

**Article XIII.—THE FISHES OF THE GENUS *ATHERINOPS*,
THEIR VARIATION, DISTRIBUTION, RELATION-
SHIPS, AND HISTORY¹**

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I.— DISTRIBUTION AND RELATIONSHIPS

The atherinoid fishes of America have become differentiated into a number of generic types, among the most sharply distinguished of which *Atherinops*, the subject of the present paper, may be placed. This genus is characterized by non-protractile premaxillaries and bifid teeth.

The species of *Atherinops*, although very abundant along the West American coast — some of them being food-fishes of good quality and some importance — and although rather frequently mentioned in the literature of the fishes of that region, are at present very imperfectly known. In fact, three of the forms have remained undescribed: *littoralis*, *cedroscensis*, and *guadalupæ*. In all, the genus includes no fewer than seven forms, each inhabiting its separate district along the western coast of the United States and Mexico. The genus has not been recorded within the Tropics nor from Puget Sound.

These seven species and subspecies of *Atherinops* are localized in their distribution to a degree rather unusual among marine fishes. Such a localized distribution is in harmony with their habits. These fishes are very closely restricted to the shore line, those of the continental coast

¹ Based upon material in the American Museum, Stanford University, the National Museum, and the Field Museum. I am particularly indebted to the authorities of the American Museum for the loan of their fine series of specimens from Lower California.

spawning in bays and estuaries, even ascending the mouths of certain streams to fresh water. No such conditions are found on the islands, but the island forms are perhaps confined largely to the more sheltered coves. The fishermen claim that *Atherinopsis californiensis*, a congener of *Atherinops*, migrates back and forth between the northern Santa Barbara Islands and the mainland, while the "Silver Smelt" (*Atherinops*) remains in and about the bays. Just such a situation may hold true, for *Atherinopsis*, of larger size than *Atherinops*, breeds along the mainland in more open waters and seems to be much the stronger swimmer of the two and of less constant occurrence near shore. A single species of *Atherinopsis* occurs along the mainland coast of California, and about the Santa Barbara Islands, and has also been recorded from Cerros Island — the type locality of a very different species, *Atherinopsis sonore*.¹

The genus is represented in the Gulf of California by *Atherinops regis*, for which a new genus or subgenus, *Colpichthys*, has recently been proposed in order to distinguish it from *Atherinops* proper. The typical subgenus in its various forms occurs along the outer coast of Lower California, California, and Oregon, and on the adjacent islands. There are three mainland and three island forms, the distribution of which is indicated on the accompanying map: *affinis*, occurring along the coast of Oregon and northern California; *littoralis*, on the mainland coast of southern California; *insularum*, about the adjacent Santa Barbara Islands; *magdalenæ*, in the bays of southwestern Lower California; *cedroscensis*, around Cedros Island off central Lower California; and *guadalupe*, about Guadalupe Island, farther offshore.

These six forms of the subgenus *Atherinops* differ from one another more or less constantly in several characters, the most important of which seems to be the size of the scales. In a tabulation of the scale counts two groups are indicated (see Table I). The forms from the mainland coast of southern California and Lower California (*littoralis* and *magdalenæ*) have larger scales than those from the offshore islands and those from the northern mainland. In certain other characters, notably the length of the pectoral and the breadth of the head, the southern island forms resemble that one of the northern mainland (*affinis*) more closely than *littoralis* and *magdalenæ* of the shores opposite the islands.

Centering our attention now upon *insularum*, from the Santa Barbara (or Channel) Islands off southern California, we find that it especially resembles *affinis*² of the mainland farther north in the several characters by which it differs from the southern mainland type, *littoralis*. It does,

¹ Osburn and Nichols, 1916, Bull. Amer. Mus. Nat. Hist., XXXV, p. 158, fig. 8.

² The island form, *insularum*, has been contrasted in the literature with *littoralis* on the erroneous supposition that the specimens of the latter form were typical of *affinis*.

TABLE I.—THE VARIATION IN THE NUMBER OF TRANSVERSE SCALE-ROWS IN THE SIX FORMS OF THE SUBGENUS *Atherinops* (EXCLUSIVE OF INTERGRADES)

Transverse Scale-rows	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
<i>A. a. affinis</i>								1	6	3	4	4	5	3	3	1	1				
<i>A. i. insularum</i>												1		3	1	2		2	4		1
<i>A. i. cedroscensis</i>								1	3	7	1	3		2	2	1					
<i>A. i. guadalupe</i>									1	2	4	2		4	1	1		1			
<i>A. a. littoralis</i>	1	4	2	5	8		4														
<i>A. a. magdalena</i>	5	2	4	5	4	2	2														

Number of Specimens

indeed, seem remarkable that *Atherinops* should be represented on these several islands by a form well differentiated from the one occurring on the mainland, which is separated from certain of the islands (Santa Catalina, Santa Cruz) by channels narrower than those which separate these islands from others (San Clemente, San Nicholas), the surrounding waters of which are inhabited by the same island species. The situation is further unusual in that the island species is related more closely to a form of a relatively distant mainland, that of central California, than to the form of the neighboring mainland shores. Some past migration of the species concerned must apparently be postulated to account for the relationships of these fishes. The discussion of this subject will be deferred, however, to a later section of this paper.

The Cedros Island and the Guadalupe Island forms, as already indicated, resemble *insularum* and *affinis* rather than the southern mainland types in several characters: their relatively fine scales; their short pectorals; their broader heads, etc. They further resemble *insularum* very closely in the form of the body. In certain other characters, however, they approach the southern mainland forms (see comparative tables). Of the two southern island forms, *guadalupæ* is the more distinct, many of its characters contrasting with those of *insularum*. In nearly all of these characters (see tables) *cedrosensis* is intermediate between the other two island types; it also seems to approach the adjacent mainland race in one character, the width of the head. Despite the resemblances between the southern island and the southern mainland forms, it is highly probable that the *Atherinops* of both Cedros and Guadalupe Islands, though separated from each other by a wide distance and by deep water, are related most closely to *affinis* through *insularum*, rather than with the form occurring on the mainland coast of Lower California.

II.—SUBSPECIFIC INTERGRADATION

A very large series of specimens¹ from representative localities along the California coast from San Francisco to San Diego has made possible a detailed study of the relations between *affinis* and *littoralis* where their ranges meet. Although the two forms are well distinguished by numerous characters, they have been found to intergrade throughout a rather wide area, extending from northern San Luis Obispo County to Point Arguello; even the series from the mainland shores of the Santa Barbara Channel show a definite approach toward *affinis* in several characters.

The series of intergrades between *affinis* and *littoralis* can