Island: LACM 8961–3, 5 (134–144).

Tanner Bank: SIO 65–6, 3 (171–186); SIO 64–901, 3 (head only).

Cortez Bank: SIO 63–239, 1 (175).

***Sebastes exsul**, sp. nov.*

Differential diagnosis.—*S. exsul* is the only species of *Sebastomus* known to occur in (and be endemic to) the Gulf of California.

S. exsul resembles *S. rosenblatti* and *S. eos* in having green vermieulations on a pink body, but its vermieulations are much finer and denser. It also has more gill-rakers (32–37 on first arch in *S. exsul*, 26–30 in *S. eos*, and 29–34 in *S. rosenblatti*). Its dorsal spines are also much too short for typical specimens of *S. rosenblatti* and *S. eos* (orbit length in fourth dorsal spine usually less than 1.2).

Description.—D. XIII, 12–13; A. III, 6 (5–6); P_1 17 (16–18); rakers on first gill-arch 32–37 (9–12 + 21–25); lateral-line pores 35–43.

Concavity of interorbital and elevation of cranial ridges and spines moderately strong for a species of *Sebastomus*. Nuchal and coronal spines absent; spines on lower edge of gill-cover more often absent than present; lachrymal projections sharp-tipped, forming definite spines in extreme cases.

Symphyseal knob round, little projecting; jaws subequal; maxillary reaching to vertical from posterior edge of pupil, or farther. Head 2.2–2.4 and snout 8.7–11.4 in standard length. Orbit length 7.2–8.2 in standard length, 0.95–1.17 in length of fourth dorsal spine. Interorbital broad for a species of *Sebastomus* (lachrymal width 1.9–2.4 in interorbital). Body depth 2.4–2.8, predorsal length 2.5–2.8, and prepelvic length 2.1–2.5 in standard length. Caudal-peduncle depth 9.5–11.2 in standard length, 4.0–4.7 in head. First anal soft-ray 2.0–2.2 in head. Membrane of spinous dorsal moderately incised (free distal part of fourth spine 1.6–2.0 in spine length); fourth dorsal spine 1.2–1.4 in second anal spine, which generally does not reach to tips of anal soft-rays. Raker at angle of first gill-arch 3.3–5.5 in second anal spine. Rakers moderately long, rarely rudimentary or spinulated.

Pectoral fin 1.4–1.6 and pelvic 1.7–2.0 in head. Upper jaw 1.0–1.2 in pelvic. Base of spinous part of dorsal 2.5–2.9, base of soft-rayed part of dorsal 4.5–4.9, and base of anal 6.7–8.1 in standard length.

Mandibles, maxillaries, and branchiostegals all finely scaled.

Color in life pink, white ventrally. Fine green vermieulations above lateral line, on top of head, and along basal part of dorsal fin. Fins pink, like body, but with trace of greenish-yellow on membranes. Scales on body sometimes with light greenish-yellow margins. Gill-cavity and mouth linings whitish, with traces of pink and dusky. Peritoneum blackish.

In preserved condition, vermiculations become black, body otherwise colorless.

Range.—*S. exsul* is known only from the Gulf of California in the vicinity of Bahia de los Angeles (about 29°N).

Size.—The largest specimen of this species examined measures 212 mm.

Depth.—The specimens of *S. exsul* examined were taken between 110 and 200 m.

Derivation of name.—From the Latin *exsul*, an exile, in reference to the geographic isolation of the species.

Material examined.—A total of 15 specimens from 150 mm to 212 mm.

Holotype: SIO 68–1, 171 mm, adult female, from Bahia de los Angeles, Gulf of California, 2 1/2 miles north of Punta Roja, 28°59'N, 113°25.5'W, collected by hook and line from the bottom at depth 110 m, by H. Geoffrey Moser on 3 December, 1967.

Paratypes: All from vicinity of the Bahia de los Angeles. SIO 62–241, 7 (158–212); SIO 68–3, 7 (150–202).

Sebastes chlorostictus (Jordan and Gilbert, 1880)

Sebastichthys chlorostictus (Jordan and Gilbert, 1880*b*: 294–295 (type locality: Monterey). Jordan and Gilbert, 1881*a*: 455 (distribution). Jordan and Gilbert, 1881*b*.' 57 (distribution, size). Bean, 1882: 316 (reference to type description). Jordan, 1884: 264 (distribution). Jordan, 1887: 896 (name only). Goode, 1888: 265 (habit, size, distribution). Eigenmann and Eigenmann, 1889*a*: 465 (San Diego). Eigenmann and Eigenmann, 1889*b*: 129 (color). Collins, 1892: 120 (San Francisco). Goode, 1903: 265 (habit, size, distribution). Jordan, 1905: 430 (color). Jordan, 1925: 641 (color).

Sebastodes chlorostictits, Jordan and Gilbert, 1882*b*: 668 (description, size, range). Eigenmann, 1892: 165 (San Diego). Eigenmann and Eigenmann, 1892: 355 (range). Rathbun, 1894: 176, 187, 192 (Monterey, Santa Barbara Is., Cortez Bank). Cramer, 1895: 599, pls. 63 and 69 (species analysis, skull drawings). Gilbert, 1896: 468 (compared with *S. eos*). Jordan and Evermann, 1896: 431 (range). Jordan and Evermann, 1898: 1811–1812 (species analysis, description, size, range). Gilbert, 1899: 26 (Monterey, 68 fathoms). Gill, 1903: Ixvii (name only). Starks and Morris, 1907: 212 (range, size, color). Ulrey and Greeley, 1928: 37 (range). Ulrey, 1928: 8 (name only). Walford, 1931: 123, fig. 98 (color, range, size). Wales, 1932: 168 (Ranger Bank). Phillips, 1935: 148 (Monterey). Barnhart, 1936: 45–60, 155, fig. 184 (key, description, range, size). Phillips, 1939: 217 (Monterey). Roedel, 1948: 102, fig. 73 (characters, size, range). Clothier, 1950: 66, pl. 17 (axial skeleton, vertebral number). Roedel, 1953: 130, fig. 125 (characters, range, size). Cannon, 1953: 274 (fig., range, characters). Berdegue, 1956: 157 (name only). Phillips, 1957: 120–121, fig. 49 (key, description, range, depth, size). Miller, 1959: 20 (fig., range, characters). Bailey et al., 1960: 38 (common name). Roedel, 1962: 30 (name only). Hoover, 1964: 73–74 (47°11'N, 124°55'W). Gotshall, 1964: 253–260, fig. 4 (tagging technique, skull photo). Miller, Gotshall, and Nitsos, 1965: 26–27 (fig., characters, range, size, depth). Hitz, 1965: 54 (fig., characters, range, depth, size). Barrett, Joseph, and Moser, 1966: 489–494 (hemoglobin electro-phoresis). Moser, 1967: 790–791, fig. 16 (larvae).

Sebastomus chlorostictus, Eigenmann and Beeson, 1893: 670 (relationships). Eigenmann and Beeson, 1894: 396 (species analysis, synonymy). Eigenmann, 1894: 402 (range, depth). Jordan, Evermann, and Clark, 1930: 367 (name only).

Differential diagnosis.—*S. chlorostictus* differs from all other congeners in having deep olive-green round spots on the upper part of the pink body, these most conspicuous on top of the head.

This species resembles *S. rosenblatti* and *S. eos* but differs in having the mandibles usually naked, and more distinct and spotlike rather than vermiculated green marks, as well as in the higher number of gill-rakers (31–36 on first arch in *S. chlorostictus*, 29–34 in *S. rosenblatti*, and 26–30 in *S. eos*).

Description.—D. XIII, 12–13 (11–15); A. III, 6 (5–7); P_1 17 (16–18); rakers on first gill-arch 31–36 (9–11 + 21–25); lateral-line pores 35–43; pyloric caeca 10–12 (10–13).

Concavity of interorbital and elevation of cranial ridges and spines strong for a species of *Sebastomus*. Nuchal spines generally absent; coronal spines absent; spines on lower edge of gill-cover always present; lachrymal projections sharp-tipped, forming definite spines in extreme cases.

Symphyseal knob round, little projecting; jaws subequal. Maxillary reaching to vertical from posterior edge of pupil, or farther. Head 2.3–2.7, generally 2.4–2.5, and snout 8.9–11.6, generally greater than 10.0 in standard length. Orbit length 7.0–10.0 in standard length, 1.2—1.8 in length of fourth dorsal spine. Inter-orbital broad for a species of *Sebastomus* (lachrymal width 1.4–2.0 in interorbital). Body depth 2.5–3.1, predorsal length 2.6–3.0, generally 2.8–2.9, and prepelvic length 2.3–2.7 in standard length. Caudal-peduncle depth 10.1–12.2 in standard length, 4.1–5.0 in head. First anal soft-ray 1.8–2.1 in head. Membrane of spinous dorsal deeply incised (free distal part of fourth spine 1.4—2.2 in spine length). Fourth dorsal spine 1.0–1.3 in second anal spine, which is long, reaching to tips of anal soft-rays in small individuals. Raker at angle of first gill-arch 3.9–6.1 in second anal spine. Rakers slender, never rudimentary or spinulated.

Pectoral fin 1.2–1.6, and pelvic 1.6–2.0, generally 1.7–1.9 in head. Upper jaw 1.0—1.3 in pelvic. Base of spinous part of dorsal 2.4–2.9, base of soft-rayed part of dorsal 4.4–5.6, and base of anal 6.6–8.4 in standard length.

Mandibles generally scaleless; occasionally with patches of very fine scales; maxillaries scaled; branchiostegals scaleless.

Color in life pinkish to orange red, white ventrally; upper part of body and basal part of dorsal with dark olive-green spots that are particularly regular and conspicuous on top of head; spots just above and below lateral line form two continuous series following the course of the lateral line. Fin rays pink, like body. Soft-dorsal membrane greenish; spinous-dorsal membrane pinkish posterior to each spine but greenish anterior to each spine; other fin membranes greenish-yellow or golden. Scales on body with light green margins. Oral lining whitish, with traces of pink and golden. Gill-cavity lining white and golden, with trace of dusky. Peritoneum black, or grayish with fine black dots.

In preserved condition, green spots become dark; body otherwise colorless.

Discussion.—Phillips (1957, 1968) failed to recognize the differences between *S. chlorostictus* and the *S. rosenblatti–S. eos* complex, and suspected that these forms were conspecific. He described the color pattern for all these three species as "pink with green spots and irregular streaks," without distinguishing the spots of *chlorostictus* from the vermiculations of the *rosenblatti-eos* complex. Phillips based his separation of *chlorostictus* from the *rosenblatti-eos* complex on the

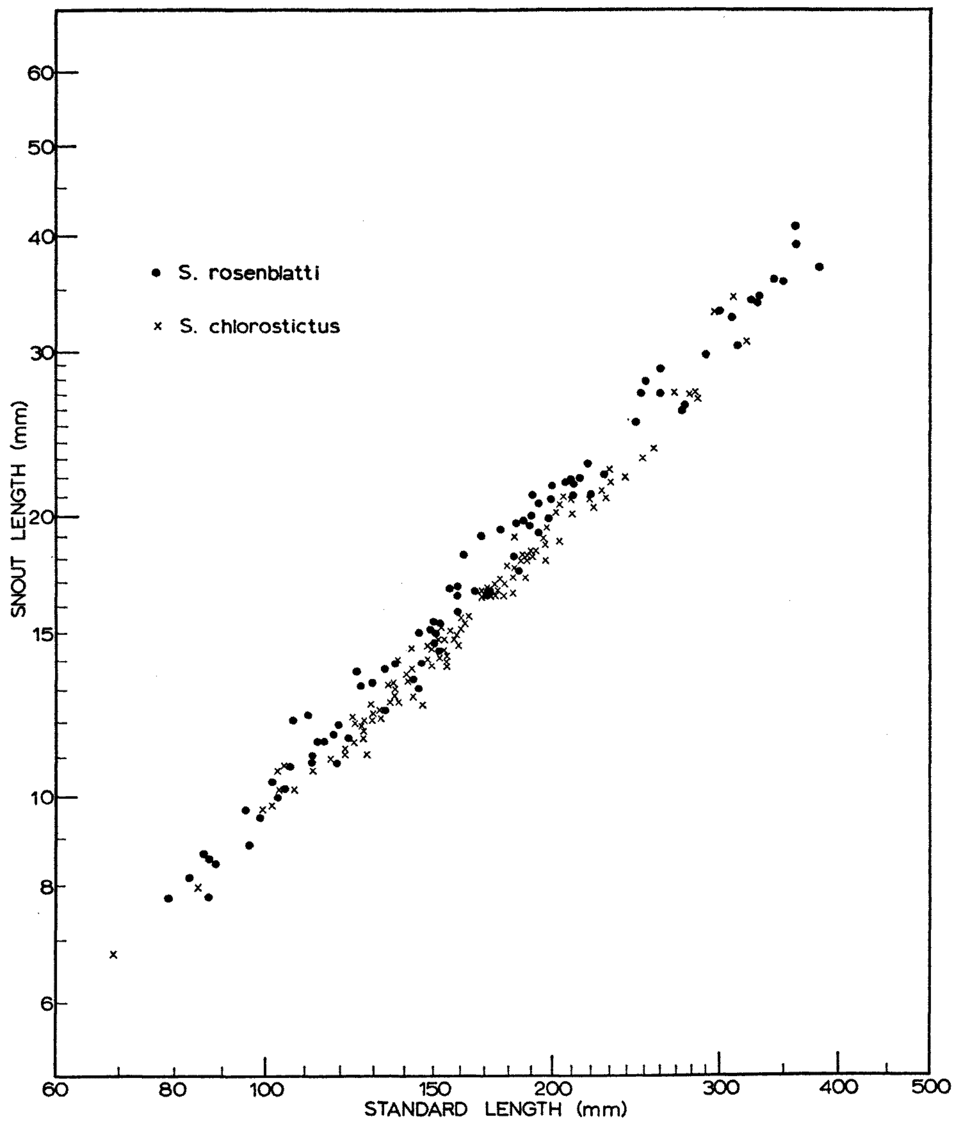

Fig. 4. Relation of snout length to standard length for *S. chlorostictus* and *S. rosenblatti*.

presence or absence of scales on the mandibles but was confused by specimens with partly scaled mandibles. The mandibles of *chlorostictus* are generally naked and, when scaled, the scales are in patches and are fine and smooth, whereas scales on mandibles of the *rosenblatti-eos* complex are rough enough to be felt by rubbing the mandibles with fingers.

Significant differences between *chlorostictus* and the *rosenblatti-eos* complex are also found in several morphometric characters (table 25), including the length of snout (fig. 4), as well as in the number of gill-rakers (table 10), but with considerable overlap.

S. chlorostictus inhabits lesser depths than do *S. rosenblatti* and *S. eos*, and it does not grow to as large a size as those species. Electrophoretically, it has been shown that the hemoglobins of *chlorostictus* and *rosenblatti* differ (Barrett, Joseph, and Moser, 1967).

Range.—Phillips (1957) defined the range of this species as Cedros Island, Baja California, to San Francisco, California. Hoover (1964) secured a specimen from 47°11'N, 124°55'W, thus extending the range northward to Copalis Head, Washington.

Size.—Phillips (1968) gave 20 inches total length [42 cm standard length] as the maximum size for the species. As Phillips apparently did not always correctly distinguish *S. chlorostictus* from *S. eos* [*S. eos* + *S. rosenblatti*], the identification of the 42-cm specimen may be questioned. The greatest length of any *S. chlorostictus* examined in the present study is 347 mm. Moser (1966, p. 488) reported specimens up to 375 mm.

Depth.—This species occurs generally in depths of about 100 m. Material at SIO was taken between 50 and 230 m.

Material examined.—A total of 165 specimens from 69 to 347 mm.

California:

> Lausen Sea Mount: SIO 67–224, 6 (159–249).
>
> La Jolla: SIO 48–100, 1 (311); SIO 48–119, 1 (297); SIO 50–103, 1 (85); SIO 50–139, 2 (69–102); SIO 50–141, 1 (112); SIO 50–144, 1 (105); SIO 64–715, 1 (104); SIO 65–13, 1 (103); SIO 67–8 & 9, 7 (124–220); SIO 67–142, 3 (152–176); SIO 67–143, 1 (169); SIO 67–248, 1 (122); SIO 67–260, 3 (136–138); SIO 67–262, 3 (124–161); SIO 67–263, 1 (164); SIO 67–266, 2 (99–117); SIO 67–295, 1 (182); SIO 68–25, 2 (135–155); SIO 68–392, 1 (321); SIO 69–262, 1 (178).
>
> Additional 86 specimens (107–285) discarded.

Coronado Bank, off San Diego: 4 (69–138) discarded.
Forty-three Fathom Bank, off San Diego: SIO 67–250, 1 (177).
Additional two specimens (225–248) discarded.
Tanner Bank, off San Diego: 6 (263–304) discarded.
Sixty Mile Bank, off San Diego: 1 (347) discarded.
Baja California:

> 32°06.7'N, 117°04.9'W: 8 (222–302) discarded.
>
> Cape Colnett: SIO 64–951, 1 (153).
>
> Guadalupe Island: SIO 57–44, 2 (272–337); SIO 60–25, 1 (248); SIO 65–54, 1 (296); SIO 65–57, 2 (257–295); SIO 65–59, 3 (243–308); SIO 65–63, 2 (306–310); SIO 65–74, 7 (255–322).
>
> Additional four specimens (276–342) discarded.

Sebastes rosenblatti*, sp. nov.*

> *Sebastodes eos* (not Eigenmann and Eigenmann), Phillips, 1957: 122–123 (in part; key, description, range, depth, size). Hitz, 1965: 55 (fig., characters, range, size, depth). Barrett, Joseph, and Moser 1966: 489–494 (hemoglobin electrophoresis). Crozier, 1967: 179–184 (carotenoid and pigment). Moser, 1967: 785–786, 790–791, fig. 16 (larvae).

It is likely that most of the literature records of *S. eos* actually apply to this species, but it is impossible to determine which with certainty.

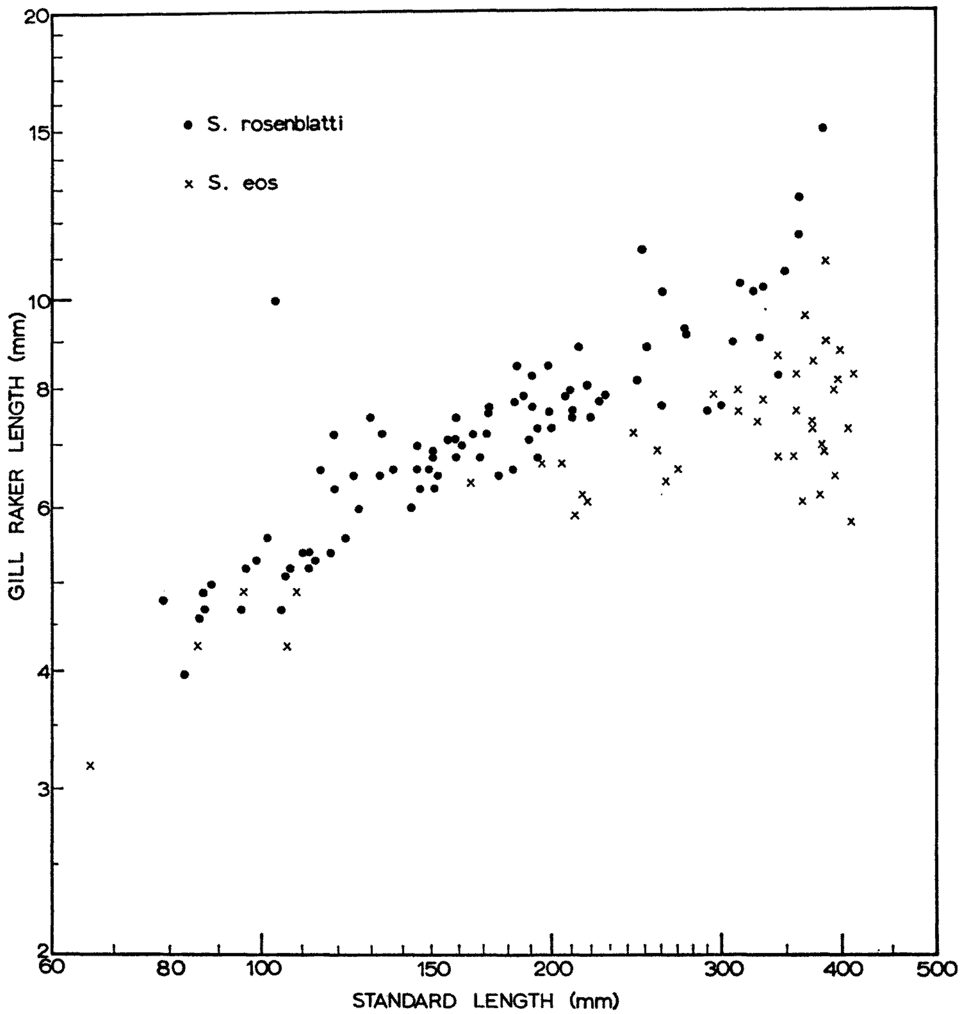

Fig. 5. Relation of gill-raker length to standard length for *S. rosenblatti* and *S. eos*.

Differential diagnosis.—*S. rosenblatti* has a pink body with olive-green vermicu-lations. It resembles *S. eos* most closely. Compared with *S. eos, S. rosenblatti* has longer gill-rakers (fig. 5), which are rarely rudimentary or spinulated (plate 5), 30 or more instead of 30 or fewer rakers on first gill-arch (table 10), usually 17 instead of 18 pectoral rays (table 8), and the spines on lower edge of gill-cover almost always present. The pelvic fin is generally longer in *S. rosenblatti* than in *S. eos* (fig. 6), thus the upper-jaw in pelvic ratio is generally greater than 1.0 in *S. rosenblatti* but less than 1.0 in *S. eos*. Compared with *S. eos, S. rosenblatti* also has a smaller head (fig. 6). *S. rosenblatti* often lacks nuchal spines, which are usually present in *S. eos*.

The color pattern of *S. rosenblatti* somewhat resembles those of *S. lentiginosus*, *S. exsul*, and *S. chlorostictus*. It differs from *S. lentiginosus* in lacking the

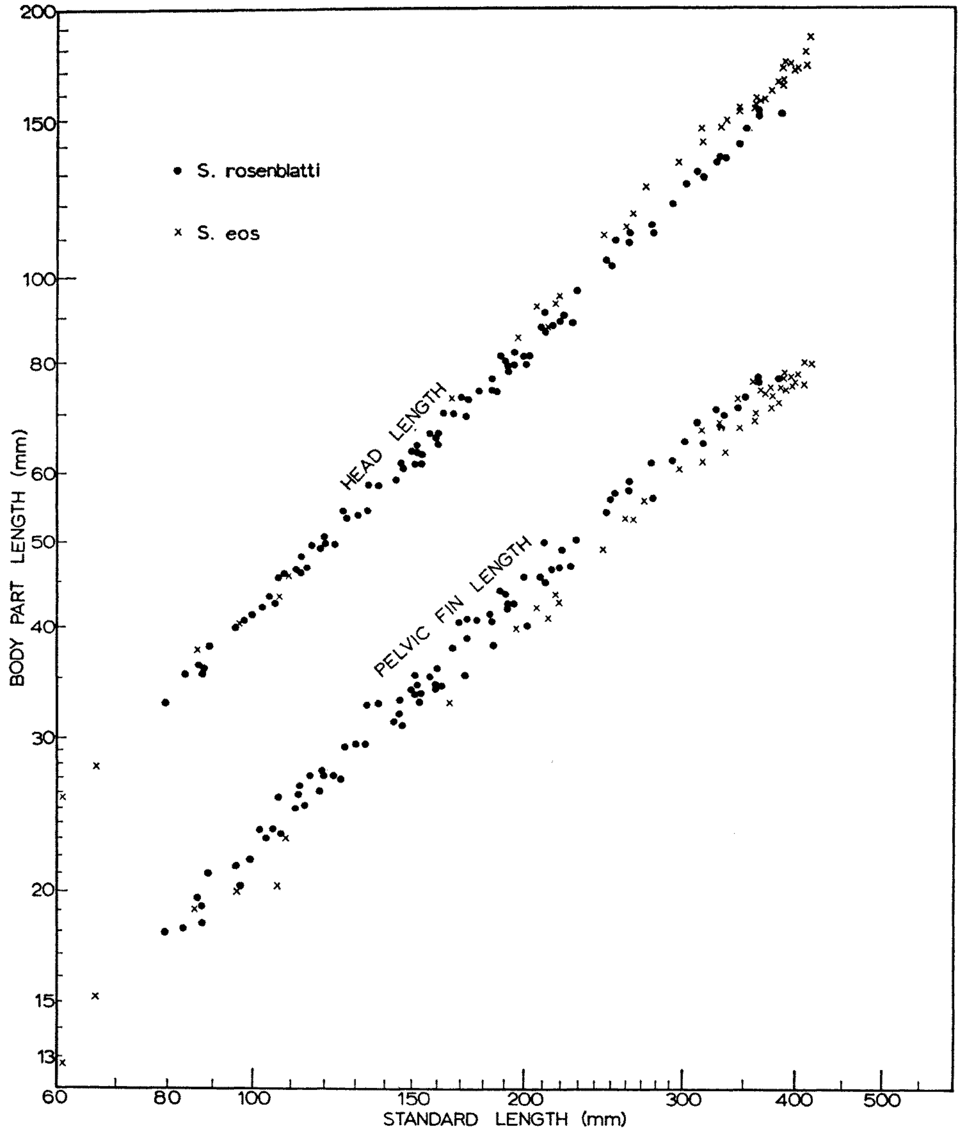

Fig. 6. Relation of head length and of the length of pelvic fin to standard length for *S. rosenblatti* and *S. eos*.

dentigerous knobs and in other respects. It differs from *S. exsul* in having longer dorsal spines (orbit length in fourth dorsal spine usually greater than 1.2); and in that its vermiculations are less fine and dense than in *S. exsul*. It differs from *S. chlorostictus* in having roughly scaled mandibles as well as vermiculations, rather than spotlike green marks.

Description.—D. XIII, 12 (11–13); A. III, 6 (5–6); P_1 17 (16–18); rakers on first gill-arch 29–34 (9–10 + 20–24); lateral-line pores 34–42; pyloric caeca 10–12 (10–15).

Concavity of interorbital and elevation of cranial ridges and spines strong for a species of *Sebastomus*. Nuchal spines more often absent than present; coronal spines absent; spines on edge of gill-cover always present; lachrymal projections sharp, forming definite spines in extreme cases.

Symphyseal knob round, little projecting; jaws subequal. Maxillary often reaching to vertical from posterior edge of orbit. Head 2.3–2.5 and snout 8.0–10.9, generally greater than 9.0 in standard length. Orbit length 7.4–10.8 in standard length, 1.0–2.2 in length of fourth dorsal spine. Interorbital broad for a species of *Sebastomus* (lachrymal width 1.4–2.1 in interorbital). Body depth 2.6–3.1, predorsal length 2.5–3.0, generally 2.7–2.8, and prepelvic length 2.3–2.8 in standard length. Caudal-peduncle depth 9.9–12.8 in standard length, 4.2–5.5 in head. First anal soft-ray 1.8–2.6 in head. Membrane of spinous dorsal deeply incised (free distal part of fourth spine 1.3–2.0 in spine length). Dorsal spines generally long, occasionally short and stout in specimens from Ja Jolla. Fourth dorsal spine 0.7–1.6 in second anal spine, which does not reach to tips of anal softrays. Raker at angle of first gill-arch 3.5–6.8 in second anal spine. Rakers moderately long, never rudimentary or spinulated.

Pectoral fin 1.3–1.8, and pelvic 1.6–2.1, generally 1.8–2.0 in head. Upper jaw 0.91–1.17 in pelvic, generally greater than 1.0. Base of spinous part of dorsal 2.4–3.0, base of soft-rayed part of dorsal 4.5–5.8, and base of anal 6.3–8.7 in standard length.

Mandibles, maxillaries, and branchiostegals covered with rough scales.

Color in life pink, white ventrally. Olive-green vermiculations on upper part of body, on top of head, and on basal part of dorsal; fading in large individuals. Fin rays pink, like body. Dorsal membrane somewhat olive-green; other fin membranes golden-yellow or greenish-yellow. Scales on body sometimes with light greenish-yellow margins. Mouth and gill-cavity linings whitish, with traces of golden and pink. Peritoneum silvery white, grayish, or black.

In preserved condition, vermiculations dark; body otherwise colorless.

Discussion.—This species has been confused with *S. eos* until very recently. It is not distinguishable from *S. eos* in coloration. The separation is based on a combination of morphological differences (see differential diagnosis of the species). Biochemically, *S. rosenblatti* and *S. eos* are different in hemoglobin electrophoretic pattern (Barrett, Joseph, and Moser, 1967: Barrett, personal communication). They differ also in depth distribution. In the vicinity of San Diego in waters shallower than 90 fathoms, only *S. rosenblatti* is taken, below 100 fathoms; however, *S. eos* predominates. Generally both species can be taken together over most of their geographic ranges. At Guadalupe Island, however, where *S. rosenblatti* abounds, and occurs in greater depths than along the mainland, *S. eos* has never been taken (see section on ZOOGEOGRAPHY). These distributional facts provide further indication of the biological distinctiveness of the two forms.

Range.—Phillips (1968) gave the geographic range for his *S. eos* [*S. eos* + *S. rosenblatti*] as Guadalupe Island to Washington but did not give the source of the Washington record. Materials of *S. rosenblatti* used in the present study are from between Avila and Point Mugu (35°10'N to 34°05'N) to Ranger Bank, Baja California (28°33'N).

Size.—Phillips (1968) assigned 22 inches total length [46 cm standard length] as the maximum size for his *S. eos* [*S. eos* + *S. rosenblatti*]. The largest specimen of this species examined in the present study is 405 mm.

Depth.—Material at SIO was taken between 60 and 400 m.

Derivation of name.—Named for Dr. Richard H. Rosenblatt, of Scripps Institution of Oceanography, who first distinguished *S. rosenblatti* from *S. eos* and who discovered *S. lentiginosus*.

Material examined.—A total of 152 specimens from 79 mm to 405 mm.

Holotype: SIO 69–223, 238 mm, adult male, from La Jolla Submarine Canyon, off La Jolla, California, collected by hook and line with squid bait from the bottom at a depth of 110 m, by Lo-chai Chen on 16 March 1969.

Paratypes:

La Jolla: SIO 48–100, 1 (362); SIO 50–103, 9 (105–252); SIO 50–104, 2 (103–112); SIO 50–139, 15 (79–208); SIO 50–140, 6 (99–210); SIO 50–141, 2 (95–200); SIO 50–144, 1 (169); SIO 50–245, 1 (162); SIO 54–198, 1 (191); SIO 56–6, 1 (249); SIO 56–7, 2 (301–345); SIO 64–348, 1 (126); SIO 64–490, 1 (102); SIO 64–715, 4 (133–159); SIO 65–19, 1 (122); SIO 65–85, 1 (363); SIO 66–177, 2 (190–261); SIO 67–8, 2 (151–246); SIO 67–143, 1 (157); SIO 67–226, 1 (351); SIO 67–255, 1 (177); SIO 67–264, 1 (143); SIO 68–392, 1 (201); SIO 68–398, 1 (219).

Guadalupe Island, Baja California: SIO 56–81, 3 (276–299); SIO 57–47, 2 (203–234); SIO 57–48, 1 (339); SIO 58–90, 1 (338); SIO 65–54, 1 (396); SIO 65–56, 2 (374–375); SIO 65–60, 1 (337); SIO 65–62, 3 (251–340); SIO 65–66, 1 (371); SIO 65–74, 1 (386); SIO 67–74, 1 (331).

Ranger Bank, Baja California: SIO 65–194, 7 (286–345); SIO 68–6, 13 (250–377).

Additional material examined:

Avila to Point Mugu, California: CAS 26410, 2 (109–170).

Santa Barbara, California: CAS 26424, 5.

La Jolla, California: 31 specimens (145–384) discarded.

Guadalupe Island, Baja California: 17 specimens (219–405) discarded.

Sebastes eos (Eigenmann and Eigenmann, 1890)

Sebastodes eos, Eigenmann and Eigenmann, 1890: 18–20 (type locality: Point Loma, California). Eigenmann, 1891: 153–156 (compared with *S. gillii*). Eigenmann, 1892: 165 (San Diego). Eigenmann and Eigenmann, 1892: 355 (range). Cramer, 1895: 599 (species analysis). Jordan and Evermann, 1896: 431 (range). Jordan and Evermann, 1898: 1810 (species analysis, description, range, size, depth). Starks and Morris, 1907: 211 (name only). Fowler, 1923: 299 (name only). Ulrey and Greeley, 1928: 37 (range). Ulrey, 1929: 8 (name only). Barn-hart, 1936: 45–60 (key, description, range, size). Roedel, 1953: 130 (characters, size). Cannon, 1953: 276 (fig., range, characters). Phillips, 1957: 122–123 (in part; key, description, range, depth, size). Bailey et al., 1960: 38 (common name). Roedel, 1962: 30 (name only).

Sebastomus eos, Eigenmann and Beeson, 1893: 670 (relationships). Eigenmann and Beeson, 1894: 396 (species analysis, synonymy). Eigenmann, 1894: 402 (range, depth). Jordan, Evermann, and Clark, 1930: 368 (name only).

Many of these records probably apply to *S. rosenblatti*.

Differential diagnosis.—The rudimentary and spinulated condition of the anteriormost 4–7 rakers on each limb of the first gill-arch (plate 5) in this species separates it from all other species of *Sebastomus*, except *S. constellatus*. From that species it differs in having the mandibles scaled and in having green vermiculations instead of white dots on the body.

This species most closely resembles *S. rosenblatti* (see differential diagnosis of *S. rosenblatti*).

Description.—D. XIII, 12 (11–13); A. III, 6 (6–7); P_1 18 (17–18); rakers on first gill-arch 26–31 (8–10 + 18–21); lateral-line pores 34–42; pyloric caeca 9–12.

Concavity of interorbital and elevation of cranial ridges and spines strong for a species of *Sebastomus*. Nuchal spines generally present; coronal spines absent; spines on lower edge of gill-cover generally absent; lachrymal projections sharptipped, forming definite spines in extreme cases.

Symphyseal knob round, little projecting; jaws subequal. Maxillary often reaching to vertical from posterior edge of orbit. Head 2.1–2.4, generally 2.2–2.4, and snout 7.4–9.9 in standard length. Orbit length 8.2–10.5 in standard length, 1.3–1.8 in length of fourth dorsal spine. Interorbital broad for a species of *Sebastomus* (lachrymal width 1.5–1.9 in interorbital). Body depth 2.0–3.0, predorsal length 2.5–2.8, generally 2.6–2.7, and prepelvic length 2.0–2.6 in standard length. Caudal-peduncle depth 10.5–12.0 in standard length, 4.6–5.3 in head. First anal soft-ray 2.2–2.8 in head. Membrane of spinous dorsal deeply incised (free distal part of fourth spine 1.3–1.6 in spine length). Dorsal spine long; fourth spine 0.7–1.1 in second anal spine, which does not reach to tips of anal soft-rays. Raker at angle of first gill-arch 5.1–8.9 in second anal spine. Rakers short; first 4–7 rakers on each limb of first gill-arch rudimentary and spinulated.

Pectoral fin 1.5–1.7 and pelvic 2.0–2.4 in head. Upper jaw 0.90–1.04 in pelvic, generally less than 1.00. Base of spinous part of dorsal 2.4–2.9, base of soft-rayed part of dorsal 4.6–5.7, and base of anal 6.8–8.4 in standard length.

Mandibles, maxillaries, and branchiostegals covered with rough scales.

Color in life pink, white ventrally. Olive-green vermiculations on upper part of body, on top of head, and on basal part of dorsal; fading in large individuals. Fin rays pink, like body. Dorsal membrane somewhat olive-green; other fin membranes golden-yellow or greenish-yellow. Scales on body sometimes with light greenish-yellow margins. Mouth and gill-cavity linings whitish with traces of golden and pink. Peritoneum silvery white, grayish, or black.

In preserved condition, vermiculations dark; body otherwise colorless.

Discussion.—Dr. Carl L. Hubbs (personal communication) has made the following counts on the holotype of *S. eos* (BM 1891.5.19.25): D. XIII, 13; A. III, 6; P_1 18 on each side; gill-rakers on first arch 9 + 20 on the left, 9 + 19 on the right. Mr. Peter J. Whitehead (personal communication) of the British Museum found that the type specimen has both nuchal spines, the anteriormost 3–5 rakers on each limb of the first gill-arch are rudimentary and spinulated, the spines on lower edge of gill-cover are very weakly developed, the upper jaw measures 0.94 in the pelvic, and the pelvic 2.12 in the head. All these characters indicate that the holotype of *S. eos* is conspecific with the material treated here under that name.

Range.—Phillips (1968) gave the geographic range for his *S. eos [S. eos + S. rosenblatti*] as Guadalupe Island to Washington but gave no source of the

Washington record. Material of *S. eos* used in the present study is from Monterey, California, to Bahia Sebastian Vizcaino, Baja California (about 28°N). This species has never been taken at Guadalupe Island.

Size.—Phillips (1968) gave 22 inches total length [46 cm standard length] as the maximum size for his *S. eos [S. eos + S. rosenblatti*]. The largest specimen of this species examined in the present study measures 412 mm.

Depth.—Material at SIO was taken at depths between 130 and 350 m.

Material examined.—A total of 42 specimens from 61 mm to 412 mm.

California:

Monterey: SIO 67–98, 2 (375–394).

La Jolla: SIO 50–243, 3 (244–271); SIO 50–245, 6 (61–165); SIO 50–249, 1 (296); SIO 65–85, 2 (381–383); SIO 67–142, 4 (196–374); SIO 68–398, 4 (359–397); SIO 68–399, 2 (360–409); SIO 68–400, 1 (212).

San Diego: SIO 65–112, 1 (400); UCLA 54–397, 1 (216).

Coronado Bank, off San Diego: SIO 56–5, 1 (333); SIO 65–149, 1 (394).

Cortez Bank, off San Diego: SIO 66–543, 2 (366–386).

Baja California:

Coronado Islands: SIO 62–513, 4 (258–407).

Cape Colnett: SIO 60–63, 2 (313–412); SIO 64–946, 2 (328–344); SIO 64–947, 1 (359).

Off San Quintin: SIO 62–522, 1 (314).

Bahia Sebastian Vizcaino: SIO 60–384, 1 (206).

Sebastes capensis (Gmelin, 1829)

The difficulties in the taxonomy of *Sebastes* are well accentuated by the problem of distinguishing and defining the forms that occur in the southern hemisphere. To this date 11 nominal species have been described from there, all referable to the subgenus *Sebastomus*. Meristics of these forms are all quite similar, and systematic separations have generally been based on minor morphometric differences that may well largely be within the limits of individual variation.

Following is a list of the nominal species so far described:

Scorpaena capensis Gmelin, 1829

Sebastes oculatus Cuvier, 1833

Sebastes ocellatus Valenciennes, 1839

Sebastodes darwini Cramer, 1896

Sebastodes chilensis Steindachner, 1898

Sebastodes jenynsi Abbott, 1899

Sebastes macrophthalnus Philippi, 1899

Sebastichthys chamaco Evermann and Radcliffe, 1917

Sebastodes prognathus Tortonese, 1942

Sebastodes unimaculatus de Buen, 1960

Sebastodes hernandezi de Buen, 1960

These forms are known from Callao (12°S), Peru, to the tip of South America, at Tristan da Cunha, and in South Africa. Phillipps (1927) described *Sebastodes maccullochi* from New Zealand but the species was later (Hubbs, 1950) referred to *Helicolenus*.

Similarities among these nominal forms have led to the query whether some or all may be conspecific (Norman, 1937). However, these forms have been based on limited study of a few scattered museum specimens. The latest study on the Chilean species referred to *Sebastodes* was that of de Buen (1960), who excluded *S. capensis* and *S. chamaco* from his study, and on the basis of only 14 specimens, accepted Tortonese's *S. prognathus*, described *S. unimaculatus* and *S. hernandezi* as new, and lumped the rest of the species into three subspecies of *S. oculatus*, with the following approximate ranges:

S. o. darwini, 18 to 30°S;

S. o. oculatus, 30 to 33°S; and

S. o. chilensis, 37 to 53°S.

Further studies of the southern hemisphere species are undoubtedly needed. I have examined specimens from Callao, Peru; Montemar, Chile; Tristan da Cunha; and Cape Town, South Africa; and all are very similar. The South American specimens in isopropyl alcohol are all black, suggesting a rather dark color in life. The Tristan da Cunha and Cape Town specimens are all light brown, but the light color is likely due to preservation, as the African form has been illustrated by Smith (1953) as being dark dorsally and red ventrally. The only difference found between South American specimens and those from Tristan da Cunha and Africa is that in the former the maxillaries are scaleless rather than being partly scaled. The significance of this difference is questionable, because de Buen reported that some of the specimens that he referred to *S. oculatus* have scaled maxillaries. All the South American specimens at hand key out to *S. oculatus*, as distinguished by de Buen. However, the specimen from Callao (12°S) fits de Buen's *S. o. chilensis*, which he thought to occur from 37 to 53°S, and the specimens from Montemar (33°S) combine the characters of *S. o. oculatus* (30–33°S) and *S. o. darwini* (18–30°S) of de Buen. I, therefore, question the validity of de Buen's subspecies. Pending further studies, it seems best to consider all these forms as conspecific and to refer them to *S. capensis.*

In the following description, meristic data from de Buen's work are included.

Description.—D. XIII, 13 (12–14); A. III, 6; P_1 18 (18–20); rakers on first gill-arch 27–32 (8–10 + 19–23); lateral-line pores 36–45.

Interorbital strongly concave; cranial ridges and spines very well developed, but stout and blunt for a species of *Sebastomus*. Nuchal spines rarely present; coronal spines absent; spines on lower edge of gill-cover absent; lachrymal projections blunt.

Symphyseal knob round, little projecting; jaws subequal. Maxillary reaching to vertical from posterior edge of orbit. Head 2.4–2.5 and snout 8.0–10.3 in standard length. Orbit length 8.3–10.4 in standard length, 1.0–1.7 in length of fourth dorsal spine. Interorbital moderately wide (lachrymal width 1.3–1.7 in interorbital). Body depth 2.6–3.0, predorsal length 2.6–2.9, and prepelvic length 2.3–2.6 in standard length. Caudal-peduncle depth 9.3–10.7 in standard length, 3.9–4.7 in head. First anal soft-ray 1.9–2.3 in head. Membrane of spinous dorsal moderately incised (free distal part of fourth spine 1.7–3.0 in spine length). Fin spines generally rather short; fourth dorsal spine 1.0–1.5 in second anal spine, which never reaches to tips of anal soft-rays. Raker at angle of first gillarch 3.5–5.8 in second anal spine. Rakers moderately long, rarely rudimentary or spinulated.

Pectoral fin 1.3–1.5 and pelvic 1.7–1.9 in head. Upper jaw 1.1–1.2 in pelvic. Base of spinous part of dorsal 2.3–3.0, base of soft-rayed part of dorsal 4.2–5.3, and base of anal 6.6–7.9 in standard length.

Mandibles scaleless; maxillaries scaleless or scaled; branchiostegals scaleless.

Color in life (Smith, 1953; de Buen, 1960) rather dark above and red ventrally; with white blotches characteristic of species of *Sebastomus*.

Color in alcohol generally dark.

These forms may reach a total length of 400 mm [330 mm in standard length] (Norman, 1937).

Material examined.—A total of 13 specimens from 114 mm to 273 mm.

Callao, Peru: SIO 65–617, 1 (114).

Montemar, Chile: SIO 66–65, 7 (177–228).

Tristan da Cunha: SIO 69–147, 3 (139–215).

Cape Town, South Africa: SIO 57–34, 1 (273); SIO 69–148, 1 (232).

RELATIONSHIPS

Sebastomus appears to be one of the most compact groups within the genus *Sebastes*. Within the group, however, species show varying degrees of similarity, indicating that certain species may have closer affinity than others. The affinities are inferred from the color patterns and the body configuration, as well as from the meristic counts.

S. constellatus itself represents a relatively independent lineage, with white dots covering the red body, a very narrow interorbital, a long and pointed head, a short tail, and rather few gill-rakers (fewer than 30), a number of which are often rudimentary. *S. capensis* represents another lineage, with a predominantly dark body, well-developed but dull cranial spines, and about 30 gill-rakers.

S. rosaceus, S. helvomaculatus, and *S. simulator* form another subgroup, showing interesting relationships. *S. rosaceus* and *S. simulator* are southern species. Although there is no question that they are closely related, they differ from each other in a number of ways. *S. helvomaculatus* occurs predominantly in the north. In a number of characters it is intermediate between *rosaceus* and *simulator.* Compared with *rosaceus, simulator* has a broader and more concave interorbital, very high cranial ridges and spines, a slender caudal peduncle, long anal soft-rays, large eyes, longer gill-rakers, shorter pelvic fins, and a low lateral-line pore count (total number in average about 72). Its color is uniformly red. In contrast, *rosaceus* has a rather narrow and less concave interorbital, very low cranial ridges and spines, a stouter caudal peduncle, shorter anal soft-rays, smaller eyes, shorter gill-rakers, longer pelvic fins, and a higher lateral-line pore count (total number in average about 82). The upper part of its body has irregular patches of deep purple. *S. helvomaculatus* resembles *S. simulator* in having more concave interorbital and very high cranial ridges and spines. It resembles *rosaceus* in its very narrow interorbital. In caudal-peduncle depth, anal soft-ray length, orbit length, gill-raker length, pelvic length, and lateral-line pore counts, however, it is intermediate between *rosaceus* and *simulator.* Its body is generally greenish-yellow but one of the specimens examined was found to have patches of light purple on the back, somewhat like those of *rosaceus*. All three species have about 30 gillrakers.

Species of the *constellatus, capensis*, and *rosaceus* subgroups all tend to have their mandibles naked or with only patches of scales. With the exception of *chlorostictus*, all species of the following subgroups have the mandible scaled. One of the subgroups is represented by the *ensifer-notius* pair. Both *ensifer* and *notius* have slightly projecting lower jaws, often with their symphyseal knobs pointing downward and forward, a rather slender body, broad interorbital, rather low dorsal spines, and numerous slender gill-rakers (36–38 in average). All the above-mentioned species tend to have 13 dorsal soft-rays instead of 12, as is true of the remaining species. The six remaining species are *umbrosus, lentiginosus, exsul, chlorostictus, rosenblatti*, and *eos*. These species all tend, to some degree, to have a ring of pigment around margins of their scales, particularly conspicuous in *umbrosus*. *S*. umbrosus usually has dusky olive-green marks on the back. When, occasionally, the dusky marks break up, they appear to be somewhat frecklelike. All the other five species have, on their backs, conspicuous olive-green marks in the form of vermiculations, freeklings, or round spots. Of these six species, *umbrosus, lentiginosus*, and *exsul* are all small, generally not much larger than 20 cm. Their dorsal spines are not exceedingly long and the spinous-dorsal membrane is moderately incised. Their gill-rakers are rather slender and numerous (34–37 in average). *S, chlorostictus, S. rosenblatti*, and *S. eos* form a species complex. All three are large species, attaining 40 cm and generally not maturing smaller than 20 cm. Their dorsal spines are very long, and the spinous-dorsal membrane is deeply incised. Their gill-rakers grade from very few in *eos* (fewer than 30) to an average of 33 in *chlorostictus*. Paralleling the situation in which *S. helvomaculatus* is intermediate between *rosaceus and simulator, rosenblatti* is intermediate between *chlorostictus* and *eos*. This intermediacy is indicated in the frequent occurrence of nuchal spines, the number of gill-rakers on the first arch, the length of the upper jaw, the length of the pelvic fin, the length of the second anal spine, the snout length, the predorsal length, the head length, and the interorbital width, as well as in the specific depth preferences. Unlike the distributional pattern in the *rosaceus-helvomaculatus-simulator* group, however, *rosenblatti* appears to be sympatric over most of its range with both *chlorostictus* and *eos*, all three being common to the south.

Table 2 compares species subgroups of the subgenus *Sebastomus*. Tables 3, 4, 5, and 6 each compares species of a subgroup. Relationships between species are diagrammatically summarized in figure 7.

VARIATION

Although the biological species concept is widely accepted by present-day taxonomists, in actual practice morphological discontinuity is the main basis for species separation. Because they are used as indicators for genotypic discontinuity, taxonomic characters must be carefully chosen, and the study of their variation is thus essential.

Members of the genus *Sebastes* are very similar. Species separations generally involve minor differences in body configuration, coloration, and meristic and morphometric combinations. As processes determining meristic or morphometric characters in fishes are generally sensitive to environmental changes, knowledge of the variability of such characters is of critical importance.

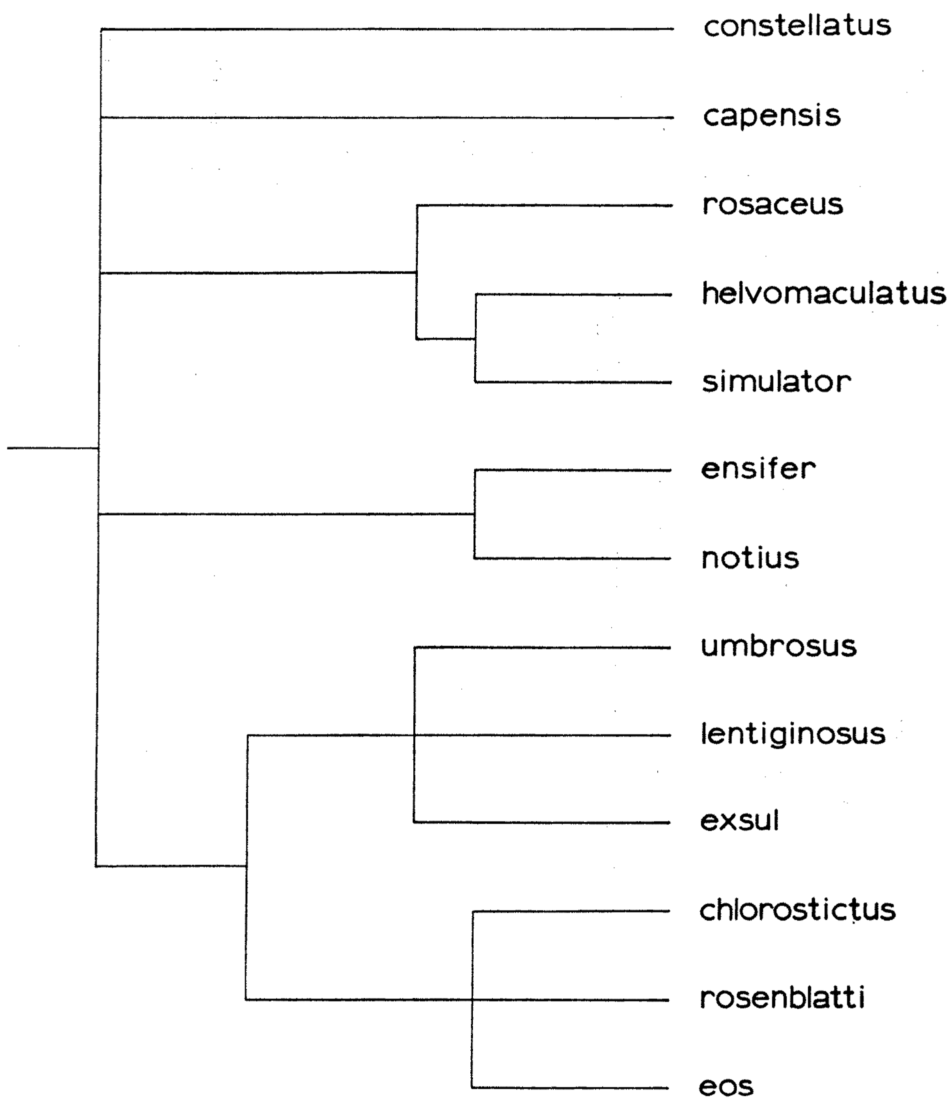

Fig. 7. Relationships of Sebastomus species.

MEEISTIC VARIATION

In the original and strict sense, meristic characters are countable structures, the numbers of which are related to body segmentation. In general usage, however, the term has come to refer to whatever is countable.

ONTOGENETIC VARIATION

Although meristic characters in fishes are generally fixed early in life, ontogenetic meristic changes have been reported frequently. In the rainbow trout, *Salmo gairdnerii*, the number of pyloric caeca increase rapidly in fry between 21 and 30 mm from 10–20 to 40–60 but with little further increase afterward (Northcote,

TABLE 2 COMPABISON OF SPECIES SUBGROUPS OF SUBGENUS *Sebastomus*

	constellatus	capensis	rosaceus helvomaculatus simulator	ensifer notius	umbrosus lentiginosus exsul	chlorostictus rosenblatti eos
Total gill-rakers	52–60	54–84	56–68	69–79	63–78	53–71
Rakers on each limb of first arch	first 4–7 rudimentary, spinulated, and in large fish, often fused	rarely rudimentary, spinulatedt never fused	rarely rudimentary, spinulated, never fused	never rudimentary, spinulated, or fused	never rudimentary, spinulated, or fused	sometimes rudimentary, spinulated, never fused
Dorsal soft-rays	generally 13	generally 13	generally 13	more often 13 than 12	12 or 13	generally 12
Jaws	subequal	subequal	subequal	lower jaw projecting	subequal	subequal
Symphyseal knob	round, little projecting	round, little projecting	round, little projecting	generally projecting downward and forward	round or projecting downward	round, little projecting
Mandibles	generally naked	generally naked	naked or with patches of fine scales	finely scaled	finely scaled	scaled or not
Cranial ridges and spines	strong	strong but stout and blunt	weak to very strong	rather weak	moderately strong	strong
Interorbital concavity	strong	strong	moderate to strong	moderate	moderate to strong	strong
Lachrymal width in interorbital	1.0–1.5	1.3–1.7	1.2–2.4	1.9–2.7	1.7–2.5	1.4–2.1
Gill-raker at angle in 2nd anal spine	7.0–10.5	3.6–5.8	3.2–7.2	2.4–6.0	3.2–5.6	3.2–8.8
Free part of 4th dorsal spine in spine length	1.5–2.4	1.7–3.0	1.6–2. 6 generally > 1.8	1. 7–2.1	1.6–2. 5 generally 1.8–2.2	1.2–2.2 generally 1.3–1.8
4th dorsal spine in 2nd anal spine	1.0–1.5	1.0–1.5	1.0–1.6	1.3–2.0	0.9–1.5	0.8–1.7 generally < 1.3
Color	red, with white dots, back dusky	dark red	plain red or with purple or green marks	mottled or vermiculated with red	back dusky or with green marks	with green spots or vermiculations
Scale margins	colored as scales	colored as scales	colored as scales	colored as scales	dark or light greenish-yellow	light greenish-yellow
Size	34cm	33 cm	30cm	22cm	23cm	40cm

TABLE 3 COMPARISON OF SPECIES OF THE Rosaeeus SUBGROUT

	rosaceus	helvomacvlatus	si’mulotor
Total pectoral rays	34, rarely 32	32, rarely 34	34, rarely 32
Cranial ridges and spines	relatively weak	very high and sharp	very high and sharp
Interorbital concavity	moderate	strong	strong
Lachrymal width in interorbital	1.3–1.9, generally < 1.6	1.3–1.9, generally < 1.8	1.8–2.5
Caudal-peduncle depth in standard length	8.9–11.4, generally < 10.5	9.8–12.4, generally > 10.5	10.6–12.4, generally > 11.0
First anal soft-ray in head	1.8–2.2, generally <2.1	1.8–2.5, generally < 2.2	2.1–2.8, generally > 2.2
Orbit length in longest dorsal soft-ray	1.0–1.6, generally 1.3–1.4	1.0–1.4, generally 1.2–1.3	1.0–1.2
Spines on lower edge of gill-cover	more often present than absent	more often absent than present	more often absent than present
Ground color	orange-red; trace of greenish-yellow	greenish-yellow mixed with pink	plain red
Dark markings	irregular patches of deep purple; band of purple across nape	upper part sometimes with olive-green	plain red
Standard length	not much greater than 20 cm	may reach 30 cm	generally less than 26cm

TABLE 4 COMPARISON OF *S. ensifer* AND *S. notius*

	ensifer	notisu
Total pectoral rays	generally 34	36
Orbit length in standard length	6.7–8.3	8.5–8.7
Head in standard length	2.4–2.7	2.3–2.4
Raker at angle of first gill-arch in second anal spine	3.6–5.0	2.4–3.5
Color	red, back mottled with red or purple of deeper hue, interlaced with greenish-yellow	dull yellow to orange with conspicuous red vermiculations in life, becoming generally red and vermiculations less conspicuous after death
Dorsal and pectoral membranes	clear	with trace of dark
Size	less than 20 cm	22cm

TABLE 5 COMPARISON OF SPECIES OF THE *Umbrosus* SUBGROUP

	umbrosus	lentiginosus	exsul
Total gill-rakers	66–74	69–78	63–73
Caudal-peduncle depth in head	3.6–4.6, generally < 4.4	4.3–5.0, generally > 4.4	4.0–4.7
Orbit length in fourth dorsal spine	1.22–1.70, generally >1.30	1.13–1.46	0.95–1.17
Dentigerous knobs	absent	present	absent
Ground color	pinkish-yellow to light orange	pink	pink
Dark markings	back dusky	dark olive-green frecklings on back and on top of head	fine olive-green vermiculations on back and on top of head
Scale margins	dark	dark	ligh greenish-yellow

TABLE 6 COMPARISON OF SPECIES OF THE *Chlorostictus* SUBGROUP

	chlorostictus	rosenblatti	eos
Mandibles	scaleless or with some pathes of fine scales	covered with rough scales	covered with rough scales
Gill-rakers on each limb	never rudimentary or spinulated	never rudimentary or spinulated	first 4–7 rudimentary and spinulated
Total gill-rakers	62–71	58–67, generally more than 60	53–61, generally less than 60
Total pectoral rays	34, rarely 33, or 32	34, rarely 36	36, rarely 34
Upper jaw in pelvic	1.02–1.27	0.91–1.17, generally > 1.0	0.90–1.04, generally < 1.0
Pelvic length in head	1. 6–2.0, generally 1.7–1.9	1.6–2.1, generally 1.8–2.0	2.0–2.4
Snout in standard length	8.9–11.6, generally > 10.0	8.0–10.9, generally > 9.0	7.4–9.9
Predorsal length in standard length	2.6–3.0, generally 2.8–2.9	2.5–3.0, generally 2.7–2.8	2.5–2.8, generally 2.6–2.7
Head in standard length	2.3–2.7, generally 2.4–2.5	2.3–2.5	2.1–2.5, geenerally 2.2–2.4
Nuchal spines	generally absent	more often absent than present	generally present
Spines on lower ede of gill-cover	present	generally present	absent
Olive-green marks	round spots, most conspicuous on top of head		

TABLE 7 MEASUREMENTS AND COUNTS OF THE TYPE SPECIMENS

	S. rhodo-chloris USMN 26967	*S. simulator* SIO 68–137	*S. ensifer* SIO 67–295	*S, notius* SIO 67–75	*S. lenti-ginosus* SIO 65–6	*S.ezsul* SIO 68–1	*S. rosen-blatti* SIO 69–223
Standard length	189.2	216	190.2	219	190.0	170.8	238
Second anal spine	40.4	36.3	37.6	36.2	37.6	30.8	38.0
Gill-raker at angle	6.8	9.8	7.2	15.4	9.5	6.8	7.5
Third anal spine	32.2	30.0	29.3	30.7	29.1	25.6	30.1
Longest dorsal soft-ray	27.9	32.0	27.6	30.3	29.4	26.7	36.2
First anal spine	18.0	17.8	19.1	20.0	18.2	14.9	18.3
Orbit length	25.1	28.9	25.0	25.1	22.5	21.6	24.5
Total length	228	256	232	271	233	207.6	284
Fourth dorsal spine	29.2	28.4	24.6	29.2	31.2	23.5	36.9
First anal soft-ray	35.8	41.9	35.2	40.7	33.6	35.0	45.6
Anal-fin base	28.1	27.2	25.2	30.4	26.8	22.4	33.6
Pelvic-fin length	41.6	45.8	37.4	46.1	42.3	40.0	49.8
Predorsal length	71.4	77.0	65.4	77.3	68.8	64.8	85.3
Pectoral-fin length	57.8	61.1	55.2	62.7	55.3	50.0	64.2
Lower peduncle length	37.3	43.1	38.1	46.1	35.9	32.2	48.0
Soft-dorsal base	41.2	43.3	40.9	47.7	38.3	36.9	48.5
Dorsal-fin incision	13.5	16.1	13.4	16.6	17.6	11.6	23.7
Caudal-peduncle depth	18.0	18.1	15.9	19.4	17.5	16.8	23.0
Upper peduncle length	25.0	29.0	28.0	30.0	27.7	22.1	32.8
Spinous-dorsal base	72.4	76.0	63.9	78.3	74.6	64.4	91.7
Snout length	18.4	19.7	15.4	19.9	16.3	16.4	23.9
Prepelvic length	77.1	91.0	73.5	86.4	77.0	70.2	94.2
Head length	78.3	94.0	73.1	90.7	77.3	73.3	95.2
Upper-jaw length	37.5	44.6	33.8	41.1	34.7	34.8	48.6
Preanal length	130.6	153.2	130.7	147.0	138.9	122.5	164.5
Body depth	66.5	76.9	59.1	72.4	69.4	66.5	88.3
Head width	36.3	42.9	30.9	36.5	35.8	35.7	52.8
Lachrymal width	5.7	7.0	4.9	6.7	6.7	5.6	9.0
Interorbital width	8.9	14.2	11.9	16.3	12.1	10.9	15.9
Lateral-line pores*	39–41	36–37	34–36	36–37	38–38	36–38	37–40
Dorsal soft-rays	14	13	14	13	12	12	12
Pectoral rays*	16–16	17–17	17–18	18–18	16–17	17–17	17–17
Anal soft-rays	6	6	6	6	6	6	6
Gill-rakers*	30–30	31–31	35–36	37–38	37–35	32–31	31–31

* Left—right.

1960). In *Alosa sapidissima* the number of rakers on the lower limb of the first gill-arch increases from 26–31 in fish of 35–70 mm long to 34–41 in fish of 110–180 mm long and to 62–76 in fish of 413–580 mm long (Hildebrand and Schroeder, 1928, p. 93). In all four western North Atlantic species of *Seriola: S. dumerili, S. rivoliana, S. fasciata*, and *S. zonata*, the number of rakers on the first gill-arch tends to increase with increasing fish size up to about 5 cm and then to decrease with further growth (personal unpublished data). Extreme cases of ontogenetic change in gill-raker number have been found in species of *Opisthonema* in which

TABLE 8 TOTAL PECTORAL RATS[a] OF *Sebastomus* SPECIES[b]

		31	32	33	34	35	36	37	N	Mean	Confidence limit[c]
S. constellatus											
La Jolla	33°N, 117°W	..	3	3	46	1	..	..	53	33.85	33.70–34.00
Tanner Bank	33°N, 119°W	..	..	4	60	5	..	..	69	34.01	33.93–34.10
Guadalupe Is	29°N, 118°W	..	..	1	15	1	..	..	17	34.06	33.73–34.35
Thetis Bank	25°N, 113°W	..	..	..	..	..	1	..	1	36.00	..
Total	..	..	3	8	121	6	2	..	140	33.97	33.89–34.05
S. capensis	..	..	..	..	..	..	..	..	..	..	..
Callao, Peru	12°S	..	..	..	..	..	1	..	1	36.00	..
Montemar, Chile	33°S	..	..	..	1	1	6	..	7	35.86	..
Tristan da Cunha	37°S	..	..	..	..	1	1	1	3	36.00	..
Cape Town, Africa	35°S	..	..	..	..	..	2	..	2	36.00	..
Total	..	..	..	..	..	2	10	1	13	35.92	35.62–36.22
S. ensifer											
Total	..	..	1	2	34	4	1	..	42	34.05	33.87–34.23
S. notius	..	..	..	..	..	..	..	..	..	..	..
Total	..	..	..	..	..	..	3	..	3	36.00	..
S. umbrosus											
La Jolla	33°N, 117°W	1	4	12	76	3	..	..	96	33.79	33.69–33.90
Tanner Bank	33°N, 119°W	..	1	3	34	..	..	..	38	33.87	33.75–33.98
Guadalupe Is	29°N	..	..	..	5	..	..	..	5	34.00	..
Total	..	1	5	15	115	3	..	..	139	33.82	33.73–33.91
S. lentiginosus											
Total	..	..	..	5	15	1	1	..	22	33.91	33.61–34.21
S. exsul											
Total	..	..	..	1	12	2	..	..	15	34.07	33.86–34.27
S. chlorostictus											
La Jolla	33°N	..	3	11	92	1	..	..	107	33.85	33.76–33.94
Guadalupe Is	29°N	..	2	1	15	..	..	..	18	33.72	33.55–33.89
Total	..	..	5	12	107	1	..	..	125	33.83	33.75–33.92
S. rosenblatti											
La Jolla	33°N	..	..	3	73	10	4	..	90	34.17	34.05–34.28
Guadalupe Is	29°N	..	..	1	22	4	1	..	28	34.14	33.97–34.39
Ranger Bank	29°N	..	..	..	14	5	1	..	20	34.35	34.08–34.62
Total	..	..	..	4	109	19	6	..	138	34.20	34.10–34.30
S. eos											
Total	..	..	..	..	8	8	26	..	42	35.43	35.18–35.68

[a] Left count + right count.
[b] Other than rosaceus, helvomaculatus, and simulator.
[c] Confidence limits for means are at 95% level.

TABLE 9

TOTAL PECTORAL RAYS[a] OF *Sebastes rosaceus*, *Sebastes helvomaculatus*, AND *Sebastes simulator*

		30	31	32	33	34	35	36	N	Mean	Confidence limit[b]
S. rosaceus											
San Francisco	38°N	..	..	..	1	6	..	..	7	33.86	..
Monterey	37°N	..	..	1	1	13	1	..	16	33.88	33.55–34.21
Morro Bay	35°N	..	..	..	1	2	..	..	3	33.67	..
Santa Barbara	35°N	..	..	..	..	1	..	..	1	34.00	..
Santa Cruz Is	34°N	..	..	..	2	5	..	..	7	33.71	..
Catalina Is	34°N	..	..	1	4	28	1	..	34	33.85	33.68–34.03
La Jolla	33°N, 117°W	..	..	..	1	20	..	1	22	34.05	33.83–34.26
Tanner Bank	33°N, 119°W	..	..	7	10	78	5	..	100	33.81	33.70–33.92
Guadalupe Is	29°N	..	..	..	..	..	1	..	1	35.00	..
Total	..	..	..	9	20	153	8	1	191	33.85	33.77–33.94
S. helvomaculatus											
Gulf of Alaska	56°N,152°W	..	..	1	..	..	..	..	1	32.00	..
Gulf of Alaska	58°N, 139°W	..	..	4	..	..	..	..	4	32.00	..
Washington	48°N, 126°W	..	1	44	6	3	..	..	54	32.20	32.05–32.36
Eureka	41°N	..	..	1	..	1	..	..	2	33.00	..
San Francisco	38°N	1	..	1	1	..	..	..	3	31.67	..
Monterey	37°N	..	2	15	3	3	..	..	23	32.30	31.96–32.66
Coronado Bank	32°N	..	..	1	..	1	..	..	2	33.00	..
Total	..	1	3	67	10	8	..	..	89	32.24	32.09–32.39
S. simulator											
Southern California	30–34°N	..	..	..	2	19	1	1	23	34.04	33.80–34.28
Guadalupe Is	29°N	..	..	1	2	24	2	1	30	34.00	33.76–34.24
Total	..	..	..	1	4	43	3	2	53	34.02	33.85–34.19

[a] Left count + right count.

[b] Confidence limits for means are at 95% level.

TABLE 10 TOTAL GILL-RAKERS[a] OF *Sebastomus* SPECIES[a], [c]

	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
S. constellatus																				
La Jolla	1	26	10	15	5	11	..	1	..	..	..	..	..	..	..	..	..	..	..	..
Tanner Bank	2	1	11	15	14	12	10	5	1	..	..	..	..	..	..	..	..	..	..	..
Guadalupe Is	..	..	..	3	4	5	3	1	1	..	..	..	..	..	..	..	..	..	..	..
Thetis Bank	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..
Total	3	3	17	28	33	22	15	6	3	..	..	..	..	..	..	..	..	..	..	..
S. capensis																				
Callao, Peru	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..
Montemar, Chile	..	..	..	..	..	..	..	..	2	3	1	..	1	..	..	..	..	..	..	..
Tristan da Cunha	..	..	..	..	..	..	1	..	2	..	..	..	..	..	..	..	..	..	..	..
Cape Twon, Africa	..	..	..	..	..	..	..	..	1	1	..	..	..	..	..	..	..	..	..	..
Total	..	..	..	..	1	..	2	..	3	4	2	..	1	..	..	..	..	..	..	..
S. chlorostictus																				
La Jolla	..	..	..	..	..	..	..	..	..	..	5	6	12	23	29	12	14	2	4	1
Gusdalupe Is	..	..	..	..	..	..	..	..	..	1	..	3	4	2	6	2	2	..	..	..
Total	..	..	..	..	..	..	..	..	..	1	5	9	16	25	35	14	16	2	4	1
S. rosenblatti																				
La Jolla	..	..	..	..	..	..	1	1	13	15	17	20	12	7	3	1	..	..	..	..
Guadalupe Is	..	..	..	..	..	..	..	..	4	2	12	5	6	1	..	..	..	..	..	..
Ranger Bank	..	..	..	..	..	..	..	..	3	2	4	4	4	2	1	..	..	..	..	..
Total	..	..	..	..	..	..	1	1	20	19	33	29	22	10	4	1	..	..	..	..
S.eos																				
Total	..	1	7	6	9	6	7	2	3	1	..	..	..	..	..	..	..	..	..	..

[a] Left count + right count.
[b] Other than *resaceus, helvomaculatus*, and *simulator.*
[c] Boldface figures indicate 95% confidence intervals for means.

TABLE 10-*Continued*

	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79
S. ensifer																	
Total	..	..	..	..	..	..	1	1	6	2	3	6	6	5	6	4	1
S.notius																	
Total	..	..	..	..	..	..	..	..	2	..	..	..	1	..	..	..	..
S. umbrosus																	
La Jolla	..	..	..	4	4	9	21	14	12	19	8	3	..	..	..	..	..
Tanner Bank	..	..	..	1	1	2	5	11	8	6	3	1	..	..	..	..	..
Guadalupa Is	..	..	..	5	5	11	27	27	20	25	13	4	..	..	..	..	..
S. lentiginosus																	
Total	..	..	..	..	.	..	1	..	1	4	5	5	2	1	2	1	..
S. exsul																	
Total	..	4	1	3	3	..	1	1	1	..	1	..	..	..	..	..	..

TABLE 11

TOTAL GILL-RAKERS OF *Sebastes rosaceus, Sebastes helvomachulateus, AND Sebastes simulator*

		56	57	58	59	60	61	62	63	64	65	66	67	68	N	Mean	Conmfidence limit[b]
S. resacesu																	
San Francisco	38°N	..	..	..	..	1	1	1	..	1	1	2	..	..	7	63.57	..
Monterey	37°N	..	..	1	..	1	..	2	5	33	2	2	..	..	10	63.19	62.09–64.29
Morro Bay	35°	..	..	..	..	..	..	..	..	33	..	..	..	..	3	64.00	..
Santa Barbara	35°N	..	..	..	..	..	..	1	..	..	..	..	..	..	..	61.00	..
Santa Cruz Is.																	
..	34°N	..	..	..	..	1	1	..	..	4	..	1	..	..	7	63.67	..
Catalia Is	34°N	..	..	..	..	3	5	10	7	6	2	..	..	1	34	62.59	62.01–63.17
La Jolla	33°N,117°W	..	..	..	..	5	..	6	2	4	1	2	1	1	22	63.00	61.95–64.05
Tanner Bank	33°N, 119°W	..	..	1	2	6	15	26	17	16	5	7	4	..	100	65.65	62.29–63.02
Guadalupe Is.	29°N	..	..	..	..	..	..	1	..	..	..	..	..	..	1	62.00	..
Total	..	6	12	21	19	18	8	4	2	1	..	..	..	..	91	58.96	58.60–59.32
S. simulator																	
South. Calif.	30–34°N	..	..	2	..	6	3	4	3	1	2	2	..	..	23	61.83	60.84–62.82
Guadalupe Is.	29°N	..	2	2	1	12	4	2	4	2	..	..	..	..	29	60.59	59.90–61.30
Total	..	..	2	4	1	18	7	6	7	3	2	2	..	..	52	61.14	60.54–61.73

[a] Left count + rignt count.

[b] confidence limits for means are at 95% level.

TABLE 12 TATAL LATERAL-LINE PORES[a] OF *Sebastomus* SEPCIES[b], [c]

	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
S.constellatus																								
La Jolla	..	..	..	..	..	..	..	..	..	1	1	4	4	2	5	8	5	7	3	6	..	..	..	..
Tanner Bank	..	..	..	..	..	..	..	..	..	2	2	2	5	10	8	9	7	2	6	5	3	2	1	1
Guadalupe Is	..	..	..	..	..	..	..	..	..	..	..	..	..	3	1	3	4	2	1	1	1	..	..	1
Thetis Bank	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Total	..	..	..	..	..	..	..	1	..	3	3	6	9	15	14	20	16	11	10	12	4	2	1	2
S. capensis																								
Callao, Peru	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..
Montemar	..	..	..	..	..	1	..	1	..	1	..	1	..	..	..	2	1	..	..	..	..	..	..	..
Tristan da Cunha	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	1	..	..	..	..	..	..	..	..
Cape Town, Africa	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	1
Total	..	..	..	..	..	1	..	1	..	2	..	2	1	..	..	3	1	..	..	..	..	..	..	1
S.ensifer																								
Total	..	..	..	1	..	1	2	1	1	4	3	5	3	5	5	..	..	3	2	2	1	..	..	..
S.notius																								
Total	..	..	1	..	..	..	1	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..
S.umbrosus																								
La Jolla	..	..	..	4	4	8	11	8	17	8	11	9	2	4	2	2	1	2	..	..	1	..	..	..
Tanner Bank	..	..	..	..	1	1	3	5	7	5	6	1	2	3	3	1	..	..	..	..	..	..	..	..
Guadalupe Is	..	..	1	..	..	..	..	1	2	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..
Total	..	..	1	4	5	9	14	14	26	13	17	11	4	7	5	3	1	2	..	..	1	..	..	..
S. lentiginosus																								
Total	1	..	..	1	4	1	2	2	3	3	..	..	..	..	1	..	..	..	..	..	..	..	..	..
S.exsul																								
Total	..	..	..	1	1	..	..	2	..	2	2	2	1	1	..	2	..	..	1	..	..	..	..	..
S.chlorostictus																								
La Jolla	..	..	..	..	..	4	9	5	11	17	13	20	11	8	5	3	1	..	..	..	..	..	..	..
Guadalupe Is	..	..	..	..	..	..	1	1	3	2	4	2	1	1	3	1	..	1	..	..	..	..	..	..
Total	..	..	..	..	..	4	10	6	14	19	17	22	12	9	8	4	1	1	..	..	..	..	..	..
S. rosenblatti																								
La Jolla	..	..	..	..	..	1	2	7	10	8	10	13	13	7	5	6	1	1	..	..	..	..	..	..
Guadalupe Is	..	..	..	..	..	..	2	2	3	3	3	4	6	2	2	..	2	..	..	..	..	..	..	..
Ranger Bank	..	..	..	..	..	..	3	1	1	2	4	3	..	3	2	1	..	..	..	..	..	..	..	..
Total	..	..	..	..	..	1	7	10	14	13	17	22	17	12	9	7	36	1	..	..	..	..	..	..
S. eos																								
Total	..	..	..	1	1	1	2	3	6	2	1	5	5	3	2	1	1	..	..	..	..	..	..	..

[a] Left count + right count.
[b] Other than *resoceus, helvomaculateus*, and *simulator.*
[c] Boldface figure indicate 95% confidence intervals for means.

TABLE 13

TOTAL LATERAL-LINE PORES[a] OF *Sebastes rosaceus, Sebastes helvomaculatus*, AND *Sebastes simulator*[b]

	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
S. rosaceus																								
Monterey	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	1	..	..	..	..	..	..	..
Morro Bay	..	..	..	..	..	..	..	1	..	..	..	1	..	..	..	..	..	1	..	..	..	..	..	..
Santa Barbara	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..
Santa Cruz Is	..	..	..	..	..	..	..	..	..	..	..	1	1	..	3	..	2	..	..	..	..	..	..	..
Catalina Is	..	..	..	..	..	..	..	..	1	..	1	1	5	6	5	3	5	2	1	2	1	1	..	..
La Jolla	..	..	..	..	..	..	..	..	..	..	..	1	2	3	2	1	5	1	6	..	1	..	..	..
Tanner Bank	..	..	..	..	..	..	..	..	..	4	2	10	4	14	14	12	14	7	5	7	4	..	..	1
Guadalupe Is	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..
Total	..	..	..	..	..	..	..	1	1	4	3	14	12	25	24	16	28	11	12	9	6	1	..	1
S. helvomaculatus																								
56°N, 152°W	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..
58°N, 139°W	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	1	1	..	..	1	..	..	..	..
Washington	..	..	..	1	..	1	3	3	6	11	3	4	5	3	6	4	2	2	1	..	..	..	..	..
Eureka	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..
Monterey	..	..	..	..	..	..	1	2	..	1	1	2	1	..	2	..	1	1	2	1	..	..	..	..
Coronado Bank	..	..	..	..	..	..	..	..	1	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..
Total	..	..	..	1	..	1	4	5	7	12	6	6	6	6	6	6	5	4	2	1	..	..	..	..
S. simulator																								
30°N-34°N	..	1	..	2	1	3	3	1	2	4	1	..	..	..	..	..	..	..	..	..	..	..	..	..
Guadalpue Is	2	..	3	2	3	4	5	5	1	2	1	..	..	..	..	..	..	..	..	..	..	..	..	..
Total	2	1	3	4	4	7	8	6	3	6	2	..	..	..	..	..	..	..	..	..	..	..	..	..

[a] Left count + right count.

[b] Boldface figures indicate 95% confidence intervals for means.

TABLE 14

ANAL SOFT-RAYS AND DORSAL SOFT-RAYS OF *Sebastomus* SPECIES[a]

			Anal					Dorsal			
		5	6	7	9	10	11	12	13	14	15
S. constellatus											
La Jolla	33°N, 117°W	..	51	2	..	..	..	6	41	7	..
Tanner Bank	33°N, 119°W	2	68	..	..	..	..	7	56	8	..
Guadalupe Is	29°N, 118°W	1	16	..	..	..	..	1	15	1	..
Thetis Bank	25°N, 113°W	..	1	..	..	..	..	..	1	..	..
Total	..	3	136	2	..	..	..	14	113	16	..
S. capensis											
Callao, Peru	12°S	..	1	..	..	..	..	..	1	..	..
Montemar, Chile	33°S	1	6	..	..	..	..	1	5	1	..
Tristan da Cunha	37°S	1	2	..	..	..	..	..	3	..	..
Cape Town, Africa	36°S	..	2	..	..	..	..	..	1	1	..
Total	..	2	11	..	..	..	..	1	10	2	..
S. ensifer											
Total	..	2	35	3	..	..	..	8	29	4	..
S. notius											
Total	..	..	3	..	..	..	..	..	3	..	..
S. umbrosus											
La Jolla	33°N, 117°W	6	98	..	..	..	6	73	28	..	..
Tanner Bank	33°N, 119°W	1	36	1	..	..	..	28	10	..	..
Guadalupe Is	29°N	..	5	..	..	..	..	4	1	..	..
Total	..	7	139	1	..	..	6	105	39	..	..
S. lentiginosus											
Total	..	..	17	2	..	..	..	17	2	..	..
S. exsul											
Total	..	2	13	..	..	..	..	7	8	..	..
S. chlorostic-tus											
La Jolla	33°N	4	101	2	..	..	1	76	30	..	1
Guadalupe Is	29°N	1	21	..	1	..	..	18	3	..	..
Total	..	5	122	2	1	..	1	94	33	..	1
S. rosenblatti											
La Jolla	33°N	4	86	..	1	..	3	75	11	..	..
Guadalupe Is	29°N	2	33	..	..	..	1	27	7	..	..
Ranger Bank	29°N	..	20	..	..	..	..	16	4	..	..
Total	..	6	139	..	1	..	4	118	22	..	..
S. eos											
Total	..	..	39	2	..	..	1	29	8	..	..

[a] Other than *rosaceus, helvomaculatus*, and *simulator.*

TABLE 15
ANAL SOFT-RAYS AND DORSAL SOFT-RAYS OF *Sebastes rosaceus, Sebastes helvomaculatus*, AND *Sebastes simulator*

		Anal			Dorsal			
		5	6	7	11	12	13	14
S. rosaceus								
San Francisco	38°N	..	7	..	..	2	4	1
Monterey	37°N	..	15	..	..	6	10	..
Morro Bay	35°N	..	1	..	..	1	2	..
Santa Barbara	35°N	..	1	..	..	1	..	..
Santa Cruz Is	34°N	..	7	..	1	1	5	..
Catalina Is	34°N	..	34	..	..	12	22	..
La Jolla	33°N, 117°W	1	21	..	..	7	15	..
Tanner Bank	33°N, 119°W	3	95	2	1	29	70	1
Guadalupe Is	29°N	..	1	..	..	1	..	..
Total	..	4	182	2	2	60	128	2
S. helvomaculatus								
Gulf of Alaska	56°N, 152°W	..	1	..	..	..	1	..
Gulf of Alaska	58°N, 139°W	..	4	..	..	..	3	1
Washington	48°N, 126°W	..	52	2	..	6	46	1
Eureka	41°N	..	2	..	..	..	1	..
San Francisco	38°N	..	7	..	..	..	6	1
Monterey	37°N	..	21	1	..	5	15	2
Coronado Bank	32°N	..	2	..	..	1	1	..
Total	..	..	89	3	..	12	73	5
S. simulator								
Southern California	30–34°N	1	20	..	..	4	17	1
Guadalupe Is	29°N	..	30	..	..	2	24	4
Total	..	1	50	..	..	6	41	5

the increase in the number of gill-rakers with increasing body size was manyfold (Berry and Barrett, 1963).

Table 16 gives the coefficients of correlation between meristic number and standard length for the total lateral-line pore counts, the total gill-raker counts, and the total pectoral-ray counts of several samples of *Sebastes*. It appears that little or no correlation exists between meristic numbers and size in these samples. Thus, in studying meristics of *Sebastes*, the ontogenetic effect can be neglected.

BILATERAL ASYMMETRY

Bilateral symmetry is a feature characterizing vertebrates as well as a number of other animal groups. However, there is a limit within which bilateral symmetry holds true. In the fish order Pleuronectiformes sinistrality or dextrality rather than bilateral symmetry is the rule. Even in essentially bilaterally symmetrical fishes the two sides of the body are not exact mirror images.

In dealing with meristic characters, the count of the right side often differs from that of the left. Furthermore, the higher count sometimes occurs significantly more often on one side than on another. This is true, for example, for

TABLE 16

STANDARD LENGTH AND MERISTIC CORRELATION IN *Sebastomus*

	Correlation coefficient	N	Significant level
S. umbrosus			
Lateral-line pores	-0.199	94	=.06
Pectoral rays	-0.043	96	
Gill-rakers	-0.136	94	
S. chlorostictus			
Lateral-line pores	-0.110	107	=.25
Pectoral rays	-0.063	107	
Gill-rakers	-0.090	108	
S. rosenblatti			
Lateral-line pores	0.112	84	
Pectoral rays	0.197	90	=.06
Gill-rakers	0.026	90	
S. eos			
Lateral-line pores	0.264	37	=.11
Pectoral rays	0.143	43	
Gill-rakers	-0.165	43	

pectoral-ray counts in *Leptocottus armatus* and *Cottus bairdii*, branchiostegalray counts of *Oncorhynchus tshawytscha, Albula vulpes*, and *Esox vermiculatus*, number of gill openings of hagfishes (Hubbs and Hubbs, 1945), and number of gill-rakers as well as of lateral-line scales of the Pacific salmon (Landrum, 1966).

Studies of meristic bilateral asymmetry are useful in comparing meristic total counts (right + left) with unilateral counts and in determining whether right-side counts can substitute for the conventional left-side counts. Tables 17, 18, and 19 compare the right and the left counts of lateral-line pores, gill-rakers, and pectoral rays for a number of species of *Sebastes*. It seems that the higher pectoralray counts tend to occur on the right side in *umbrosus* from La Jolla, and in *ensifer.* In *rosaceus* from Catalina Island and in *umbrosus* from La Jolla, the higher lateral-line pore counts tend to occur on the left side. In *helvomaculatus* and *ensifer*, the higher gill-raker counts tend to occur on the left side. As the data presented are rather fragmentary, no generality can be drawn and no discussion is offered here.

GEOGRAPHIC VARIATION

It is well known that meristic characters of fishes often vary from one locality to the next, parallel to such environmental gradients as temperature and salinity. Explanations have been sought by Hubbs (1926), Gabriel (1944), Tâning (1952), Lindsey (1954), Gordon (1957), Barlow (1961), and many others. It has been demonstrated again and again that meristic differences comparable to geographic variations can be induced by changing the environmental conditions, particularly temperature, during development of the individual. Thus geographic meristic differences in fishes are often considered to be effects of the environment rather than a product of genetic differences.

Hubbs and Schultz (1933) found no geographic variation in counts of the dorsal soft-rays, anal soft-rays, and pectoral rays of *S. melanops* from Seattle,

TABLE 17

BILATERAL ASYMMETRY IN THE NUMBER OF LATERAL-LINE PORES IN *Sebastes*

	N	L	R	$\frac{100(L+R)}{N}$	P
S. constellatus					
La Jolla	46	17	11	61	
Tanner Bank	66	30	19	74	
S. rosaceus					
Catalina Is	34	20	8	83	<.02
Tanner Bank	98	36	43	81	
S. helvomaculatus					
Washington	40	16	13	72	
S. ensifer					
Total	34	13	17	88	
S. lentiginosus					
Total	18	4	10	78	
S. umbrosus					
La Jolla	94	47	29	81	<.05
Tanner Bank	38	19	13	84	
S. exsul					
Total	15	2	7	60	<.10
S. chlorostictus					
La Jolla	107	41	40	75	
Others	31	14	7	68	
S. rosenblatti					
La Jolla	84	39	25	76	<.10
Guadalupe Is	29	10	14	82	
Ranger Bank	20	9	5	70	
S. eos					
Total	37	12	19	83	

L = number of higher count on the left, R = number of higher count on the right, P = level of significant difference between left and right.

Washington (48°N), to Point Arguello, California (34°N). Westrheim (1965, 1966*a*, 1966*b*, and 1968) and Westrheim and Pletcher (1966), on comparing meristic characters between northern and southern samples of a number of *Sebastes* species, observed no geographic variation, except in the diagonal scale-row counts of *S. zacentrus*. The diagonal scale-row counts of *S. zacentrus*, while reported to be 43–50 for California specimens (Phillips, 1957), were found to be 45–55 for specimens from 142°W, 50–54 for those from 155°W, and 54–59 for those from 162°W. The pattern of geographic variation in this case is, without doubt, clinal.

Various meristic counts of species of *Sebastomus* have been tabulated, along with their means and 95 percent confidence intervals (tables 8, 9, 10, 11, 12, 13, 14, 15, and 20). Similarities or differences between samples are indicated by the presence or absence of overlap of the confidence intervals.

Total lateral-line pores (for both sides, tables 12 and 13).—The range of this character for species of *Sebastomus* is from 67 in *simulator* and *lentiginosus* to 92 in *constellatus*. The count varies intraspecifieally with a range for one species

TABLE 18
BILATERAL ASYMMETBY IN THE NUMBER OF GILL-RAKERS IN *Sebastes*

	N	L	R	$\frac{100(L+R)}{N}$	P
S. constellatus					
La Jolla	51	11	17	55	
Tanner Bank	71	21	18	55	
S. rosaceus					
Catalina Is	34	9	8	50	
Tanner Bank	100	31	19	50	<.10
S. helvomaculatus					
Washington	40	16	6	55	<.05
S. ensifer					
Total	36	17	7	66	<.05
S. lentiginosus					
Total	22	8	6	63	
S. umbrosus					
La Jolla	94	28	22	53	
Tanner Bank	38	14	8	61	
S. exsul					
Total	15	5	3	53	
S. chlorostictus					
La Jolla	108	26	22	44	
Others	33	8	7	45	
S. rosenblatti					
La Jolla	90	28	21	54	
Guadalupe Is	30	6	5	37	
Ranger Bank	20	5	4	45	
S. eos					
Total	43	13	8	49	

L = number of higher count on the left, R = number of higher count on the right, P = level of significant difference between left and right.

at one locality as wide as 18 (9 for the unilateral count). No differences have been found between conspecifie samples containing more than 10 individuals.

Total gill-rakers (for both sides, tables 10 and 11).—The range of this character for the subgenus *Sebastomus* is from 52 in *constellatus* to 79 in *ensifer*. Within a species the greatest range at one locality is 11 (5–6 for the unilateral count). Geographically, the raker count seems to be very consistent, with a characteristic mode and range for a given species.

Pectoral-ray counts.—Except *notius, eos*, and *capensis*, which normally have 18 pectoral rays, and *helvomaculatus* which normally has 16 pectoral rays, the majority of the individuals of the present species group have 17 pectoral rays. The total pectoral-ray count (for both sides, tables 8 and 9) varies at one locality for a given species within a range of 5 (3 for unilateral count). Geographic variation appears to be insignificant.

Anal soft-rays (tables 14 and 15).—This character seems to vary little. A majority of the individuals of all the species of *Sebastomus* have 6 anal soft-rays, occasionally 5 or 7. There appears to be no geographic variation.

TABLE 19
BILATERAL ASYMMETRY IN THE NUMBEER OF PECTORAL RAYS IN *Sebastes*

	N	L	R	$\frac{100(L+R)}{N}$	P
S. constellatus					
La Jolla	42	3	1	9	
Tanner Bank	63	2	7	14	<.10
S. rosaceus					
Catalina Is	34	3	2	15	
Tanner Bank	100	4	11	15	=.10
S. helvomaculatus					
Washington	40	2	2	10	
S. ensifer					
Total	37	0	5	14	=.02
S. umbrosus					
La Jolla	96	3	13	17	<.02
Tanner Bank	38	2	1	8	
S. lentiginosus					
Total	22	2	4	27	
S. exsul					
Total	15	1	2	20	
S. chlorostictus					
La Jolla	111	7	6	12	
Others	31	2	1	9	
S. rosenblatti					
Total	141	9	14	16	
S. eos					
Total	35	1	5	17	
S. mystinus					
San Miguel Is	94	1	0	1	
S. saxicola					
33–34°N	78	5	3	10	

Dorsal soft-rays (tables 14 and 15).—This character also does not show much variation in species of *Sebastomus*. The number is generally 13 in *constellatus, helvomaculatus, simulator*, and *notius*, more often 13 than 12 in *rosaceus* and *ensifer*, 12 or 13 in *exsul*, more often 12 than 13 in *umbrosus, lentiginosus*, and *chlorostictus*, and 12 in *rosenblatti* and *eos*. Occasionally individuals may possess 11 or 14 dorsal soft-rays and two abnormal specimens, one of *rosenblatti*, and one of *chlorostictus*, were found to have only 9 dorsal soft-rays. Geographically, this character is quite consistent and no trend in variation was observed.

Pyloric caeca (table 20).—The pyloric caeca range from 9 to 15 in the present species group. The number does not seem to vary geographically. There also seems to be a species-specific mode, 10–11 in *umbrosus*, 11 in *constellatus*, and 11–12 in *rosaceus* and *chlorostictus*. In the dwarf species *S. dallii*, the number ranges from 6 to 8; in *semicinctus*, from 8 to 9; and in *elongatus*, from 8 to 11. Although most variable within populations, this character is of value in systematics.

Although within-sample variation is of considerable magnitude in certain characters, there appear to be no differences between samples within a species. As

TABLE 20 PYLORIC-CAECAL NUMBERS OF *Sebastes*

Species		6	7	8	9	10	11	12	13	14	15	N	Mean*
S. paucispinis	33°N, 117°W	..	..	..	3	..	..	..	..	..	..	3	..
S. goodei	33°N, 117°W	..	..	..	..	1	1	..	..	..	..	2	..
S. hopkinsi	33°N, 117°W	..	..	..	1	3	1	..	..	..	..	5	..
S. mystinus	33°N, 117°W	..	..	..	..	..	..	..	2	2	..	4	..
S. serranoides	33°N, 117°W	..	..	..	..	..	..	..	2	..	..	2	..
S. miniatus	33°N, 117°W	..	..	..	..	..	1	..	..	..	..	1	..
S. semicinctus	33°N, 117°W	..	..	7	3	..	..	..	..	..	..	10	8.30 ± 0.34
S. elongatus	33°N, 117°W	..	..	2	7	10	2	..	..	..	..	21	9.57 ± 0.37
S. rubrivinctus	33°N, 117°W	..	..	..	..	1	..	..	..	..	..	1	..
S. dallii	33°N, 117°W	3	12	8	..	..	..	..	..	..	..	23	7.22 ± 0.29
S. vexillaris	33°N, 117°W	..	..	..	1	..	..	..	..	..	..	1	..
S. carnatus	33°N, 117°W	..	..	..	1	..	..	..	..	..	..	1	..
S. serriceps	33°N, 117°W	..	..	..	..	1	1	..	..	..	..	2	..
S. constellatus													
Tanner Bank	33°N, 119°W	..	..	..	1	12	23	14	..	..	..	50	11.00 ± 0.22
La Jolla	33°N, 117°W	..	..	..	2	6	14	2	..	..	..	34	11.12 ± 0.34
S. rosaceus													
Tanner Bank	33°N, 119°W	..	..	..	1	11	32	26	5	1	..	76	11.33 ± 0.18
La Jolla	33°N, 117°W	..	..	..	..	1	2	2	2	..	..	7	..
S. ensifer													
Total	..	..	..	..	..	4	2	..	..	..	..	6	..
S. umbrosus													
La Jolla	33°N, 117°W	..	..	..	7	37	35	9	3	..	..	91	10.60 ± 0.15
S. chlorostictus													
La Jolla	33°N, 117°W	..	..	..	..	11	30	24	3	..	..	68	11.33 ± 0.22
Others	29°N-33°N	..	..	..	..	4	8	7	..	..	..	19	11.16 ± 0.37
S. rosenblatti													
La Jolla	33°N	..	..	..	..	2	5	5	..	..	1	13	11.54 ± 0.70
Guadalupe Is	29°N	..	..	..	..	3	2	2	..	..	..	7	..

* With 95% confidence limit.

species of **Sebastes** are all viviparous, meristic elements of these fishes may be fixed early, within the maternal body and thus near the bottom where the environmental temperature does not differ much geographically. Soon after birth, the larvae would rise to the surface (as *S. alutus* was reported to do by Moiseev and Parketsov, 1961), thus exposing themselves to the latitudinal surface-temperature gradient. However, I have not been able to detect any meristic elements other than the body somites in a number of late-stage intraovarian larvae of *S. chlorostictus* and *S. macdonaldi* stained with alizarin. According to Moser (1966), fin rays in *S. paucispinis* are all formed after birth. It is not known, however, whether meristic elements are determined and formed simultaneously. Lindsey (1954), in studying the determination of meristic characters in the paradise fish, *Macropodus opercularis*, reported that some meristic series were still subject to environmental influence 20 days after hatching. Templeman and Pitt (1961) found a negative correlation between vertebral number of *S. mentella* and surface temperatures. They thought that the phenocritical period for this fish must be in the early larval pelagic stage.

Because there is a temperature difference between La Jolla and Tanner Bank, about 90 miles offshore, meristic data for the two localities were compared. No marked difference was found. As these two sampling localities are within a common eddy system south of Point Conception (Reid, Roden, and Wyllie, 1958), considerable mixing of pelagic larvae from different localities probably takes place every year. Under such circumstances no segregation is likely to occur within this general area.

Guadalupe Island is not in the eddy system. It probably receives recruits from waters north of Point Conception. However, individuals from Guadalupe Island do not seem to differ in meristics from those from La Jolla and from Tanner Bank.

During the late-spring and summer months there are surface temperature gradients along the northern Channel Islands; it has been suggested that a difference of as much as 12° C in surface temperature may at times be found between the west end of San Miguel Island and Anacapa Island (Hubbs, 1967). As this period coincides with the spawning season (= phenocritical season?) and as the northward-flowing Davison Current generally develops north of Point Conception only during the winter, and by then most of the *Sebastomus* larvae have already settled to the bottom, meristic differences between samples north and south of Point Conception, if due to the direct effect of the environment, would likely exist. However, the data of *rosaceus* from localities north of Point Conception seem to indicate that the meristic consistency holds true. The lack of differences between two samples of *helvomaculatus* separated by 11 degrees of latitude is another indication of meristic consistency.

It seems then that statistically significant differences in the presently examined meristic characters would exist between the populations of a species of *Sebastomus* if the meristic values are determined by the environment directly. Since such differences were not found, it seems probable that meristic characters have a genetic basis and are thus more useful in species separation than in some other fishes.

TABLE 21 DORSAL SPINES AND VERTEBRAE IN SPECIES OF *Sebastes*

	Dorsal spines			Vertebrae		
	12	13	14	25	26	27
S. constellatus	..	133	2	1	6	..
S. rosaceus	..	162	1	..	7	..
S. helvomaculatus	1	71	1	..	1	..
S. simulator	..	40	..	..	1	..
S. ensifer	..	46	..	..	..	..
S. notius	..	3	..	..	..	..
S. umbrosus	1	143	1	..	12	..
S. lentiginosus	..	20	..	..	..	..
S. exsul	..	15	..	..	..	..
S. chlorostictus	..	143	..	..	5	1
S. rosenblatti	..	153	2	..	9	..
S. eos	..	42	..	..	..	..
S. dallii	..	..	..	..	..	1
S. semicinctus	..	..	..	..	2	..

VERTEBRAE AND DORSAL SPINES

The number of vertebrae of American Pacific *Sebastes* is generally considered to be very consistent. Cramer (1895) and Jordan and Evermann (1898) gave a vertebral formula of $12 + 15 = 27$ as the generic character of *Sebastodes* (referring to the American Pacific *Sebastes*), but their statement was apparently based on very limited count numbers. Jordan and Gilbert (1920) reported the vertebral counts to be 27 in *mystinus, flavidus, vexillaris, atrovirens, nebulosus, carnatus, chrysomelas, rosaceus*, and *constellatus* and 25 in *paucispinis, goodei, pinniger*, and *miniatus.* Follett (1952) questioned Jordan and Gilbert's counts, and reported a vertebral count of 26 in his specimens of *paucispinis, flavidus, miniatus, rosaceus, constellatus, ruberrimus*, and *nebulosus*. Clothier (1952) examined 39 specimens of *Sebastes* and found that, except for one specimen of *rosaceus* with 27 vertebrae, all the species, including *pinniger, flavidus, chlorostictus, semicinctus, atrovirens, miniatus, paucispinis, rosaceus, mytinus*, and *carnatus*, have 26 vertebrae. In studying the Gulf of Alaska species of *Sebastes*, Barsukov (1964) found the number of vertebrae to be 27 in *aleutianus, melanostomus, zacentrus, alutus*, and *proriger*; 26 in *rubrivinctus* (probably = *babcocki*), *entomelas*, and *melanops*; 28 in *ciliatus* and *polyspinis*; and 29 in *glaucus*. Matsubara (1943), in his detailed study of the Japanese species of *Sebastes*, reported the vertebral number to be 30 in *owstoni*, 29 in *glaucus*, 28 in *steindachneri*, 27 in *wakiyai* and *melanostictus*, and 26 in other 19 species.

Vertebral counts made in the present study of species of *Sebastomus* are also predominantly 26 (table 21). It thus appears that the vertebral number in the American Pacific species of *Sebastes* is not as consistent as previously thought and that there are more species with 26 than with 27 vertebrae. There is a general

TABLE 22 COEFFICIENTS OF VARIATION FOR MERISTIC COUNTS OF *Sebastes*

	Pylorie caeca	Lateral-line pores	Dorsal soft-rays	Anal soft-rays	Gill-rakers	Pectoral rays
S. constellatus						
Tanner Bank	7.11	4.10	3.56	2.81	3.11	1.07
La Jolla	8.79	3.30	3.80	3.19	2.91	1.58
S. rosaceus						
Tanner Bank	8.03	3.55	3.94	3.67	3.46	1.86
La Jolla	9.50	3.08	3.76	3.58	3.76	1.43
Catalina Is		3.51	3.84	0.00	2.64	1.48
S. helvomaculatus						
Washington		4.38	2.75	3.16	2.63	1.75
Monterey		4.93	3.85	5.46	3.06	2.55
S. simulator 30–34°N		3.47	3.43	4.08	3.70	1.65
Guadalupe Is		3.56	3.02	0.00	3.06	1.89
S. ensifer						
Total	5.00	5.14	4.18	5.93	3.45	1.71
S. umbrosus						
Tanner Bank		3.59	3.64	3.87	2.40	1.22
La Jolla	8.42	4.46	4.32	3.94	2.81	1.82
S. lentiginosus						
Total		4.24	2.61	5.16	2.85	2.02
S. exsul						
Total		5.28	4.12	6.00	4.28	1.34
S. chlorostictus						
La Jolla	7.96	3.28	3.82	3.97	2.85	1.33
S. rosenblatti						
La Jolla	6.70	3.36	4.19	3.49	2.86	1.60
Guadalupe Is	8.29	3.44	3.72	3.96	2.16	1.60
Ranger Bank		3.61	3.36	0.00	2.79	1.71
S. eos						
Total		4.04	3.85	5.04	3.55	2.25
S. rosenblatti + eos		3.55	3.89	3.73	4.80	2.34
S. rosenblatti + chlorostictus	7.15	3.46	4.02	3.70	3.91	1.44
S. helvomaculatus + simulator		5.14	3.10	3.44	3.59	3.41
S. sinensis						
Total		4.37	4.44	8.50	3.11	2.10

tendency in the family Scorpaenidae for the forms of high latitudes to have more vertebrae than those of the tropics. It may be more than a coincidence that *polyspinis* and *ciliatus*, the only two American Pacific species of *Sebastes* with 28 vertebrae, both are of northern distribution, and that the Atlantic species of *Sebastes*, with vertebral numbers as high as 30–31, occur far to the north.

The number of dorsal spines among the *Sebastomus* species is remarkably consistent (table 21). Departures from the number 13 occur in less than 1 percent of the specimens examined.

COEFFICIENTS OF VARIATION

The range of within-sample variation has been given for each character in the previous discussions. As counts of different characters are of different magnitudes, it is not possible to appreciate relative variability by a direct comparison of the ranges of variation. Within-sample variation between different characters can be compared in terms of their coefficients of variation, obtained by dividing the standard error by the respective mean, thus taking into consideration the relative magnitudes of different characters. In studying hexagrammids, Quast (1964) found that for a given character the magnitude of the coefficient of variation was quite consistent throughout the family, and the ranking of various meristic characters based on the magnitude of the respective coefficient of variation was also very consistent.

A direct comparison of the ranges of various characters would lead to the conclusion that the total count of lateral-line pores and the total gill-raker count are the most variable characters, while the count of anal soft-rays is the least variable. However, a comparison of their coefficients of variation (table 22) changes the picture entirely. It seems true that there is a characteristic range and rank for the magnitude of the coefficient of variation for various meristic counts of a number of *Sebastes* species. The pectoral-ray count is always the least variable character with a coefficient of variation generally less than 2.0. Total gill-raker count is often the second least variable one with a coefficient of variation generally less than 4.0. The count of anal soft-rays is on the average more variable than the total count of lateral-line pores. The number of pyloric caeca is the most variable character, with a coefficient of variation always greater than 5.0.

For the count of anal soft-rays, the coefficient of variation is generally less than 5.0, except in *S. sinensis* in which the coefficient is 8.5. This value is extraordinary, because although in all other species observed the anal soft-ray number is generally 6, it is 5 in half of the specimens of *S. sinensis*. Tâning (1952) stated that characters that are differentiated at an earlier stage in ontogeny may be less variable than those that are fixed later, because the developmental mechanism of the former are subject to environmental influences for a shorter period of time. Quast (1960) accepted this interpretation and suggested that consistency in rank of coefficient of variation within a group may be an indication of their ontogenetic consistency, implying that similarity in the ranks of the meristic characters between species may be an indication of close phylogenetic relationship. However, evolutionary changes involving changing of meristic numbers would inevitably cause high coefficients of variation during the transitional stage. The case in *S. sinensis* is likely an example of a high coefficient of variation being an indication that the species is on the way to reducing its anal soft-rays from 6 to 5. This species is endemic to the Gulf of California, the warmest water within the geographic ranges of *Sebastes*. Scorpaenid fishes from warm waters generally tend to have lower meristic numbers than those from high latitudes, which may be favored directly by natural selection or indirectly because of the selective advantage of other expression of the pleiotropic gene.

On the basis of published indications that vertebral variation in *Fundulus heteroclitus, Etheostoma exile*, and *Oncorhynchus tschawytscha* is considerably higher in samples from modified environments than it is in samples from natural situations, Quast (1960) suggested that variation of samples may be of value as an index of the degree to which a population has adapted to local conditions.

It seems that except in cases of evolutionary transition or of low degree of adaptation to local environment, an extraordinarily high coefficient of variation may well indicate heterogeneity in the material. Thus, as shown in table 22, for the pectoral-ray count, although the coefficients of variation of various samples of species of *Sebastomus* are generally less than 2.0, the coefficient of *Sebastomus* are generally less than 2.0, the coefficient for *S. simulator* and *S. helvomaculatus* combined is 3.41. Similarly, the coefficient of variation for the total gill-raker count is generally less than 4.0 but is 4.80 for *S. rosenblatti* and *S. eos* combined. These circumstances confirm the specific distinction of the two species in each case, and illustrate the value of the coefficient of variation in systematics.

MORPHOMETRIC VARIATION

As in meristic characters, variation in morphometric characters may be ontogenetic, individual, or geographic.

ALLOMETRY—ONTOGENETIC MORPHOMETRIC CHANGES

It is common in many animal groups that body proportions change with ontogeny—a phenomenon called allometry. It reflects the differences in growth rates between different parts of the body or in the same body part but in different directions (allometric growth). If the length of a body part of an organism is plotted against its body length, a curve rather than a straight line will often be observed. In such studies, however, as data of ontogenetic changes in body proportions of a single individual are often not available, body proportions of individuals of various sizes within a single population or species are used.

The conventional mathematical way of treating allometry is by fitting the body-part length (*Y*) and body length (*X*) relationship with a power-regression equation (allometric equation), $Y = {}_{a}X^{b}$. Since the curve $Y = {}_{a}X^{b}$ is a straight line in a log-log plot, *a* and *b* are generally estimated from the linear regression:

$$(\log Y) = (\log a) + b(\log X)$$

by the least squares method. When the slope *b* is equal to unity, *Y* in relation to *X* is constant throughout the size range under consideration (isometry). When *b* is greater than unity, *Y* increases in relation to *X* with increasing size (positive allometry), or vice versa (negative allometry).

In extending the size range under consideration to cover the entire life of the organism, allometric growth is often divided into stanzas, each of which is characterized by a specific slope. Transition from one growth stanza to the next is called the growth inflection, and is often associated with certain important events such as hatching, metamorphosis, ecological transition, and sexual maturity. The subject of allometric growth has been treated in detail by Huxley (1932), and in fishes by Martin (1949).

The fit of the power regression $Y = {}_aX^b$ to actual data is not always good. The departure of *Y-X* log-log plot from linearity in the growth of the rostrum of *Polyodon* (Thompson, 1934) is a well-known example. Since the anti-log (1/2 (log $Y1$ + log $Y2$)) is always smaller than 1/2($Y1 + Y2$) (except when $Y1 = Y2$), the equation $Y = {}_aX^b$ obtained with the least square method from the linear regression (log Y) = (log a) + b (log X) does not represent the actual situation and the estimated *Y* value corresponding to a given *X* based on this equation will be smaller than it should be. However, this equation gives a way of judging whether the allometry of a body part is present and if so, whether it is positive or negative. It also standardizes mathematical formulation, facilitating morphometric comparisons.

In the species of *Sebastomus*, linearity of the *X-Y* log-log plot is clearly shown in a number of characters over a wide size range (figs. 2, 3, 4, and 6). However, some departures from linearity are also found (fig. 8). Greatest departures are generally found in the size range below 100–120 mm.

In order to facilitate comparison, it is assumed that beyond the size 110 mm the power regression can describe allometric growth of all the species under consideration. Positive or negative allometry is assumed when the entire range of the 95 percent confidence interval of the slope of the character is above or below unity. Isometry is assumed if unity falls within the range of 95 percent confidence interval of the slope. The direction of allometric growth has been determined for 28 selected morphometric characters of 15 samples of the species of *Sebastomus* (table 23). In the table positive allometry, negative allometry, and isometry are represented by +, -, and 0 respectively. Characters are so arranged that the most frequently negative one is placed above and the most frequently positive one is placed below. Also presented in the table are the ranks of the magnitude of the average values of the slopes of various characters, which correspond rather well with the ranks of characters arranged from the most frequently negative one to the most frequently positive one. A coefficient of concordance, $W = 0.69$, is obtained from the 15 sets of the ranks of the 28 characters. This coefficient indicates that there is significant agreement among these sets of ranks ($P = .01$ at $W = .19$). It thus seems that the pattern of allometric growth, positiveness, negativeness, and the occurrence of growth inflections are very similar among the species of *Sebastomus*. It would be interesting to see if this similarity would be less when comparing species of *Sebastomus* with other species of *Sebastes*.

Allometric growth in the lengths of various fin spines, soft-rays, and gill-rakers, as well as in the length of orbit, is definitely negative; the body part becomes relatively smaller in larger individuals. In extreme cases, such as the second anal spine and the length of the gill-raker at the angle, the slopes were often smaller than 0.7. Allometric growth in interorbital width, lachrymal width, head width, as well as in body depth is, on the other hand, definitely positive; the body part becomes relatively larger in larger individuals. For the interorbital width the slope is often greater than 1.2. Table 24 gives two examples of a set of slope and intercepts for species of *Sebastomus*.

In taxonomic studies morphometric characters are, as a rule, presented in ratios, either between two body parts or between a body part and standard length. When

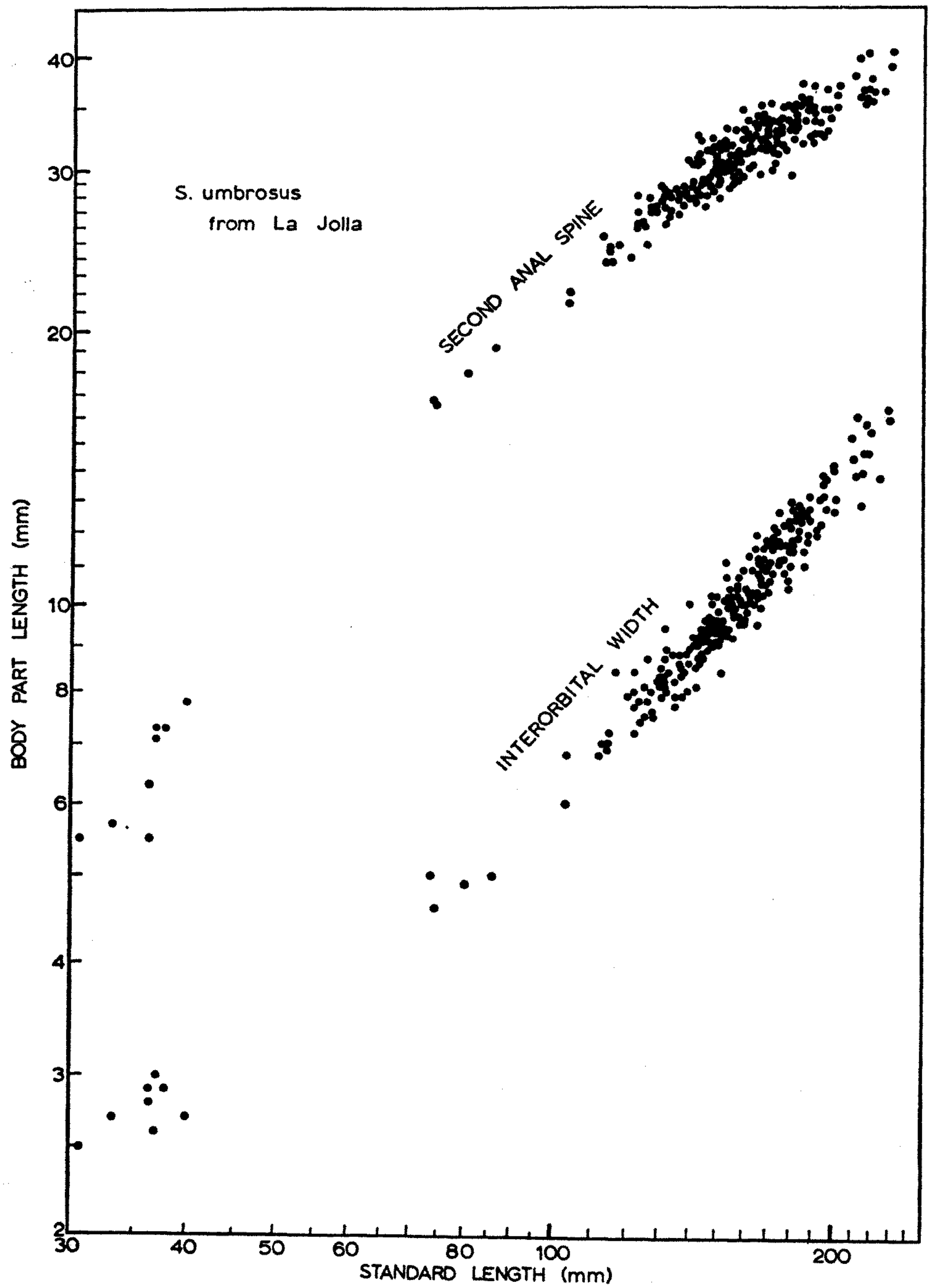

Fig. 8. Relation of the length of second anal spine and of interorbital width to standard length for *S. umbrosus* at La Jolla, showing departures from linearity in log-log plot.

TABLE 23 ALLOMETRY IN *Sebastomus*

	constellatus, La Jolla	constellatus, Tanner Bank	rosaceus, Catalina Is.	rosaceus, La Jolla	rosaceus, Tanner Bank	helvomaculatus	simulator	ensifer	umbrosus, La Jolla	umbrosus, Tanner Bank	lentiginosus	exsul	eos	rosenblatti, La Jolla	chlorostictus, La Jolla	Sum	Rank of average slope rank
Number of specimens	59	86	34	16	250	52	39	33	256	37	19	15	36	75	112		
Second anal spine	-	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-14	1
Gill-raker at angle	-	-	-	-	-	-	0	-	-	-	-	0	-	-	-	-13	2
Third anal spine	-	-	-	0	-	0	-	-	-	-	-	0	-	-	-	-12	3
2nd dorsal soft-ray	-	-	0	0	-	0	-	-	-	-	-	0	-	-	-	-11	9
Orbit length	-	0	-	-	0	0	-	-	0	-	-	0	-	-	-	-10	4
First anal spine	-	-	-	0	-	0	0	-	-	-	0	0	-	-	-	-10	6
Total length	-	-	-	0	-	0	0	-	-	-	-	+	-	-	-	-10	13
Fourth dorsal spine	-	-	-	0	-	0	-	-	0	-	0	0	-	-	0	- 9	5
1st anal soft-ray	-	-	0	+	-	0	-	-	-	-	-	0	-	-	0	- 9	7
Anal-fin base	0	-	0	0	-	0	-	0	-	-	0	0	-	0	0	- 6	8
Pelvic-fin length	0	-	0	+	-	0	0	-	-	-	0	0	0	-	0	- 5	10
Predorsal length	0	+	0	0	0	0	-	-	0	0	0	0	0	-	-	- 3	14
Lower peduncle length	0	0	-	0	-	0	0	-	0	0	0	0	+	0	0	- 2	11
Pectoral-fin length	0	-	0	+	-	0	0	0	0	-	0	0	0	0	0	- 2	15
Soft-dorsal base	0	0	0	0	0	0	0	-	0	0	0	0	0	0	0	- 1	12
Dorsal-fin incision	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16
Caudal-peduncle depth	0	0	+	0	0	0	0	-	-	0	0	0	0	0	+	0	19
Upper peduncle length	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19
Snout length	0	0	0	+	0	-	0	-	0	0	0	+	0	0	+	+ 1	17
Prepelvic length	0	0	0	0	0	0	0	0	0	0	0	+	0	0	0	+ 1	18
Spinous-dorsal base	0	0	0	0	0	0	0	0	0	0	+	0	0	0	0	+ 1	23
Upper-jaw length	0	+	0	+	0	0	0	0	0	0	0	+	0	0	0	+ 3	21
Head length	0	+	0	+	0	0	0	-	+	0	0	+	0	0	0	+ 3	22
Preanal length	+	+	0	+	+	0	+	+	+	+	0	0	0	+	+	+10	24
Body depth	+	+	+	+	+	+	0	0	0	+	+	+	0	0	+	+10	25
Head width	+	+	+	+	+	+	0	0	+	+	0	0	+	+	+	+11	26
Lachrymal width	+	+	0	+	+	+	0	0	0	+	+	+	+	+	+	+11	27
Interorbital	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+15	28

"−" = negative allometry, "+" = positive allometry, "0" = isometry, significant at $P < .05$ level.

TABLE 24

MORPHOMETRIC REGRESSIONS OF *S. umbrosus* AND *S. rosenblatti* FROM LA JOLLA

log, Y = A + B log, X, Y = body part length, *X* = standard length				
Species	*S. umbrosus*		*S. rosenblatti*	
Number of specimen and size range	256 (113–231)		75 (111–387)	
	A	B	A	B
Second anal spine	-0.39901	0.761 ± .096	0.05546	0.671 ± 066
Raker at angle of first gillarch	-0.24191	0.442 ± .234	-0.69501	0.519 ± .118
Third anal spine	-0.25935	0.691 ± .114	-0.45866	0.728 ± .055
Longest dorsal soft-ray	-0.85645	0.817 ± .095	-1.04882	0.847 ± .053
First anal spine	-1.12303	0.757 ± .158	-1.26889	0.779 ± .080
Orbit length	-1.86314	0.954 ± .104	-1.00653	0.777 ± .049
Total length	0.39198	0.965 ± .023	0.35950	0.969 ± .014
Fourth dorsal spine	-1.41455	0.933 ± .114	-0.40831	0.732 ± .188
First anal soft-ray	-0.47906	0.787 ± .072	-0.90817	0.866 ± .060
Anal-fin base	-1.09605	0.834 ± .099	-1.71955	0.953 ± .055
Pelvic-fin length	-0.84670	0.886 ± .080	-1.11854	0.926 ± .043
Predorsal length	-1.06736	1.008 ± .067	-0.70295	0.941 ± .039
Pectoral-fin length	-0.77389	0.922 ± .080	-1.17109	0.982 ± .060
Lower peduncle length	-1.25961	0.920 ± .157	-1.54691	0.985 ± .056
Soft-dorsal base	-1.32113	0.956 ± .066	-1.62610	1.004 ± .055
Dorsal-fin incision	-3.81521	1.264 ± .307	-1.68696	0.891 ± .381
Caudal-peduncle depth	-1.64134	0.873 ± .077	-2.28266	0.980 ± .054
Upper peduncle length	-1.93076	0.985 ± .099	-2.18679	1.039 ± .056
Spinous-dorsal base	-1.33535	1.072 ± .097	-1.24039	1.052 ± .057
Snout length	-2.53684	1.031 ± .133	-2.50779	1.044 ± .060
Prepelvic length	-0.81589	0.979 ± .083	-0.90345	0.994 ± .035
Head length	-1.23711	1.067 ± .061	-0.81622	0.988 ± .029
Upper-jaw length	-1.88072	1.050 ± .052	-1.51482	0.983 ± .030
Preanal length	-0.82014	1.091 ± .056	-0.54674	1.034 ± .030
Body depth	-1.32631	1.067 ± .074	-1.14166	1.020 ± .046
Head width	-3.67187	1.392 ± .157	-2.55016	1.171 ± .070
Lachrymal width	-3.49052	1.012 ± .111	-4.34376	1.192 ± .072
Interorbital width	-3.69175	1.195 ± .094	-3.66408	1.163 ± .070

two characters do not have the same slope of allometric growth, their ratio changes with body size. Neglecting allometric effects in such cases would make the presentation meaningless. Examples can be seen in Phillips's (1957) rockfishes study in which the ratios of orbit length in interorbital width were presented for 49 species of California *Sebastes*. As the allometric growth of these two characters is in different directions (negative for orbit length but positive for interorbital width), the result is that the range of the ratios given is a function of the size range of the specimens examined.

In constructing a ratio of the form $Y1/Y2$, one should keep in mind that $Y_1 = A_1\, X^B\; Y_2 = A_2\, X^B{}_2$, and $Y_1/Y_2 = (A_1 A_2)\, X^{(B_1\, -\, B_2)}$. Only if the two characters have the same slope of allometric growth ($B_1 = B_2$) would Y_1/Y_2 equal $A_1/A_2 = C$, and be constant regardless of the body size X.

INDIVIDUAL VARIATION

Individual variations in morphometric characters within populations of the species of *Sebastomus* are obvious upon examining the morphometric scatter-diagrams as well as the range of the morphometric ratios, as shown in figures 2, 3, 4, 5, 6, and 8 and table 1. Such variations may obscure specific morphometric differences. The cause of such variation may be genetic or environmental, and such variation is often associated with individual differences in growth rate. Slow-growing individuals (older individuals within a size group) in populations of *Clupea pallasi* (Tester, 1937) and in populations of *Leucichthys artedi* (Hile, 1937) have relatively larger heads. In *Melanogrammus aeglefinus*, older fish of a size group have larger otoliths than younger ones (Templeman and Squires, 1956). Martin (1949) demonstrated experimentally the correlation between growth rate and body proportion in *Salmo gairdnerii*. In each of these cases the slope of the morphometric regression of a sample of a year class was different from that of the population and the regression curves of the two crossed.

Regressions of a number of selected characters for fish of different age groups in the La Jolla sample of *S. umbrosus* (fig. 9) show that slow-growing individuals tend to have lesser preanal length but greater predorsal length, orbit length, head length, interorbital width, as well as otolith radius, than fast-growing ones. Covariance analyses confirm that in the orbit length and the otolith radius the observed differences in level of regression curves between age groups are real ($P < .01$).

GEOGRAPHIC VARIATION

As in meristic characters, morphometric characters often vary geographically, paralleling environmental gradients. As with individual variations, morphometric differences between conspeeific populations are also often associated with differences in growth rate. Specimens of herring (*Clupea harengus*) taken from colder waters of the Gulf of St. Lawrence were characterized by a slower growth rate and by having smaller heads than those from warmer waters (Jean, 1945). In studying the effect of temperature and salinity on the body form of *Cyprinodon macularius*, Sweet and Kinne (1964) found that most of the measured body parts had a minimum value at 32° C, the temperature at which the fish grew fastest; the values increased with increasing or decreasing temperature. Martin (1949) proved experimentally with rainbow trout, *Salmo gairdnerii*, that growth is faster in warmer water, resulting in larger head and fins, owing to a shift of growth inflections and consequent changes in the intercepts of the morphometric regressions, but that the slopes remained unchanged. This finding corresponds well with field data that in conspeeific populations that differ morphometrically, their morhometric regression curves often parallel each other and the differences are in the intercepts rather than in the slopes. Constancy of scatter among both small and large fish in the plots of allometric growth for a population also indicates the absence of divergence in the slope of allometric regression. Martin further showed the constancy of slope by demonstrating that morphometric differences between fast-growing and slow-growing individuals of *Salvelinus fontinalis* in a hatchery were maintained after a period of growth.

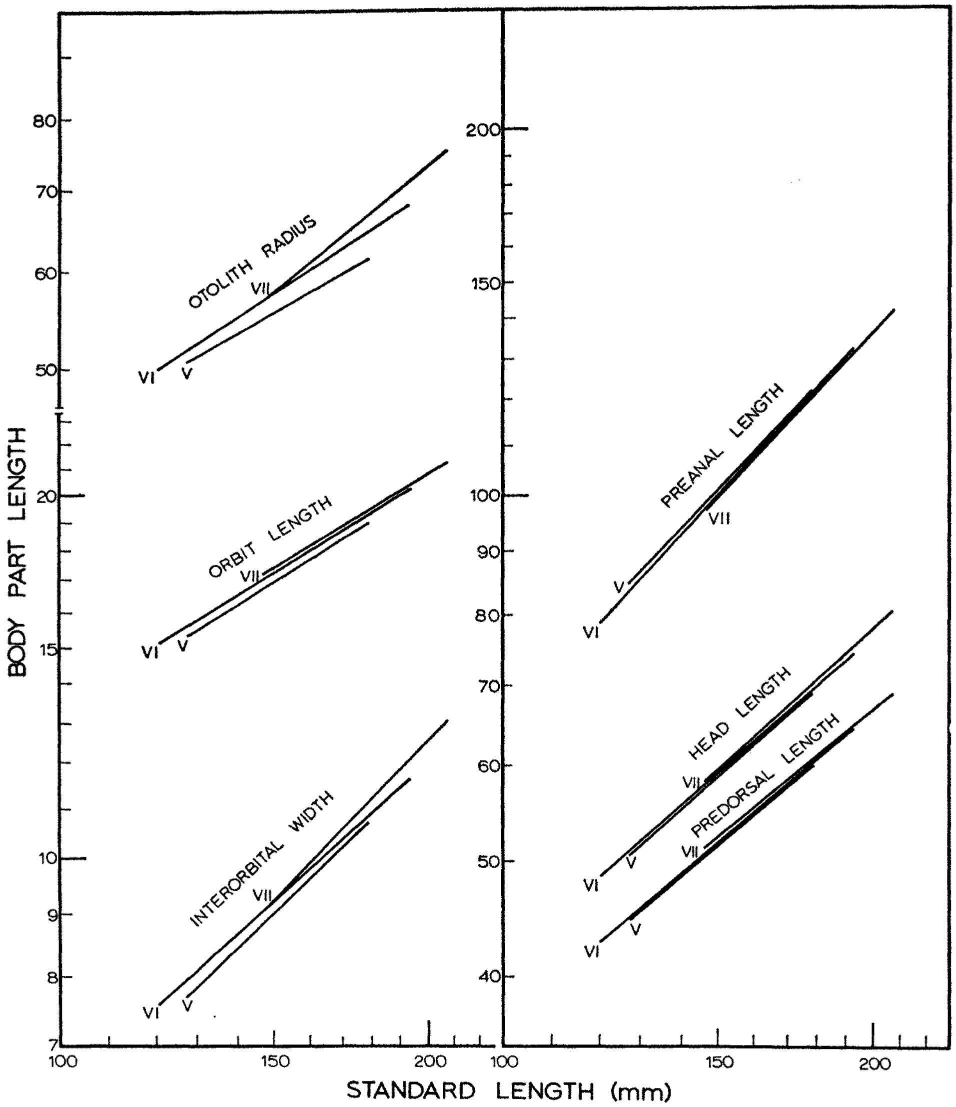

Fig. 9. Morphometric regressions of some selected body parts for fish of different age groups of the La Jolla sample of *S. umbrosws*, showing the effect of growth rate on body form.

The great deviation from isometric growth during early developmental stages, the number of different growth inflections during early developmental stages, and the intra- and interpopulation constancy of slopes of morphometric features over an extensive size range point to the importance of early developmental stages in the determination of morphometric characters. In conclusion, Martin stated that rate of early development and subsequent rate of growth may both influence body form through their effect on body size at growth inflection. In contrast, however, Hamai and Kyushin (1966) found in *Hexagrammus otakii* that temperature operated on the body part by altering the allometric slope instead of the intercept.

TABLE 25
INTERSPECIFIC AND GEOGRAPHIC MORPHOMETRIC VARIATIONS IN *Sebastomus*

	constellatus Tanner Bank-La Jolla	rosaceus Tanner Bank-La Jolla	umbrosus Tanner Bank-La Jolla	rosenblatti La Jolla-Guadalupe Is.	rosenblatti La Jolla-Ranger Bank	helvomaculatussimulator	rosenblattichlorostictus	rosenblattieos
Second anal spine	2	1	3	2	0	2	3	2
Gill-raker at angle	3	0	2	2	2	3	1	3
Third anal spine	2	3	2	2	3	2	3	3
2nd dorsal soft-ray	2	1	0	0	0	3	1	2
Orbit length	3	2	3	2	2	3	3	0
First, anal spine	0	1	0	0	0	0	0	0
Total length	2	3	0	2	0	0	2	0
Fourth dorsal spine	0	0	2	2	2	1	3	2
First anal soft-ray	2	3	0	0	0	2	1	2
Anal-fin base	3	2	0	0	3	2	3	2
Pelvic-fin length	3	3	2	0	0	2	3	2
Predorsal length	3	0	2	2	0	0	2	2
Lower peduncle length	0	0	0	0	0	2	2	1
Pectoral-fin length	3	3	2	2	0	0	2	2
Soft-dorsal base	0	0	0	0	2	2	0	2
Dorsal-fin incision	0	0	0	2	2	0	0	0
Caudal-peduncle depth	2	2	3	3	0	3	3	2
Upper peduncle length	2	0	0	0	0	0	1	0
Snout length	0	1	0	0	2	0	2	2
Prepelvic length	0	0	0	2	0	2	0	2
Spinous-dorsal base	0	2	0	2	2	0	0	2
Upper jaw length	3	0	0	2	1	2	2	2
Head length	0	1	2	2	2	2	2	2
Preanal length	0	2	0	0	0	0	0	2
Body depth	0	0	0	0	0	3	1	0
Head width	1	0	1	2	2	3	0	0
Lachrymal width	2	2	3	2	0	2	2	0
Interorbital	3	0	2	2	0	2	2	2

"0"—no difference, "1"—difference in slope, "2"—difference in intercept, "3"—differences in both slope and intercept.

In both individual variation and geographic variation, morphometric differences are often associated with differences in growth rates. However, with similar differences in growth rates, the directions of the associated morphometric differences are often different between individual variation and geographic variation. In Martin's experiments, within the same lot, fast-growing individuals had smaller heads and fins than slow-growing ones. Individuals from a lot of fast-growing fish may, on the other hand, have a relatively larger head and larger fins than those from a lot of slow-growing fish. It seems that individual variation and geographic variation are two entirely different events as far as morphometries are concerned.

In the present study covariance analyses were applied to test morphometric

TABLE 26

DIRECTIONS OF GEOGRAPHIC MORPHOMETRIC VARIATIONS IN *Sebastomus*

	Tanner Bank sample compared with La Jolla sample			Guadalupe Is. sample compared with La Jolla sample
	constellatus	*rosaceus*	*umbrosus*	*rosenblatti*
Second anal spine	>	—	>	>
Gill-raker at angle	>	—	<	>
Third anal spine	>	> <	>	>
2nd dorsal soft-ray	>	—	—	—
Orbit length	< >	<	>	>
Total length	>	> <	—	>
Fourth dorsal spine	—	—	>	>
1st anal soft-ray	>	> <	—	—
Anal-fin base	>	>	—	—
Pelvic-fin length	>	> <	>	—
Predorsal length	< >	—	>	>
Pectoral-fin length	>	> <	>	>
Dorsal-fin incision	—	—	—	>
Caudal-peduncle depth	>	>	>	<
Upper peduncle length	>	—	—	—
Prepelvic length	—	—	—	>
Spinous-dorsal base	—	>	—	<
Upper-jaw length	>	—	—	>
Head length	—	—	>	>
Preanal length	—	>	—	—
Head width	—	—	—	<
Lachrymal width	>	>	>	>
Interorbital	< >	—	>	>

< > —smaller in small individuals but larger in large individuals.
> < —larger in small individuals but smaller in large individuals.

differences between conspecific samples as well as between sympatric samples of different species (table 25). With the exception of body depth, geographic variation was observed in all the characters considered. Contrary to what would be expected from Martin's hypothesis, differences in slope occurred as often as differences in intercept between samples of a species from different localities. In some of the cases both slope and intercept are different. In comparing the samples from Tanner Bank and the samples from La Jolla in several of the species, it is found that for a given character, the difference between samples may be in slope in one species, in intercept in the next, and in both slope and intercept in another. There seems to be no consistency in the mode of difference between conspecific samples and between samples of different species. Shifting of the point of growth inflection is, in the present cases, apparently not so important in determining body form as suggested by Martin.

Different species occasionally respond differently, when subjected to similar physical environmental differences (table 26). Thus the eye is smaller in *S. rosaceus* from Tanner Bank than in the same species from La Jolla, but larger in *S. umbrosus* from Tanner Bank than in that species from La Jolla. The gill-raker at angle of first arch is longer in *S. constellatus* from Tanner Bank than in that species from La Jolla but shorter in *S. umbrosus* from Tanner Bank than in that species from La Jolla.

In view of the frequent occurrence of geographic variation, morphometric characters should be used most carefully in the taxonomy of *Sebastes*.

SEXUAL DIMORPHISM

In species of *Sebastes* the urogenital papilla is cylindrical in males but appears as a triangular flap in females (Moser, 1966). Otherwise, no sexual dimorphism is obvious externally. However, analyses of covariance indicate that in *S. umbrosus*, males tend to have lesser preanal length, but greater anal base, upper-jaw length, length of longest anal soft-ray, snout length, and prepelvic length than females ($P < .01$). Similar differences between sexes may exist in other species of *Sebastomus*.

CRANIAL SPINE PATTERNS AND MANDIBULAR SQUAMATION

The presence or absence and the degree of development of certain cranial spines are very important in the taxonomy of *Sebastes*. Lack of understanding of the variability of the spine pattern, however, led Gilbert and Cramer (Gilbert, 1896) to describe an abnormal specimen of *S. rosaceus* as *S. ayresii*. In the only extensive study of variation in cranial spine patterns in *Sebastes*, Hitz and DeLacy (1961) found that about half of the 751 specimens of *S. auriculatus* examined from the Puget Sound area had both coronal spines, a quarter of the specimens had only one, and the others were without either. In examining 49 specimens of this species from southern California, I found only one specimen with a single coronal spine, all others had both. The cranial spine pattern may vary geographically but it is also possible that the Puget Sound specimens examined by Hitz and DeLacy and the southern California specimens represent wholly or in part different species or subspecies. Coronal spines are generally absent in the species of *Sebastomus*. Among over a thousand of the specimens I have examined, I found both coronal spines in only two specimens, one of *umbrosus* and one of *helvomaculatus*; I found one coronal spine in three other specimens, one of *constellatus* and two of *umbrosus*.

The cranial spine pattern in species of *Sebastomus*, however, does show some variation (table 27). The supraocular spine, the postocular spine, and the tympanic spine are rarely absent, whereas the presence and absence of the nuchal spine and the spines on lower edge of the gill-cover are rather variable. Nuchal spine or spines are found rarely in specimens of *constellatus, helvomaculatus, rosaceus, ensifer, lentiginosus, umbrosus*, and *exsul*, but are found in nearly one-third of the specimens of *simulator, chlorostictus*, and *rosenblatti*, and in the majority of the specimens of *eos*. The spines on the lower edge of gill-cover are found consistently in specimens of *umbrosus, chlorostictus*, and *rosenblatti*, but are missing in nearly two-thirds of the specimens of *constellatus, helvomaculatus*, and *ensifer*, and in the majority of the specimens of *eos* and *simulator.*

Some degree of variation in mandibular squamation is obvious in species of *Sebastomus* (table 27). In specimens of *ensifer, lentiginosus, umbrosus, exsul, rosenblatti*, and *eos* the mandibles are consistently scaled. In *simulator*, the

TABLE 27 VARIATION IN CRANIAL SPINE PATTERN AND MANDIBULAR SQUAMATION IN *Sebastomus*

	Number of specimens in which the spine is absent[a]													
	N	Nuchal		Supraocular		Postocular		Tympanic		Spines on lower edge of gill-cover		Mandibular squamation[b]		
	1	2	1	2	1	2	1	2	1	2	0	1	2	
S. constellatus														
Tanner Bank	61	1	59	1	0	0	0	0	0	10	46	45	12	1
La Jolla	59	1	58	1	0	0	0	0	0	7	28	31	11	2
S. helvomaculatus														
Washington	55	2	52	0	1	0	0	0	0	5	33	45	2	5
Monterey	24	0	22	1	0	0	0	0	0	3	13	18	3	0
S. simulator														
34–30° N	16	2	11	0	0	0	0	0	0	1	13	2	8	3
Guadalupe Is	24	4	17	0	0	0	0	0	0	4	19	4	11	3
S. rosaceus														
Catalina Is	31	3	28	0	0	0	0	0	0	3	4	20	1	0
Tanner Bank	115	2	113	5	0	1	0	0	0	16	19	93	9	1
S. ensifer														
Total	37	1	36	0	0	0	0	0	0	7	24	0	0	32
S. notius														
Total	3	2	1	0	0	0	0	0	0	0	3	0	0	3
S. lentiginosus														
Total	23	0	23	1	0	0	0	0	0	3	2	0	0	23
S. umbrosus														
La Jolla	209	9	198	5	3	2	0	2	1	2	0	0	0	209
S. exsul														
Total	15	0	15	0	0	0	0	0	0	3	9	0	0	15
S. chlorostictus														
La Jolla	102	21	72	1	0	0	0	0	0	0	0	81	9	0
Others	35	3	32	0	0	0	0	0	0	0	0	28	4	0
S. rosenblatti														
La Jolla	90	24	57	1	0	0	0	1	0	0	0	0	0	90
Guadalupe Is	35	9	25	0	0	0	0	0	0	1	0	0	0	35
Ranger Bank	20	8	11	0	0	0	0	0	0	0	0	0	0	20
S. eos														
Total	42	11	6	0	0	0	0	0	0	11	28	0	0	38

[a] For the cranial spines, "1" = absent on one side, "2" = absent on both sides; specimens with both spines developed = number N — ("1" + "2").
[b] For mandibular squamation, "0" = naked, "1" = with patches of scales, "2" = completely scaled.

mandibles of the majority of the specimens are partially sealed. In specimens of *constellatus, helvomaculatus, rosaceus*, and *chlorostictus* the mandibles tend to be scaleless, although specimens with partially scaled mandibles are not uncommon and specimens with wholly scaled mandibles have also been found.

ZOOGEOGRAPHY

Most species of the genus *Sebastes* occur in the temperate North Pacific Ocean. Sixty-five species have been found in the eastern North Pacific (table 28), including five Gulf of California endemics (two as yet undescribed). At least three of the 65 (*S. polyspinis, S. alutus, S. aleutianus*, and possibly *S. melanostomus* and *S. ciliatus*) are transpacific, as they occur also off Kamchatka (Moiseev, 1935; Barsukov, 1964; and Schmidt, 1950). Except for the Gulf of California endemics, most of these species are limited to the warm-temperate to boreal waters north of the latitude of Magdalena Bay (25°N), but one species, *S. macdonaldi*, probably extends around the tip of Baja California, since it has been collected as far south as 23°24.0'N, 111°11.5'W (SIO 65–230), as well as in the Gulf of California (26°59.1'N, 111°48.9'W, LACM 8837–4). Matsubara (1955) listed 26 species from Asiatic waters of the western North Pacific, all as confined to that region. Three of these, however, have been synonymized by Barsukov (1964) with two American species (*S. melanostictus* and *S. kawaradai* with *S. aleutianus* and *S. paucispinosus* with *S. alutus*). One of the Asiatic species, *S. joyneri*, occurs as far south as Taiwan (22–25°N) (Matsubara, 1955; Chen, 1956). In the boreal North Atlantic, Templeman (1959) recognized three species but Tâning (1961) and others have accepted four. All these added to the form or forms in the southern hemisphere bring the total number of recognized species of *Sebastes* to nearly 100.

Many of the Asiatic species are related to American forms (Jordan and Starks, 1904; Jordan and Hubbs, 1925; Matsubara, 1943, 1955; Jordan and Evermann, 1898), but none seems to be referable to the speciose subgenus *Sebastomus* of the eastern North Pacific. On the other hand, all representatives of the genus in the southern hemisphere are referable to *Sebastomus* and are obviously of northern origin. The predominantly southern occurrence of *Sebastomus* species in the eastern North Pacific and the late-spring and early-summer (rather than winter) spawning habit of these forms (Moser, 1967) may explain the potential of the group to have crossed the tropics and the inability of the group to have crossed the Bering Sea, in appropriate Pleistocene time.

The forms occurring in the southern hemisphere are either conspecific or comprise a complex of closely related species, so that the crossing of the tropics was presumably a single event. In discussing antitropical distributions in fishes, Hubbs (1952) grouped *Sebastes* among those which presumably crossed the tropics through deep water during the Pleistocene. In the Gulf of California species of *Sebastes* are more or less confined to the vicinity of the Ballenas Channel (about 29°N), where winter surface temperatures (14°C) are the coolest and bottom temperatures the warmest (Roden, 1964). These species seem to take advantage of the cool surface water and spawn in the winter. Because the larvae are pelagic, the surface rather than the bottom temperatures could be the critical factor in crossing the tropics. The concept of submergence during the adult stage may not

TABLE 28 DISTRIBUTION OF EASTERN NORTH PACIFIC SPECIES OF *Sebastes*

Secies	Southernmost known end point	Northernmost known end point
S. polyspinis	Gulf of Alaska (Barsukov, 1964)	Western Pacific (Barsukov, 1964)
S. jordani	31°19'N, 116°38'W (SIO 60–71)*	48°23'N, 126°02'W (Westrheim and Pletcher, 1966)
S. paucispinis	29°05'N, 118°13'W (SIO 65–66)*	57°14'N, 136°13'W (Westrheim, 1966b)
S. brevispinis	33°34'N, 119°04'W (Strachan, 1965)	Bering Sea (Phillips, 1957)
S. goodei	Magdalena Bay, 24°N (Phillips, 1957)	50°40'N, 128°40'W (Westrheim, 1965)
S. hopkinsi	29°10'N, 118°16'W (SIO 66–18)*	Halfmoon Bay, 37°30'N (Phillips, 1968)
S. ovalis	30°54'N, 116°31'W (per. Robert Lea)	San Francisco, 38°N (Phillips, 1968)
S. rufus	29°02'N, 118°13'W (SIO 67–78)	San Francisco, 38°N (Phillips, 1968)
S. entomelas	San Diego, 32°40'N (SIO 60–473)	57°30'N, 150°27'W (Barsukov, 1964)
S. ciliatus	54°13'N, 132°42'W (Westrheim, 1968)	Bering Sea (Moiseev, 1935)
S. mystinus	Santo Tomas, 31°30'N (Phillips, 1957)	Bering Sea (Phillips, 1957)
S. melanops	34°03'N, 120°21'W (SIO 54–191)	Amichitka Is., 52°N, 179°E (Wilimovsky, 1964)
S. flavidus	La Jolla, 32°50'N (SIO 67–252)	59°49'N, 134°00'W (Westrheim, 1966*b*)
S. serranoides	28°18'N, 115°34'W (SIO 61–371)*	Shelter Cove, 40°N (Phillips, 1968)
S. pinniger	30°50'N (Phillips, 1957)	55°16'N, 134°07'W (Westrheim, 1966*b*)
S. miniatus	28°20'N, 115°30'W (UCLA 52–139)	Vancouver Is., 49°N (Phillips, 1957)
S. proriger	San Diego, 32°40'N (Phillips, 1957)	Bering Sea (Phillips, 1957)
S. crameri	33°25'N, 118°31'W (SIO 68–227)*	Bering Sea (Phillips, 1957)
S. macdonaldi	26°59'N, 111°49'W (LACM 8837–4)*	36°18'N, 122°04'W (Phillips, 1961)
S. reedi	43°11'N (Westrheim & Tsuyuki, 1967)	56°50'N (Westrheim & Tsuyuki, 1967)
S. alutus	La Jolla, 32°50'N (SIO 48–139)	Western Pacific (Barsukov, 1964)
S. wilsoni	32°30'N, 119°14'W (SIO 63–239)*	53°40'N, 131°30'W (Harling, 1966)
S. emphaeus	San Juan Is., 48°40'N (Starks, 1911)	
S. zacentrus	San Diego, 32°40'N (Phillips, 1957)	54°13'N, 161°37'W (Westrheim, 1965)
S. saxicofa	28°01'N, 115°03'W (SIO 52–124)	S.E. Alaska (Phillips, 1957)
S. Semicinctus	28°09'N, 115°27'W (SIO 62–92)	Pt. Conception, 34°30'N (Phillips, 1968)
S. elongatus	Cedros Is., 28°10'N (Phillips, 1957)	60°11'N, 147°26'W (Westrheim, 1966*a*)
S. babcocki	San Diego, 32°40'N (SIO 64–1025)*	55°05'N, 156°56'W (Barsukov and Lisovenko, 1965)
S. rubrivinctus	31°03'N, 116°22'W (SIO 68–18)*	Monterey?
S. levis	29°N, 118°W (SIO 65–70)*	39°49'N, 123°58'W (Odemar, 1964)
S. cortezi	26°N, 111°W (SU 17704)*	29°N, 113°30'W (SIO 62–239)
Species a	26°59'N, 111°49'W (LACM 8837–3)*	29°44'N, 113°58'W (SIO 68–89)*
Species b	28°55'N, 112°51'W (LACM 8818)*	28°58'N. 113°11'W (LACM 8821–11)*

* New range record. Collections without the asterisk are from end points of the ranges given by Phillips (1957, 1968), who did not refer to the source of his records.

TABLE 28 *(Continued)*

Secies	Southernmost known end point	Northernmost known end point
S. sinensis	28°35'N, 112°53'W (LACM 30065–1)	29°44'N, 113°58'W (SIO 68–89)
S. diploproa	30°30'N (SIO 47–161)*	Vancouver, 49°N (Phillips, 1957)
S. aurora	La Jolla, 32°50'N (SIO 64–335)	48°47'N, 126°35'W (Westrheim, 1968)
S. phillipsi	33°25'N, 118°W (SIO 65–153)*	Monterey, 36°36'N (Fitch, 1964)
S. aleutianus	Monterey, 36°36'N (Phillips, 1957)	Western Pacific (Barsukov, 1964)
S. melanostomus	Cedros Is., 28°10'N (Phillips, 1957)	Western Pacific? (Barsukov, 1964)
S. auriculatus	27°19'N, 114°40'W (per. Robert Lea)	S.E. Alaska (Phillips, 1957)
S. dallii	28°10'N (SIO 64–701)*	Morro Bay, 35°20'N (Phillips, 1968)
S. atrovirens	29°N (SIO 52–164)	Bodega Bay, 38°20'W (Phillips, 1968)
S. caurinus	Monterey, 36°36'N (SIO 65–356)	60°00'N, 147°26'W (Westrheim, 1966*a*)
S. vexillaris	28°20'N (SIO 62–279)*	53°40'N, 131°30'W (Phillips 1957)
S. maliger	Monterey, 36°36'N (Phillips, 1957)	60°N, 147°W (Hubbs & Schultz, 1941)
S. carnatus	San Roque, 27°10'N (Phillips, 1957)	Eureka, 41°N (Phillips, 1957)
S. chrysomelas	Ensenada, 31°50'N (Phillips, 1957)	Eureka, 41°N (Phillips, 1957)
S. nebulosus	Pt. Buchon, 35°10'N (Phillips, 1957)	S.E. Alaska (Phillips, 1957)
S. rastrelliger	28°50'N (SIO 52–168)	44°30'N, 124°10'W (van Arsdel & Bond, 1964)
S. serriceps	Cedros Is., 28°10'N (Phillips, 1957)	San Francisco, 38°N (Phillips, 1957)
S. nigrocinctus	Pt. Buchon, 35°10'N (Phillips, 1957)	S.E. Alaska (Phillips, 1957)
S. gillii	Ensenada, 31°50'N (Phillips, 1957)	Monterey, 36°36'N (Phillips, 1957)
S. ruberrimus	Ensenada, 31°50'N (Phillips, 1957)	Gulf of Alaska (Phillips, 1957)
S. constellatus	24°57'N, 112°36'W (SIO 68–5)*	San Francisco, 38°N (Phillips 1957)
S. rosaceus	Turtle Bay, 27°30'N (Phillips, 1957)	San Francisco, 38°N (Girard, 1858)
S. helvomaculatus	32°40'N, 117°30'W (SIO 56–5)*	56°24'N, 152°21'W (AB 67–63)*
S. simulator	28°52'N, 118°16'W (SIO 56–74)*	San Pedro, 33°35'N (UCLA 48–19)*
S. ensifer	28°25'N, 115°32'W (SIO 68–6)*	San Francisco, 38°N (Phillips, 1957)
S. notius	25°35'N, 113°21'W (SIO 64–29)*	29°09'N, 117°16'W (SIO 67–75)*
S. umbrosus	25°48'N (per. Robert Lea)*	Pt. Conception, 34°30'N (Phillips, 1957)
S. lentiginosus	32°27'N, 117°15'W (LACM 8961–3)*	33°29'N, 118°39'W (SIO 68–258)*
S. exsul	28°59'N, 113°26'W (SIO 68–1)*	
S. chlorostictus	Cedros Is., 28°20'N (Phillips, 1957)	47°11'N, 124°55'W (Hoover, 1964)
S. rosenblatti	28°31'N, 115°32'W (SIO 68–6)*	San Francisco? (Phillips, 1957)
S. eos	28°10'N (SIO 60–384)*	San Francisco? (Phillips. 1957)

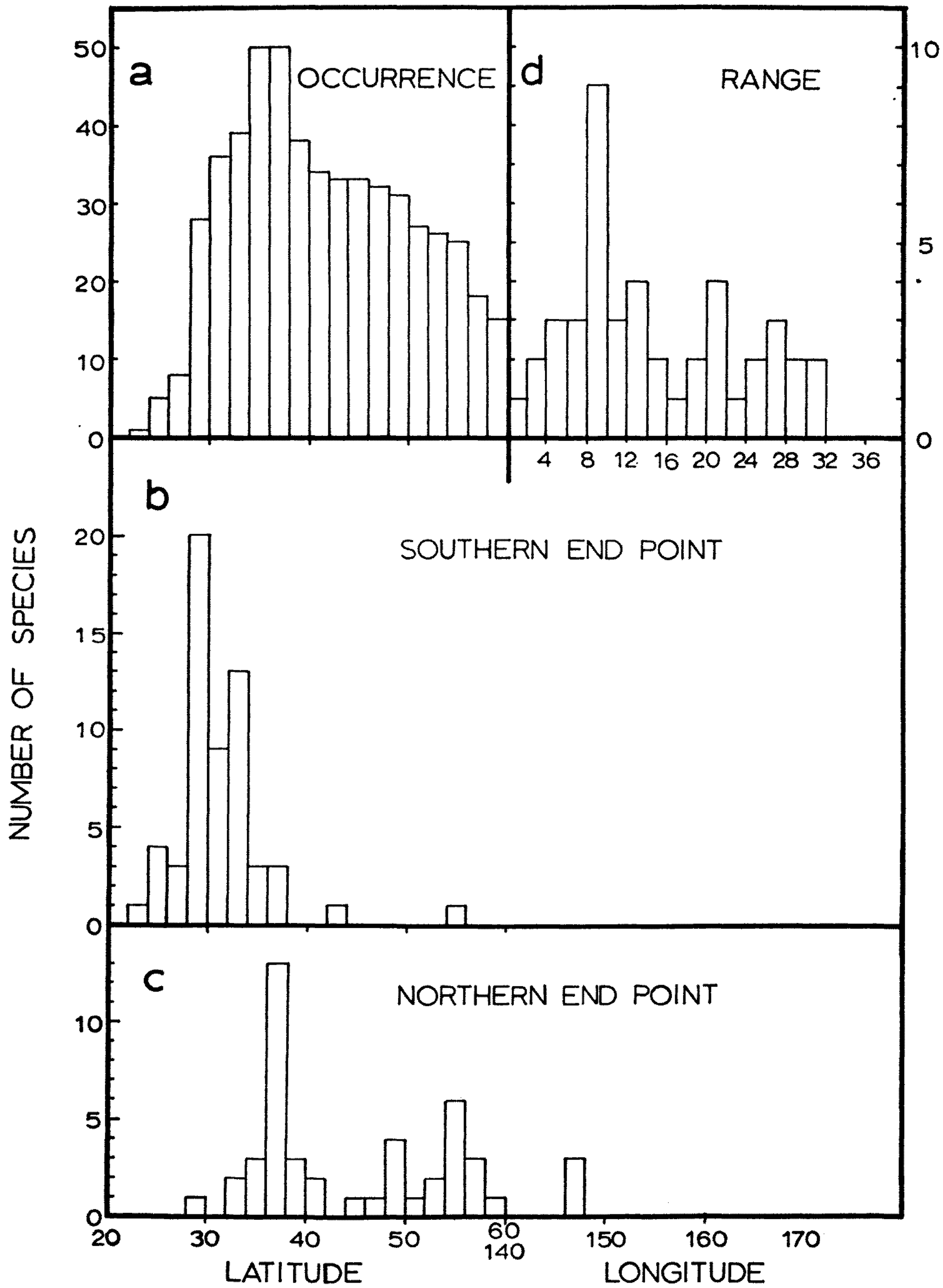

Fig. 10. Latitudinal occurrence, distribution of end points of ranges, and distribution of the lengths of ranges of the eastern North Pacific species of *Sebastes*.

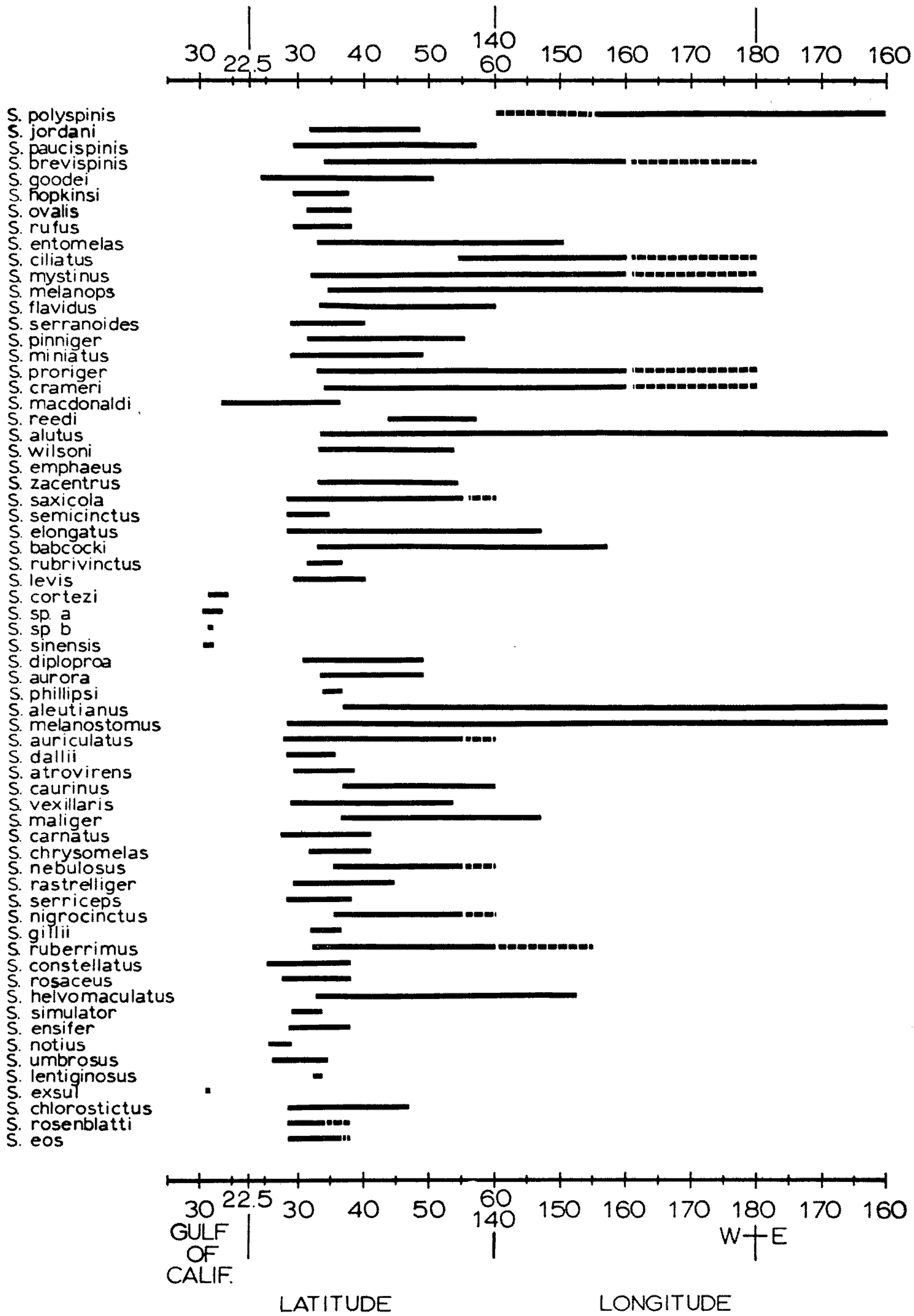

Fig. 11. Geographic ranges of the eastern North Pacific species of *Sebastes*.

be necessary in explaining the crossing of the tropics by *Sebastes*. The circumstance that winter surface temperatures in the tropics are generally about 26° C, about 9° C higher than the highest temperature (17.2° C, Ahlstrom, 1959) of the water from which *Sebastes* larvae have been found, is consistent with Hubbs's (1952) estimate of 8° C Pleistocene oceanic cooling as a condition for the crossing of the tropics by temperate forms.

DISTRIBUTION OF EASTERN NORTH PACIFIC SPECIES OF *Sebastes*

Detailed study of the pattern of the distribution of the species of *Sebastes* is precluded because of lack of precise data for the forms in the Atlantic, in Japan, and in the southern hemisphere. The known distribution of all of the eastern North Pacific species, however (table 28, fig. 10a-d and 11), allows some interpretations.

The eastern North Pacific species of *Sebastes* exhibit considerable diversity in respect to: the number of species occurring at various latitudes (fig. 10*a*); the latitude of the southern end point of the range (fig. 10*b*); the latitude and longitude of the northern end point of the range (fig. 10*c*); and the frequency distribution of the ranges in terms of the number of degrees of latitude and longitude covered by the range of the species (fig. 10*d*). Since *Sebastes* species generally occur along the coast, the abscissas of these diagrams represent the coast line, scaled with degrees of latitude from California northward to 60°N, and, beyond that latitude, because the coast line turns westward, with degrees of longitude. In these analyses, *S. emphaeus* and the Gulf of California endemics are excluded.

The majority of the species of *Sebastes* occurs between 34° and 38°N (fig. 10*a*). As many as 50 species are found within this latitudinal range; an amazing degree of congeneric sympatry. Only six degrees southward, at 28°N, the number of recorded species drops from 50 to 8. From 38° to 40°N, there is an abrupt drop of 12 species, but from 40°N northward, the species drop out gradually, on the average at the rate of about one for every degree of latitude. Tarp (1952) indicated a similar distribution pattern for the species of the Embiotocidae, another taxon that is notably diverse in the eastern North Pacific. In that group a majority of the species occur between 33° and 37°N, and the species drop out southward and northward in a similar pattern. The transition zone between the tropical Panamic faunal region and the temperate North American faunal region has been placed at approximately from 23° to 25°N, from Cape San Lucas to Bahia Magdalena area (Hubbs, 1960). This area corresponds well with the existence of an oceanic front (Cromwell and Reid, 1956; Reid, Roden, and Wyllie, 1958), but seems to be too far south to explain the southward dropout of the species of *Sebastes* and Embiotocidae. Extensive collections by the Scripps Institution of Oceanography indicate that the tropical fauna reaches Magdalena Bay and that the transition zone may extend to Bahia Sebastian Vizcaino, at about 28°N (Richard H. Rosenblatt and Carl L. Hubbs, personal communications).

Forty-two known southern end points of range lie between 28° and 34°N; 20 within a two-degree range, between 28° and 30°N (fig. 10*b*).

The northward dropout of species follows a strikingly different pattern (fig. 10*c*). There appear to be more than one peak. Forty-three known end points lie between 28° and 60°N (32 degrees of latitude) but 13 are between 2 degrees (36° and 38°N). The prominent peak about 36–38°N seems to suggest some kind of a barrier through which many of the species of *Sebastes* do not pass. However, this region hardly corresponds with the distribution of sea surface temperature, the parameter that is generally considered to be most important in limiting the distribution of marine organisms. The sharpest gradient in surface temperature in this area is generally indicated to be near Point Conception, at about 34°N.

An analysis of the frequency distribution of the ranges in terms of the number of degree of latitude (southward) and of longitude (northward) covered (fig. 10*d*, excluding ranges longer than 32°) shows that the distribution is possibly polymodal, but that, in general, species are either of short range or of intermediate range, with a break between 14 and 20 degrees. Most prominent is the peak at 8–10 degrees, for nine species.

Several points of distributional and speciational significance seem to appear when the actual ranges of all the eastern North Pacific species of *Sebastes* are so arranged that those believed to be related are placed together (fig. 11). It seems clear from this analysis that short-range species generally occur south of 30–40°N (possibly limited by the barrier discussed above), and that species of intermediate and long range are capable of crossing this barrier, to range from 28–34°N to 50–60°N, or farther westward. Furthermore, it appears that each species pair or species group often includes species of long or intermediate range as well as those of short range. For example, in one apparent species pair, *S. serranoides* has a short range and *S. flavidus* has a long range. The same is true for the apparent species pairs *semicinctus* and *saxicola, rubrivinctus* and *babcocki, simulator* and *helvomaculatus*, and *serriceps* and *nigrocinctus*; for the species group comprising *hopkinsi, ovalis, rufus*, and *entomelas*; and for the group constituted by *caurinus*, vexillaris, maliger, carnatus, chrysomelas, and *nebulosus*. These relationships suggest strongly that species differentiation has followed the successful breakthrough of the area at about 36–38°N.

The close relationship between certain North American and Japanese forms and the existence of some transpacific forms today, already referred to, support the idea that the successful crossing of the Bering Sea has led to speciation.

Although geographic speciation explains in part the abundance of the species of *Sebastes*, sympatric speciation should not be excluded. Barsukov (1964) has suggested that new species of *Sebastes* may evolve through shifting of bathymetric preference or bottom association or both. An analysis of the known bathymetric ranges of the species of *Sebastomus*, although not yet very precise, clearly shows that each species has its characteristic depth range (fig. 12). Bathymetric segregation is indicated between the two closely related sympatric species, *rosaceus* and *simulator*, which respectively inhabit rather shallow and only deep water. The same may also be true for *ensifer* and *notius*. Members of another subgroup of *Sebastomus* show bathymetric segregation: *chlorostictus* occurs in shallower waters, *rosenblatti* in deeper waters, and *eos* goes still deeper. The recorded overlaps in the bathymetric distribution of related species is in part amplified by the circumstances that younger fish occur in shallower waters and associate with the

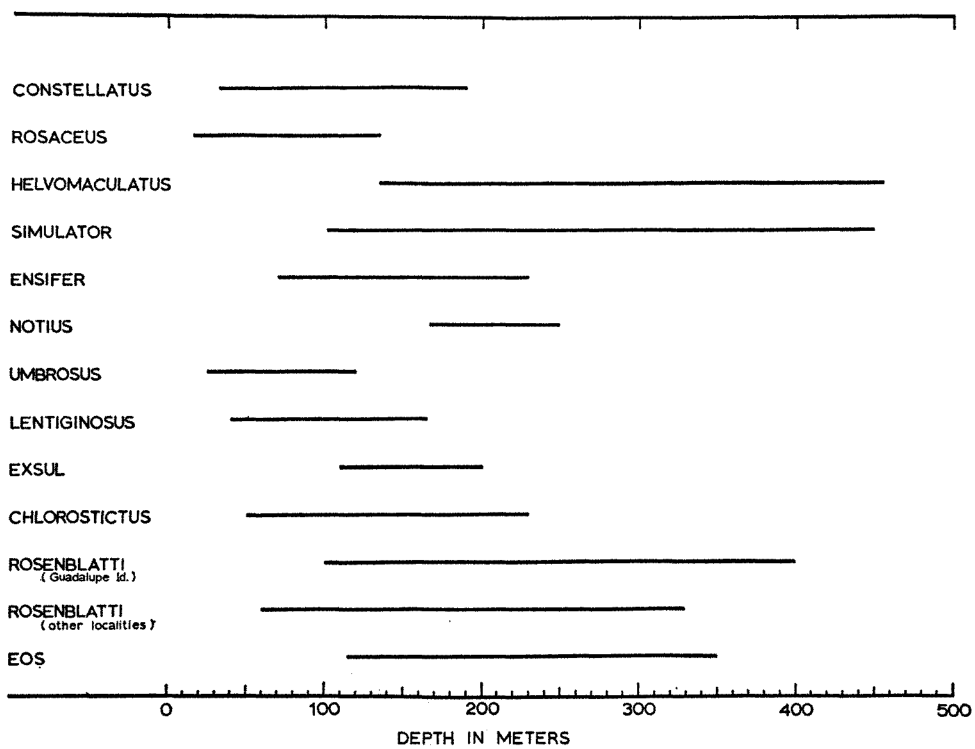

Fig. 12. Bathymetric distribution of the species of *Sebastes* referable to the subgenus *Sebastamus*.

adults of shallower-water forms, and that the depth range for a given species varies with locality (as is indicated by the occurrence of *rosenblatti* in deeper water about Guadalupe Island than elsewhere).

BIOLOGY

GROWTH

DETERMINATION OF AGE

Since scales of adults of the species of *Sebastomus* were found to be predominantly regenerated, otoliths (sagittae) were used for age determination. The sagitta can be removed without material damage to the fish by lifting the gill-cover and opening the prootic bone. All otoliths were examined when fresh. In water, over a dark background, they appear to have an opaque nucleus, surrounding which are alternating hyaline and opaque rings. Fish otoliths are composed mainly of $CaCO_3$, CaO, and organic matter (Lunde, 1929; Dannevig, 1956; Fitch, 1951). The opaqueness comes from the organic matter.

Growth is the difference between the amount of nutrient intake and the maintenance requirement. It is affected by temperature, food supply, and many other environmental factors. Since all these factors usually fluctuate annually, the rate of growth in fishes generally also fluctuates with an annual cycle. As the addition of organic matter to the otolith is probably related to the rate of growth of the

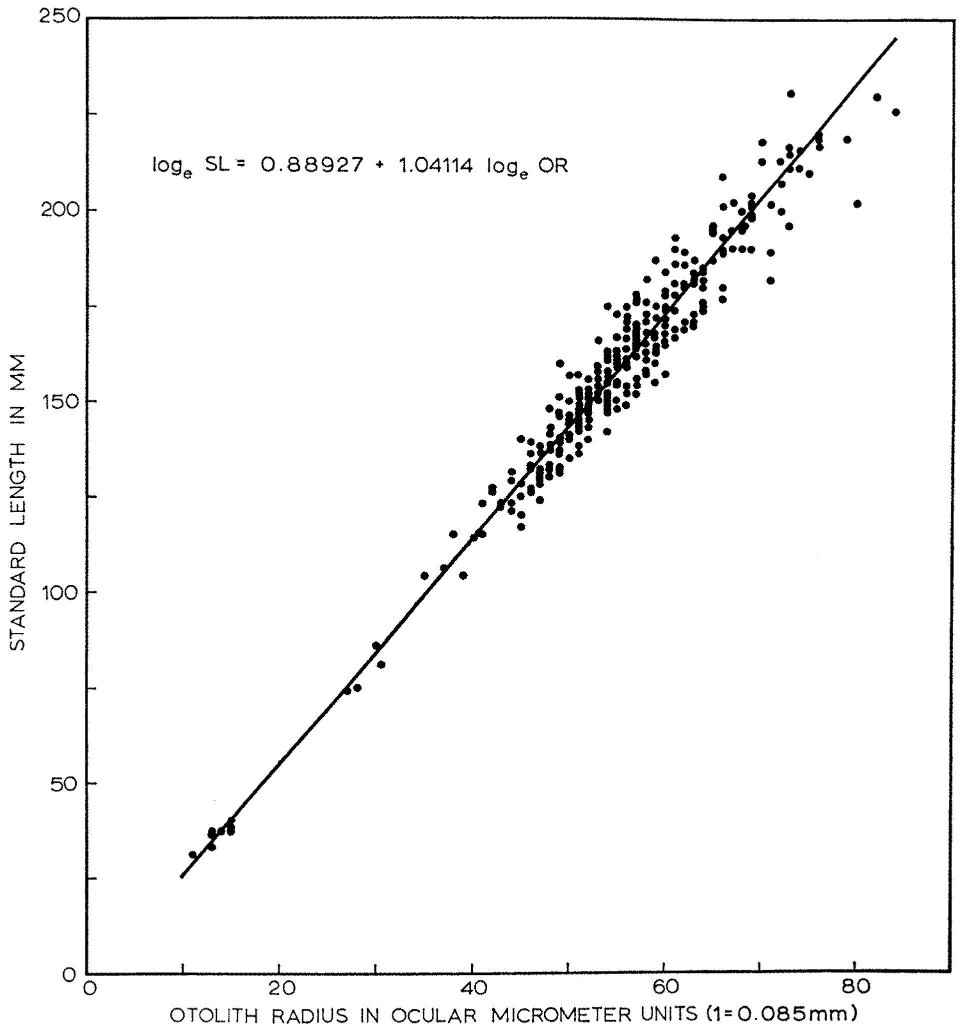

Fig. 13. Relation of otolith radius to standard length for *Sebastes umbrosus* at La Jolla.

fish, an opaque ring and a hyaline ring are added to the otolith each year. In *Sebastes*, such ring formation has been demonstrated for *S. marinus* by Kelly and Wolf (1959) and for *S. inermis* by Mio (1960). In the present study the opaque nucleus is considered as the first year's growth and each surrounding pair of hyaline and opaque rings as an additional year of growth.

GROWTH OF Sebastes umbrosus

Because of the large number (273) of available specimens and because of the completeness of the size range, the growth of *Sebastes umbrosus* was studied in greatest detail. The material was obtained in La Jolla Submarine Canyon, where the species abounds.

Under a 7X wide-field binocular microscope equipped with a calibrated ocular micrometer (8.5 mm per 100 scale units), the anterior radius of the opaque nucleus and of each suceeding opaque ring-pair (from center of otolith to outer anterior edge of the opaque ring) of either the left or the right otolith of each fish were measured. Using the average radius of each annulus and an equation ($\log_e Y = 0.88927 + 1.04114 \log_e X$) derived from the fish length (Y) and otolith radius (X) data (fig. 13), lengths of the fish at various ages were back-calculated. On this basis, a Bertalanffy growth equation:

$$L_t = L_\infty(1 - e^{-k(t-t_0)})$$

was derived, using methods described by Ricker (1958). In the equation, L_t denotes standard length at age t, L_∞ denotes the average theoretical maximum length, k is a constant indicating the degree of curvature, and t_o is the t value when $L_t = 0$. As the spawning season of *S. umbrosus* ranges from March to July and young of the year with otoliths equal in size to a normal otolith nucleus have been found in November, what is considered here to be the growth of the first year is actually the growth of only about six months. For this reason, in deriving the Bertalanffy equation, data of first-year's growth were discarded. Because of the small sample size, data of growth beyond 10 years of age were also discarded in deriving the equation. With the Bertalanffy equation, theoretical lengths at different ages were calculated. Based on these and the derived weight (W) and length (L) relationship:

$$\log_e W = -11.34475 + 3.19694 \log_e L$$

the theoretical growth in weight was also estimated.

Data on the observed length, the back-calculated length, the theoretical length, the theoretical weight, the annual length increment, and the annual weight increment of each age (table 29) indicate that *S. umbrosus* grows very slowly and that the annual length increment decreases year after year, until, at older ages, the increment is less than 1 cm per year. Individual growth varies widely. The observed standard lengths range from 122 mm to 166 mm for the five-year-old fish, 117 mm to 178 mm for the six-year-old fish, and 139 mm to 190 mm for the seven-year-old fish. In contrast to the length increment, the weight increment increased year after year until the fish reached eight years of age, from then on it decreased year after year. The oldest individual obtained was 17 years old. The largest individual obtained was 231 mm standard length. This 231 mm is greater than the theoretical maximum length of 224 mm. Although it is not known whether 224 mm is really indicative of the average individual growth potential, it is an average value and is expected to be smaller than individual extremes.

Presented in table 29 in parentheses behind each of the observed length is the number of specimens of the age. Since except when very small, *S. umbrosus* at all sizes seems to be equally available by my collecting methods, the relative abundance of individuals of various age groups presumably approximates the actual age structure of the population, although fish younger than four or five years are underrepresented. The sudden drop in the number of individuals from age group 7 to age group 8 could reflect age-related migration. This, however, is not supported by evidence at hand. Extensive collections over two years at other depths and localities have not revealed aggregations composed of a high proportion of older individuals. Most migrations in fishes are related to feeding or reproduction (Harden Jones, 1968). However, *S. umbrosus* matures at 3–5 years rather than 7–8 years, and there is no evidence that there is a shift in diet necessitating a movement between the 7th and 8th years. Furthermore, the geographic morphometric variation between nearby populations indicates that movements of adults cannot be extensive. The alternative explanation for this drop in abundance between 7th and 8th years would be mortality. As individual variation in the rate of growth is great, such mortality would appear to be age specific rather than size specific.

TABLE 29 GROWTH OF *Sebastes umbrosus* AT LA JOLLA

Age		Standard length (in mm)		Theoretical body weight (in gm)	Annual increment	
	Observed*	Back calculated*	Theoretical	Length	Weight	
1		42.5 (184)	56.9	5.1	56.9	5.1
2		75.9 (263)	78.3	14.4	21.4	9.3
3	111.1 (4)	97.2 (267)	97.0	28.7	18.7	19.5
4	122.3 (14)	114.4 (262)	113.3	47.2	16.3	21.9
5	139.2 (41)	128.9 (238)	127.6	69.1	14.3	24.0
6	150.2 (60)	140.8 (186)	140.0	93.1	12.4	25.1
7	163.0 (59)	151.3 (123)	150.8	118.2	10.8	25.5
8	174.4 (22)	158.8 (74)	160.2	143.7	9.4	25.0
9	176.1 (19)	167.5 (59)	168.4	168.7	8.2	24.2
10	187.3 (13)	176.2 (39)	175.5	192.9	7.1	22.9
11	190.9 (11)	184.6 (27)	181.8	215.8	6.3	21.5
12	194.6 (6)	192.6 (20)	187.2	237.3	5.4	19.8
13	202.1 (6)	200.7 (14)	191.9	257.1	4.7	18.1
14	209.1 (5)	209.6 (9)	196.1	275.4	4.2	16.6
15	230.0 (1)	197.8 (3)	199.7	292.0	3.6	15.0

* Numbers in parentheses indicate number of specimens.

All the theoretical lengths correspond well with the back-calculated lengths (except the length of the first year, but this was to be expected as the back-calculated length at age one represents only about six-months' growth). It seems that the Bertalanffy equation describes the growth of *S. umbrosus* rather well. Correspondence between observed length and back-calculated length is not so good. Every one of the observed lengths is greater than the corresponding back-calculated length. The back-calculated length at age N is the average length of the fish at the time when the Nth annulus has just finished its formation. The observed length at age N is the average length of the individuals with a completely formed Nth annulus as well as with a partially formed ($N+1$) th annulus. Thus an observed length should always be greater than the corresponding back-calculated length. Furthermore, the back-calculated length at age N is based on measurements of all the Nth otolith annuli, including many from fish older than N years. If fish mortality is size dependent, in a population, older fish would tend to be the slow-growing ones. Back-calculated length, which is based on more older fish, thus, on more slow-growing fish than the observed length, would then be less than the observed length.

To test whether older fish would tend to be the slow-growing ones, the otolith measurement data were divided into groups according to the age of the fish from which the otolith was collected. A comparison of the mean and 95 percent confidence intervals of the radii of various otolith annuli of each of these groups (fig. 14) renders it obvious that, starting from age 7 (the age at which increased mortality probably started to occur), fish of older age tend to be the slow-growing ones. Since these are only otolith measurements and since slow-growing fish would tend to have larger otoliths than fast-growing ones (fig. 9), the actual discrepancy

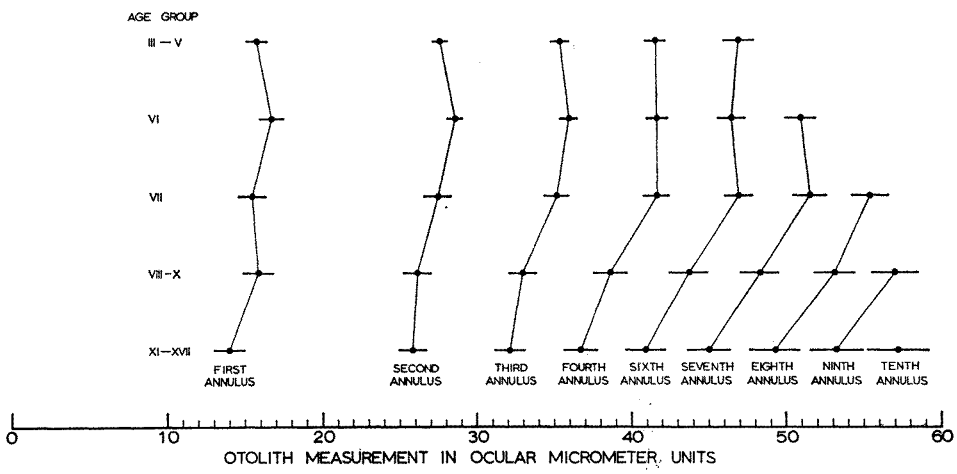

Fig. 14. Lee's phenomenon, the discrepancy in the calculated growths between age groups, as indicated by otolith measurements, in the La Jolla sample of *S. umbrosus*.

in size at a given age between age groups is presumably even more pronounced. A similar situation, called Lee's phenomenon, has been found in many other fishes. It has been explained as resulting from one of several reasons: (1) methodological error in calculating growth, (2) fishing selectivity, (3) size segregation of the fish, or (4) size dependence of mortality. This problem has been reviewed by Zamakhaev (1964). As the correlation between body size and otolith radius is good (fig. 13), there is no reason to suspect a systematic error in calculation. I cannot accept explanation (1). I also reject explanations (2) and (3) for reasons given previously. Thus the possible explanation left would be that mortality is size dependent, that is, slow-growing fish live longer. However, this contradicts the idea that age specific mortality occurred at about age 8.

To call a fish fast-growing or slow-growing involves the assumption that growth of a fish is related to its previous growth; that is, a fast-growing fish remains fast-growing. This is not in consonance with a phenomenon known as compensatory growth, which results in a decrease in size discrepancy between individuals with increasing age. This phenomenon has been discussed in detail by Zamakhaev (1964). To test for compensatory growth, coefficients of correlations

TABLE 30

COEFFICIENTS* OF CORRELATION IN THE AMOUNT OF GROWTH IN THE OTOLITH BETWEEN AGES—FEMALES OF *Sebastes umbrosus* AT LA JOLLA

Age	2	3	4	5	6	7	8	9	10	11	12	13	14
1...	−.27	−.12	.03	.00	.00	−.13	−.29	.18	.09	−.04	.98		
2...		−.09	−.04	.10	−.23	−.09	−.22	−.22	.07	−.13	−.87		
3...			.24	.15	.01	.04	−.10	−.03	−.06	.50	.02	.94	.45
4...				.39	.13	.03	.42	.25	.29	.01	−.31	.37	
5...					.27	.01	.32	.02	.01	−.15	−.28	.61	
6...						.37	.21	.26	−.10	−.08	−.08	−.34	−.43
7...							.58	.43	.40	.28	−.11	.50	.71
8...								.16	.44	.21	−.70	.63	
9...									.63	.33	−.34	.79	.43
10...										.41	.11	.86	.85
11...											.09	.92	.71
12...													.71

* Coefficients enclosed by rectangles are significant at $p < .05$ level. Solid rectangle indicates positive correlation, dotted rectangle indicates negative correlation.

TABLE 31

COEFFICIENTS* OF CORRELATION BETWEEN RADII OF ANNULI IN THE OTOLITHS OF THE MALES OF *Sebastes umbrosus* AT LA JOLLA

Age	2	3	4	5	6	7	8	9	10	11	12	13	14
1...	.71	.53	.48	.50	.40	.33	.46	.41	.38	.49	.41	.67	
2...		.87	.77	.70	.64	.51	.54	.55	.55	.71	.77	.82	.88
3...			.93	.86	.79	.65	.65	.60	.61	.72	.69	.44	.61
4...				.95	.90	.80	.76	.69	.68	.78	.77	.48	.57
5...					.97	.90	.86	.75	.69	.75	.74	.47	.58
6...						.96	.90	.82	.72	.76	.76	.49	.59
7...							.96	.92	.86	.86	.80	.53	.67
8...								.97	.91	.92	.90	.73	.84
9...									.97	.95	.93	.80	.92
10...										.98	.95	.89	.98
11...											.99	.95	1.00
12...												.99	.99
13...													1.00

* Coefficients enclosed by solid lines are significant at $p < .01$ level. Coefficients enclosed by dotted lines are significant at $p < .05$ level.

between annual increments in the radius of otolith were calculated (table 30). There is a slight indication of negative correlation between growth in the first year and growths in the subsequent years (also noted for *S. rosaceus* from Tanner Bank). It is not known, however, whether the discrepancy in growth in the first year was due to differences in growth rates between individuals or because of differences in the time of birth. Compensatory growth thus is not obvious in the present study. On the other hand, significant positive correlations along the diagonal line in table 30 indicate that rapidity or slowness in the rate of growth often

TABLE 32 OTOLITH GROWTH OF MALES AND FEMALES OF *S. umbrosus* AT LA JOLLA

Age		Male		Female
N	Mean radius*	N	Mean radius*	
1	75	15.8 ± 0.5	91	15.5 ± 0.5
2	106	27.3 ± 0.4	132	27.2 ± 0.4
3	107	34.5 ± 0.5	137	34.6 ± 0.4
4	107	40.2 ± 0.6	135	40.5 ± 0.5
5	99	45.1 ± 0.8	123	45.4 ± 0.6
6	81	48.8 ± 1.0	92	49.6 ± 0.7
7	55	52.2 ± 1.1	59	53.2 ± 1.1
8	36	54.9 ± 1.5	32	55.5 ± 1.5
9	28	57.5 ± 1.7	25	58.4 ± 1.7
10	18	60.2 ± 2.1	19	61.7 ± 2.2
11	14	63.4 ± 2.7	12	64.3 ± 2.9
12	12	66.3 ± 3.3	8	67.0 ± 3.4
13	8	68.0 ± 3.1	6	71.0 ± 4.5
14	5	69.6 ± 5.3	4	75.5 ± 8.2

* In ocular micrometer unit, with 95% confidence limit.

continued for a year or two (as is also indicated for *S. rosaceus* from Tanner Bank).

There is no good evidence of compensatory growth or correlation between early growth and latter growth. However, the highly significant positive correlations between radii of annuli shown in table 31 indicate that a fish that grew fast in early years would keep the advantage it had gained and continue to be larger.

So far, all the discussions on growth are based on the pooled sample of males and females. Growth patterns in fishes often differ between sexes, however. In *S. umbrosus*, during the reproductive season, ovaries at times are found to comprise 20 percent of the body weight, whereas testes generally weigh no more than 1 percent of the body weight. In mature fish, annual reproductive drain could be serious in females but not in males. Under such circumstances one would expect that adult males would grow faster than adult females. However, Kelly and Wolf (1959) indicated that the reverse is true in *S. marinus*, in which females grew much faster than males after reaching sexual maturity. Table 32 compares otolith measurements of males *S. umbrosus* with those of females *S. umbrosus*. Surprisingly there does not seem to be any sexual difference in growth.

The growth of *S. umbrosus* at La Jolla has been compared with that of 25 specimens of *S. umbrosus* from Tanner Bank (table 33). This species appears to grow faster at La Jolla than at Tanner Bank. The discrepancy in back-calculated length between La Jolla and Tanner Bank fish is highest at age 3 (15 mm) and the difference remains significant until age 8. The greatest discrepancy in theoretical body weight between fish from the two localities is found at age 7, at which, on the average, La Jolla fish outweigh those from Tanner Bank by

TABLE 33 GROWTH COMPARISON BETWEEN *S. umbrosus* FROM LA JOLLA AND TANNER BANK

Age		Back-calculated length			Theoretical body weight	
La Jolla*	Tanner Bank*	Difference	La Jolla	Tanner Bank	Difference	
1	42.5 ± 1.1	34.8 ± 2.3	7.7	5.1	1.5	3.6
2	75.9 ± 1.0	63.8 ± 3.2	7.9	14.4	6.2	8.2
3	97.2 ± 1.1	82.2 ± 4.5	15.0	28.7	15.3	13.4
4	114.4 ± 1.3	100.1 ± 5.4	14.3	47.2	29.0	18.2
5	128.9 ± 1.6	114.1 ± 6.0	14.8	69.1	46.9	24.2
6	140.8 ± 2.0	125.8 ± 6.2	15.0	93.1	68.4	24.7
7	151.3 ± 2.6	137.1 ± 6.3	14.2	118.2	92.7	25.5
8	158.8 ± 3.7	147.4 ± 8.2	11.4	143.7	119.1	24.6
9	167.5 ± 4.0	156.7 ± 9.6	10.8	168.7	146.8	21.9
10	176.2 ± 5.2	171.0 ± 11.4	5.2	192.9	175.2	17.1
11	184.6 ± 6.6	178.8 ± 11.4	5.8	215.8	203.6	12.2
12	192.6 ± 8.0	186.5 ± 14.7	6.1	237.3	231.6	5.7
13	200.7 ± 8.9	194.7 ± 14.5	6.0	257.1	259.0	-1.9
14	209.6 ± 15.5	196.1 ± 18.1	13.5	275.4	285.3	-9.9
15	197.8 ± 11.5	199.9 ± 19.8	-2.1	292.0	310.4	-18.4

* With 95% confidence limit.

25 grams. The Tanner Bank fish may have a slower but more prolonged growth than the La Jolla fish, but the small size of the Tanner Bank sample precludes any conclusion. Taylor (1958), Holt (1959), and Beverton and Holt (1959) found that a change in environmental temperature alters the curvature constant "k" as well as the maximum length "L_∞" of the Bertalanffy growth equation in fishes, whereas changes in nutrient supply alter only the maximum length "L_∞". The value of k, L_∞, and t_o of the La Jolla and of the Tanner Bank *S. umbrosus* are presented in table 34. Although differences are found both in k and L_∞, it is not known if physical environmental differences can be the explanation. The Tanner Bank fish have a larger theoretical maximum length than those at La Jolla. Although actual data do not support the indication that *S. umbrosus* grows larger at Tanner Bank than at La Jolla, other species of *Sebastes* are found to grow much larger at Tanner Bank than at La Jolla. It is generally true that slow-growing individuals can reach to a larger final size than fast-growing ones. It may also be that because of the lighter fishing pressure, however, fish at Tanner Bank live longer,

TABLE 34

PARAMETERS OF THE BERTALANFFY EQUATION, KNOWN MAXIMUM AGE AND LENGTH, WEIGHT AND LENGTH RELATIONSHIP, AND AGE AND SIZE AT SEXUAL MATURITY IN 15 SPECIES OF *Sebastes*

Species[a]	Known maximum		Bertalanffy parameters			Weight-length $W = aL^b$		Sexual maturity	
age	size[b]	L_∞	k	t_o	$log_e\ a$	b	age	size	
S. paucispinis	30	709	667	0.14784	-0.64			3	291
S. pinniger	22	550	537	0.12235	-0.40			3	198
S. miniatus	22	533	564	0.09841	-0.69			3	187
S. flavidus	24	475	430	0.17249	-0.32			3	229
S. crameri	30	467	412	0.15653	-0.12			5	229
S. goodei	16	459	454	0.18204	-0.23			2	182
S. entomelas	16	438	432	0.21456	-0.11			3	250
S. chlorostictus	25	347	392	0.05820	-0.87	- 11.37161	3.18	10	211
S. diploproa	18	332	343	0.12251	-0.41			4	156
S. saxicola	17	270	268	0.14738	-0.60			2	104
S. jordani	10	250	258	0.27520	-0.27			2	125
S. rosaceus from Tanner Bank	18	247	202	0.17416	-1.13	- 12.98497	3.52		
S. umbrosus from Tanner Bank			249	0.10926	-0.54	- 11.35964	3.22		
La Jolla	17	230	224	0.13733	-1.13	- 11.34475	3.20	3	106
S. ensifer	17	190	176	0.14126	-1.04				114
S. dallii	12	157	162	0.12196	-2.95				

[a] The species are arranged in inverse order of maximum known size.

[b] Maximum sizes reported by Phillips as total lengths, which are here converted to standard lengths by applying a factor of 0.82.

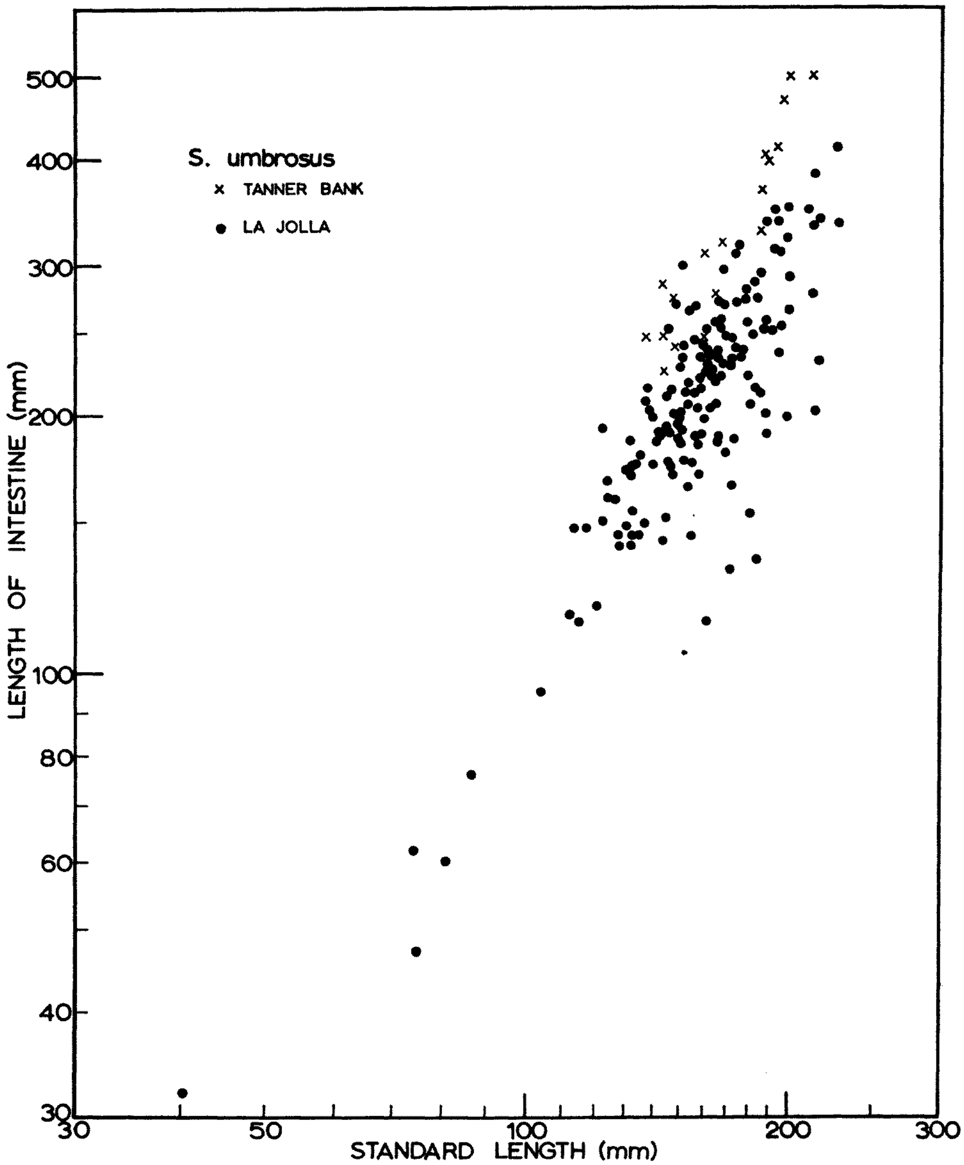

Fig. 15. Discrepancy in the length of intestine between the La Jolla and the Tanner Bank samples of *S. umbrosus*.

get bigger, and with a higher population density, their growth has thus been suppressed.

Since growth is an accumulation of anabolic products, it is often thought of as being limited by the respiratory surface and/or intestinal absorptive surface (von Bertalanffy, 1960). However, the slow-growing individuals of *S. umbrosus* from Tanner Bank are found to have longer intestines than the fast-growing individuals from La Jolla (fig. 15). Individuals of *S. rosaceus* from Tanner Bank also have longer intestines than those from La Jolla.

TABLE 35 GROWTH OF *Sebastes rosaceus* AT TANNER BANK

Age	Standard length (in mm)		Theoretical body weight (in gm)	Annual increment	
	Back-calculated*	Theoretical		Length	Weight
1	51.2 ± 1.1 (205)	62.5	4.8	62.5	4.8
2	84.4 ± 1.3 (226)	84.8	14.2	22.3	9.3
3	105.0 ± 1.2 (231)	103.5	28.6	18.7	14.4
4	119.8 ± 1.2 (227)	119.2	47.0	15.7	18.4
5	131.9 ± 1.2 (231)	132.4	68.0	13.2	21.0
6	143.2 ± 1.3 (228)	143.5	90.3	11.1	22.3
7	152.2 ± 1.5 (201)	152.9	112.7	9.3	22.4
8	160.2 ± 1.8 (162)	160.7	134.4	7.8	21.7
9	167.3 ± 2.2 (117)	167.3	154.8	6.6	20.4
10	173.2 ± 2.8 (64)	172.8	173.6	5.5	18.8
11	178.4 ± 3.8 (40)	177.5	190.6	4.7	17.0
12	176.1 ± 5.8 (15)	181.4	205.8	3.9	15.2
13	177.1 ± 13.2 (6)	184.6	219.2	3.3	13.4

* With 95% confidence limit; numbers in parentheses indicate number of specimens.

TABLE 36 GROWTH OF *Sebastes ensifer* IN SOUTHERN CALIFORNIA

Age	Back-calculated length (in mm)*	Theoretical length	Annual increment
1	36.8 ± 2.1 (17)	44.0	44.0
2	61.2 ± 3.7 (18)	61.3	17.4
3	76.3 ± 4.3 (19)	76.4	15.1
4	90.0 ± 5.2 (19)	89.5	13.1
5	100.6 ± 5.5 (18)	100.9	11.3
6	110.8 ± 6.4 (18)	110.7	9.8
7	118.9 ± 7.3 (17)	119.3	8.6
8	127.2 ± 9.1 (15)	126.8	7.5
9	133.0 ± 9.7 (13)	133.2	6.5
10	139.0 ± 9.2 (10)	138.8	5.6
11	147.4 ± 10.1 (9)	143.7	4.8
12	155.3 ± 13.2 (7)	147.9	4.3
13	165.9 ± 13.8 (5)	151.6	3.6
14	180.3 ± 36.3 (2)	154.8	3.2

* With 95% confidence limit; numbers in parentheses indicate number of specimens.

GROWTH OF Sebastes *IN GENERAL*

Species of *Sebastes* vary greatly in maximum size. Adults of small species, such as *S. dallii* and *S. semicinctus*, generally measure only 13–15 cm in standard length. The largest individual of *S. dallii* I have seen is only 158 mm long (SIO 69–216). The largest *S. semicinctus* I have seen measures 167 mm (SIO 69–215). On the other hand, individuals of certain species from the Gulf of Alaska may attain the length of 96 cm (120 cm total length, personal communication, V. V. Barsukov to Carl L. Hubbs, 24 April, 1965). In attaining such a great discrepancy

TABLE 37 GROWTH OF *Sebastes chlorostictus* AT LA JOLLA

Age	Standard lenght (in mm)		Theoretical body weight (in gm)	Annual increment	
	Back-calculated*	Theoretical	Length	Weight	
1	29. 5 ± 0.9 (111)	40.5	1.5	40.5	1.5
2	57.3 ± 1.3 (123)	60.4	5.3	19.9	3.8
3	79.7 ± 1.6 (125)	79.1	12.4	18.7	7.2
4	98.1 ± 1.9 (124)	90.8	23.6	17.7	11.2
5	114.9 ± 2.3 (122)	113.5	39.2	16.7	15.5
6	130.2 ± 2.9 (108)	129.3	59.2	15.7	20.0
7	143.8 ± 4.0 (82)	144.1	83.6	14.9	24.4
8	159.0 ± 5.7 (58)	158.1	112.3	14.0	28.7
9	169.6 ± 7.5 (37)	171.4	144.9	13.2	32.6
10	188.0 ± 13.8 (22)	183.8	181.2	12.5	36.3
11	201.3 ± 17.3 (11)	195.6	220.7	11.8	39.5
12	216.2 ± 32.2 (7)	206.7	263.1	11.1	42.4
13	228.7 ± 63.6 (5)	217.2	307.9	10.5	44.8
14		227.1	354.6	9.8	46.8
15		236.4	403.0	9.4	48.4
16		245.2	452.7	8.8	49.6
17		253.5	503.2	8.3	50.5
18		261.4	554.3	7.9	51.1
19		268.7	605.7	7.4	51.4
20		275.7	657.0	7.0	51.4
21		282.3	708.2	6.6	51.1

* With 95% confidence limit; numbers in parentheses indicate number of specimens.

in final size, different species must have very different growth patterns. Marked variation in size and growth was shown by Phillips (1964) when he presented growth data for 10 species of *Sebastes*, and is also indicated in the present study, which, in addition to *S. umbrosus, S. rosaceus, S. ensifer, S. chlorostictus*, and *S. dallii*, have also been subjected to studies of growth (tables 35, 36, 37, and 38). The L_∞ and the k values of the Bertalanffy equation and the maximum known age and length are compared (table 34). The negative correlation between L_∞ and k that Beverton and Holt (1959) found for several groups of fishes does not seem to exist within the genus *Sebastes*. However, there seems to be a tendency for a large species to have a longer life-span than a small species. The Bertalanffy growth curves that have been calculated for these 15 species (fig. 16) rarely cross. This seems to suggest that to reach a greater final size, a large species relies more on faster growth in early years than on more prolonged growth.

Compared with other species of *Sebastes*, species of *Sebastomus* are slow-growing.

It is possible to distinguish the growth pattern of some species of *Sebastes* by the relative size of the annuli on the otolith. Comparison of figures of the otoliths of ten species of *Sebastes* (plate 6) shows several growth types. Growth rings on otoliths of *S. rosaceus, S. constellatus, S. ensifer, S. umbrosus, S. exsul, S. chlorostictus*, and *S. carnatus* are of rather similar size. The otolith of *S. dallii* has a

TABLE 38 GROWTH OF *Sebastes Dallii* AT LA JOLLA

Age	Back-calculated length (in mm)*	Theoretical length	Annual increment
1	50.2 ± 1.1 (101)	61.8	61.8
2	72.1 ± 1.3 (103)	73.3	11.3
3	83.3 ± 1.7 (103)	83.4	10.1
4	92.4 ± 1.7 (100)	92.4	9.0
5	101.3 ± 1.9 (99)	100.4	7.9
6	108.1 ± 1.9 (92)	107.4	7.0
7	114.0 ± 1.8 (85)	113.6	6.2
8	118.8 ± 1.8 (73)	119.1	5.5
9	123.5 ± 1.8 (58)	124.0	4.9
10	129.7 ± 3.0 (29)	128.3	4.3
11	137.5 ± 12.1 (5)	132.2	3.8
12		135.5	3.4

* With 95% confidence limit; numbers in parentheses indicate number of specimens.

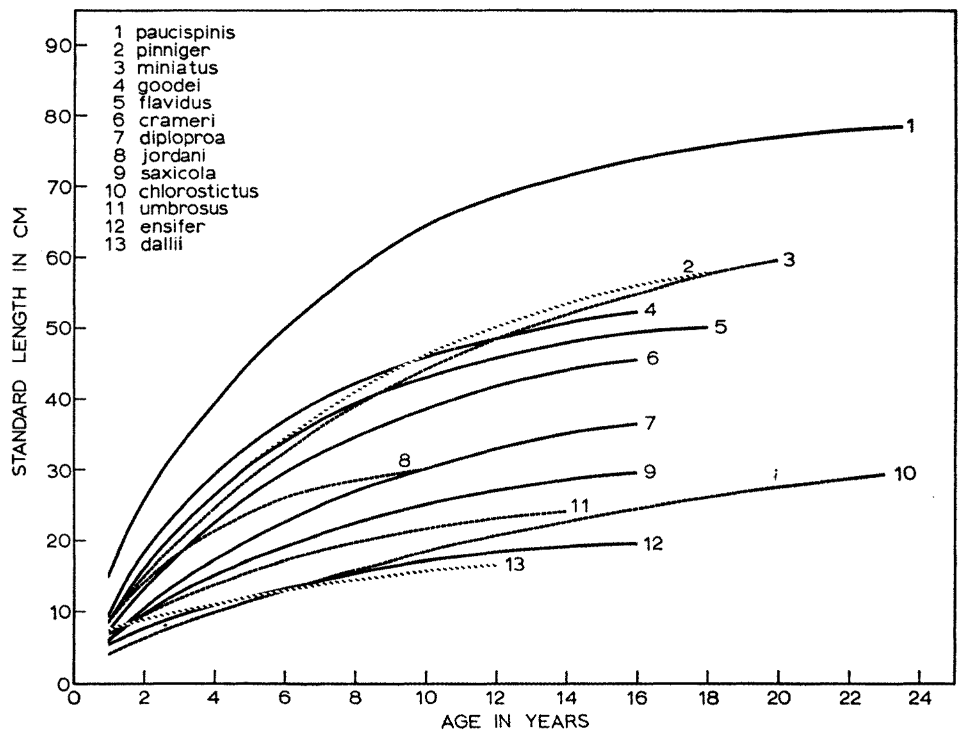

Fig. 16. Bertalanffy growth curves of 13 species of *Sebastes*.

nucleus of about the same size as that of otolith of species of *Sebastomus*, but the surrounding rings are much finer. On the contrary, the otolith of *S. goodei* has an extremely large nucleus and the surrounding growth rings are less well defined. The broader growth rings on the otolith of *S. ruberrimus* makes it appear that this species grows faster than those of *Sebastomus*.

LIFE HISTORY

All species of *Sebastes* are ovoviviparous, giving birth to yolk-sac larvae. Copulation generally takes place before the ova reach their final stage of development. Thus females and males differ temporally in their reproductive cycle, especially in that the gonads ripen earlier in males than in females (Magnusson, 1955; Moser, 1967). In the present research, the gonadal cycle was studied only in adult females. Ovaries were categorized according to their stages of development: (1) inactive, small and loose, white or pink, (2) starting to develop but small, tiny ova clearly visible, yellowish, (3) ovaries of good size, ova large, yellowish, (4) ovaries very large, ova large and somewhat translucent, (5) ovaries containing eyed larvae. When stage-5 ovaries were observed, spawning was assumed to be imminent. From such evidence it appears that *S. umbrosus* spawns over a period of five months, from March to July (table 39). Miscellaneous original data, together with those of Moser (1967), makes it appear that all species of *Sebastomus* spawn in spring and early summer (table 40).

After birth, larvae of *Sebastes* rise to the surface and start a pelagic life. Young of the year of *S. umbrosus* have been found already settled on the bottom in La Jolla Submarine Canyon in October. Pelagic life in this species seems at the most not to be much longer than six months. The same may be true of other

TABLE 39 SEASONAL CHANGE IN THE GONADAL CONDITION OF FEMALES OF *Sebastes umbrosus*.

Stage	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Deo.
1	10						8	5	16	15	6	12
2	9	3		3	1							
3			14	3	1							
4			6	10	2		1					
5			4	8	4		2					

TABLE 40 SPAWNING SEASONS* OF THE SPECIES OF *Sebastomus*

Speciea	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Deo.
S. constelIatus		+++		+++								
S. rosaceus			+++		+++							
S. simulator		++++++										
S. ensifer		+++			+++							
S. lentiginosits			+++									
S. chlorostictus				+++		+++	+++					
S. rosenblatti			++++++++++++									

* "+++" indicates the month in which females with eye diarvae were found.

species of *Sebastomus*. Several juveniles of *S. rosenblatti* (UCLA 58–397, 58–398, and 59–30) ranging in size from 39 mm to 49 mm, caught in October-November 1958, in a trawl operated mainly in 60 m of water off Los Angeles, show a well-developed adult color pattern. These individuals presumably had already settled to the bottom.

My limited observations indicate that species of *Sebastomus* feed mainly on shrimps, crabs, octopus, and squids, and only occasionally on fishes.

Although spawning migrations and feeding migrations have been reported by Moiseev and Paraketsov (1961) for *S. alutus*, tagging observations indicate that many of the species of *Sebastes* are rather sedentary (Miller, Odemar, and Gotshall, 1967). The same is probably true for the species of *Sebastomus*.

Smaller species, such as *S. umbrosus* and *S. ensifer*, may start to mature at a standard length of 10 cm and at an age of 3 years. However, large species, such as *S. chlorostictus, S. rosenblatti*, and *S. constellatus*, generally do not mature until reaching 20 cm standard length, at the age of about 10 years. Large species may live for 25 years or longer, whereas in small species such as *S. umbrosus* age-related mortality apparently begins at 8 years.

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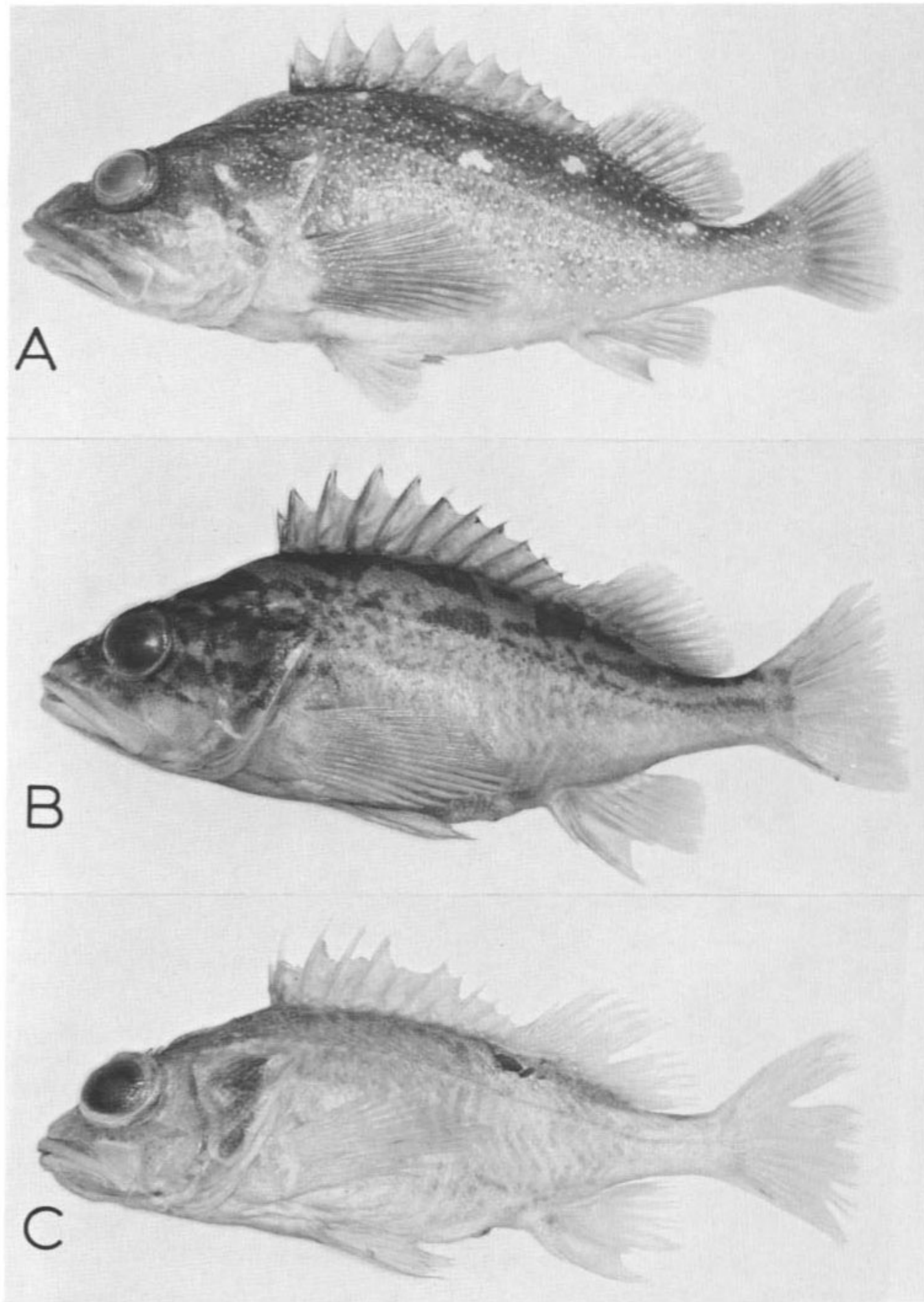
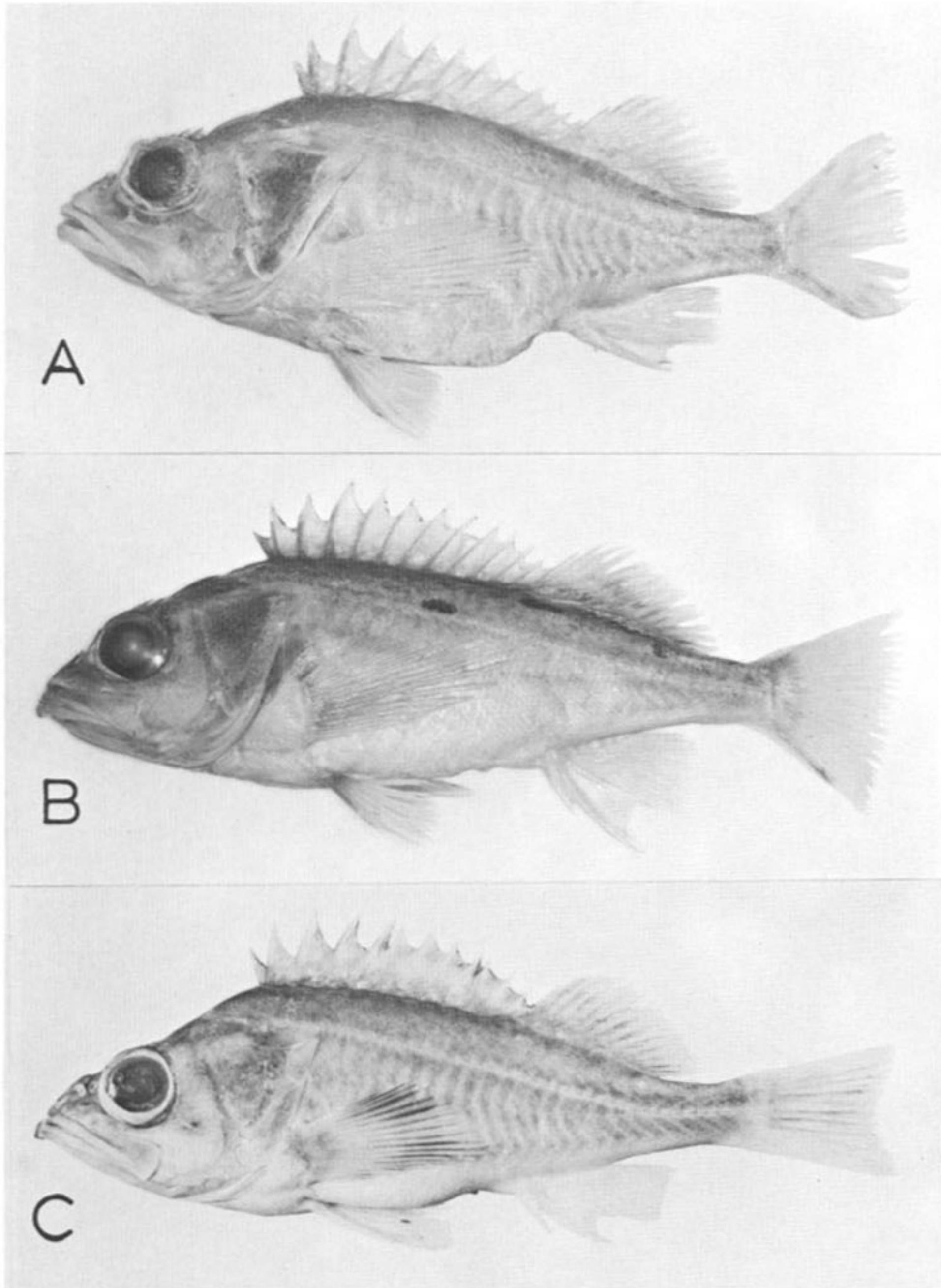
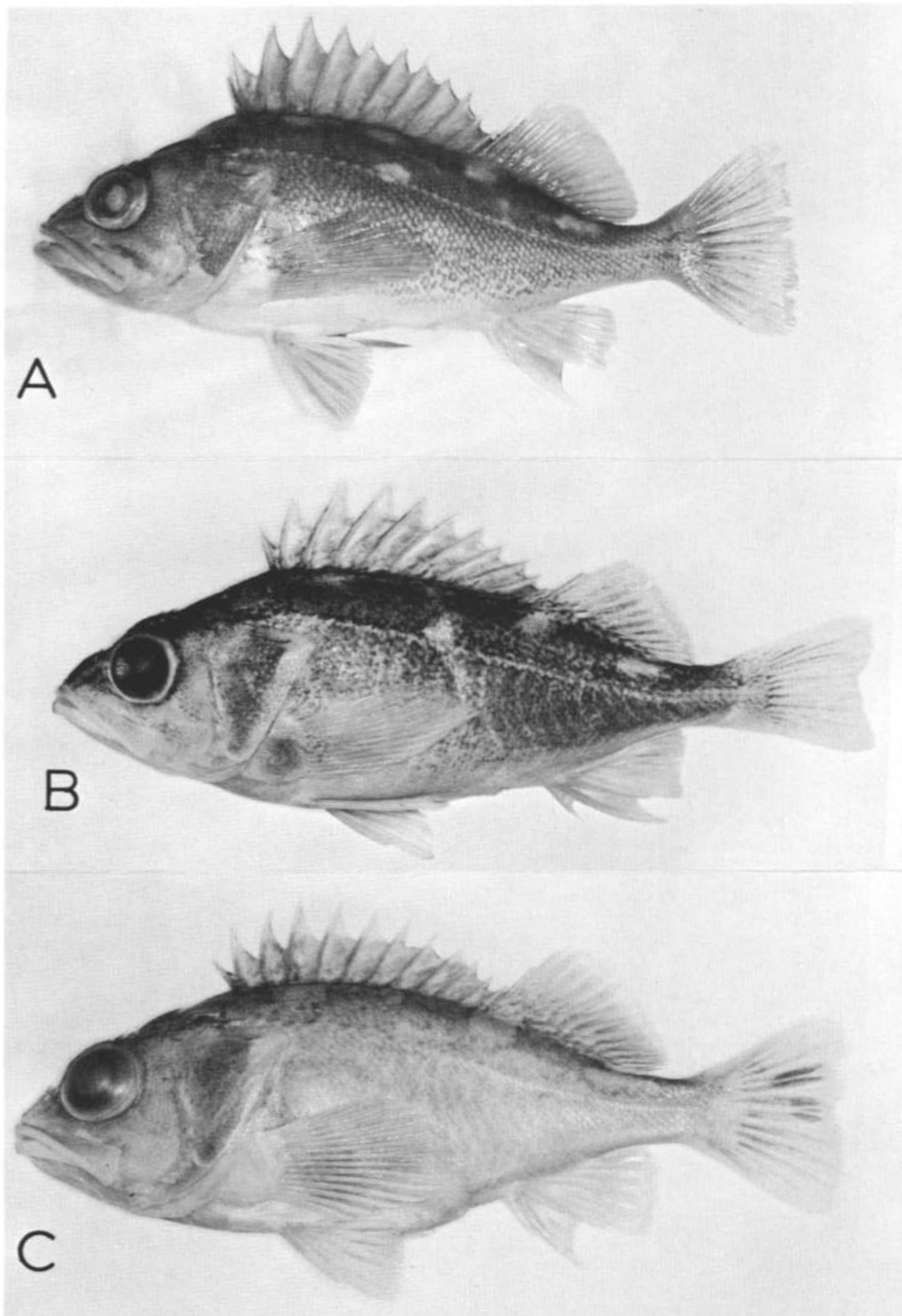
PLATES



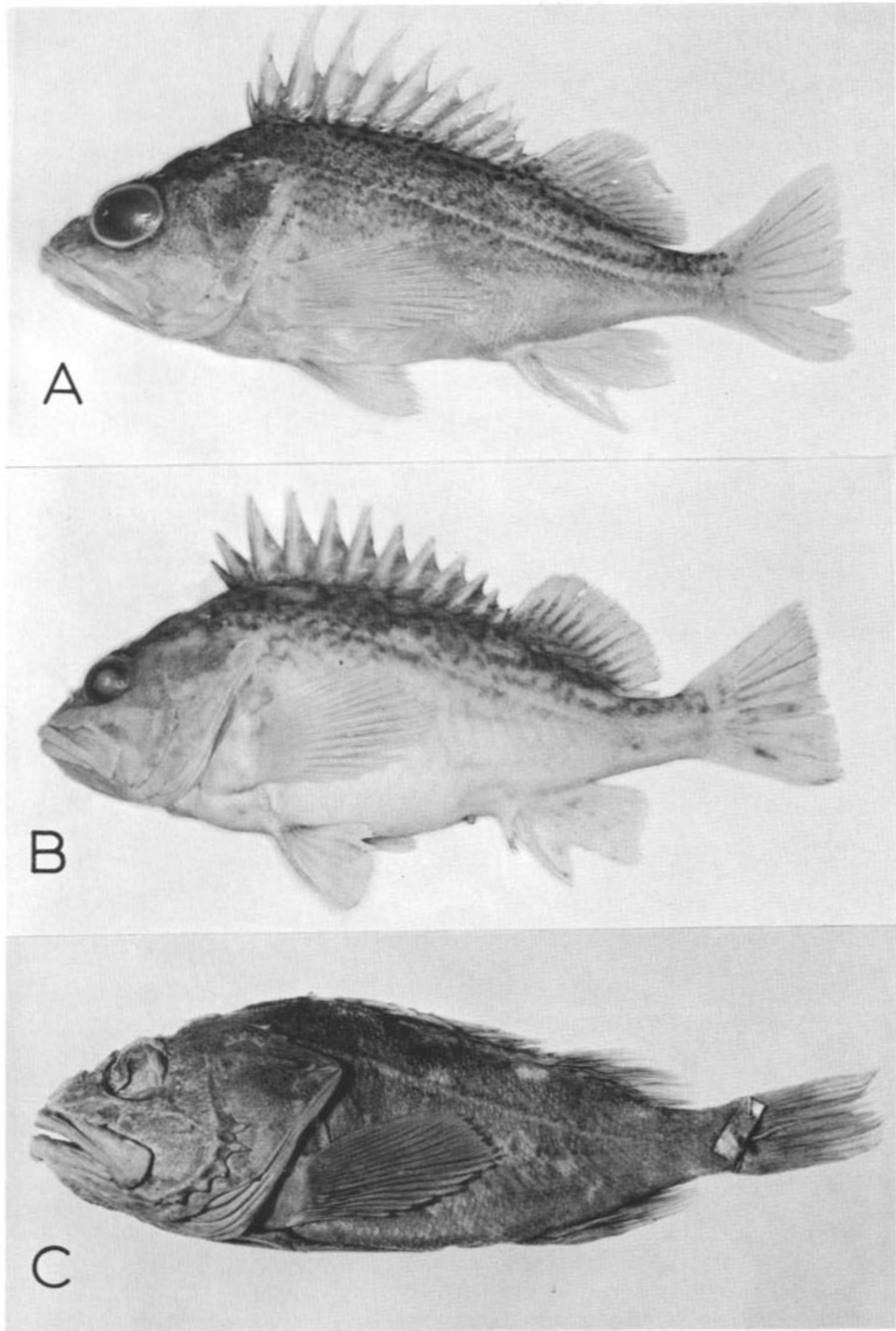
A) S188ebastes constellatus, a 273 mm male, from La Jolla, SIO 69–261; *B) Sebastes rosaceus*, a 169 mm female, from Tanner Bank, SIO 67–223; *C) Sebastes helvomaculatus*, a 226 mm female, from Washington, SIO 68–404. The patch of black below the last dorsal spine in *S. helvomaculatus* is an artifact.



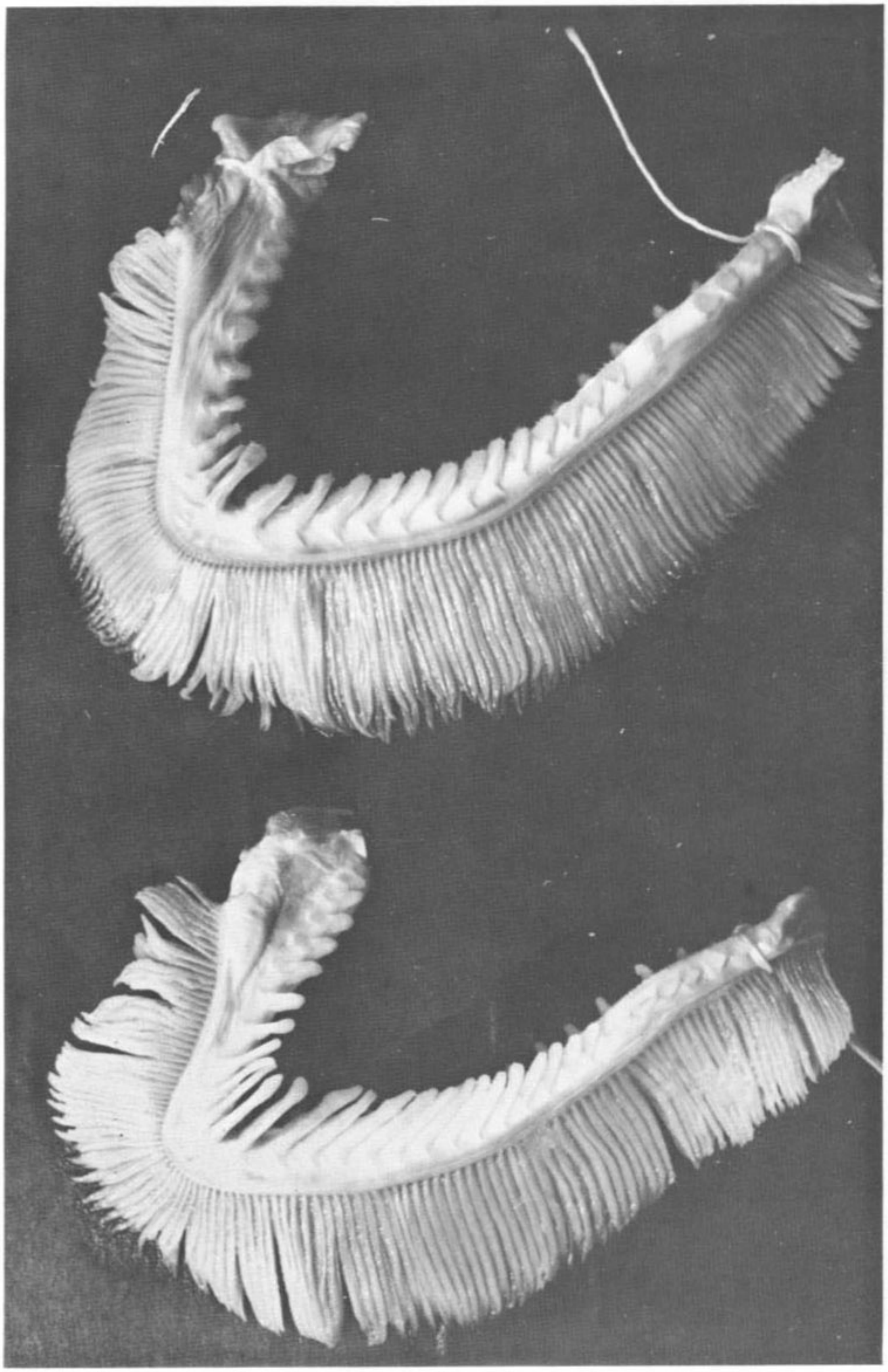
A) Holotype of *Sebastes simulator*, a 216 mm female, from Oceanside, SIO 68–137; *B)* Holotype of *Sebastes ensifer*, a 190 mm female, from La Jolla, SIO 67–295; *C)* Holotype of *Sebastes notius*, a 219 mm male, from Guadalupe Island, SIO 67–75.



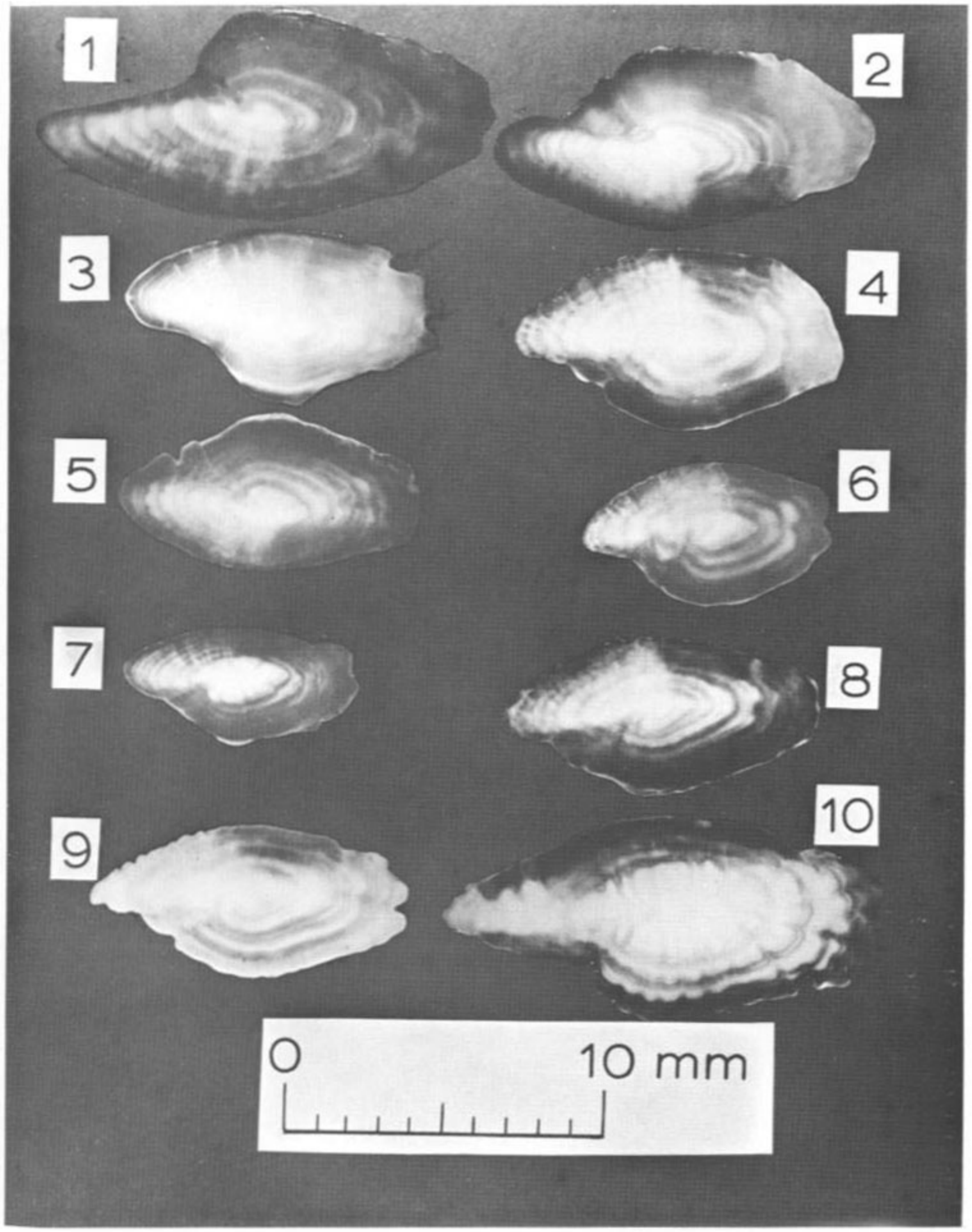
A) Sebastes umbrosus, a 163 mm male, from La Jolla, SIO 69–261; *B)* Holotype of *Sebastes lentiginosus*, a 190 mm female, from Tanner Bank, SIO 65–6; *C)* Holotype of *Sebastes exsul*, a 171 mm female, from the Gulf of California, SIO 68–1.



A) Sebastes chlorostictus, a 178 mm female, from La Jolla, SIO 69–262; *B)* Holotype of *Sebastes rosenblatti* a 238 mm male, from La Jolla, SIO 69–223; *C)* Holotype of *Sebastes eos*, 380 mm, from Point Loma, California, BM 1891.5.19.25.



First gill-arches of *S. rosenblatti* (lower) and *S. eos* (upper).



Otoliths of 10 species of *Sebastes:* 1) *S. constellatus*, 2) *S. rosaceus*, 3) *S. ensifer*, 4) *S. umbrosus*, 5) *S. exsul*, 6) *S. chorostictus*, 7) *S. dallii*, 8) *S. carnatus*, 9) *S. ruberrimus*, 10) *S. goodei*.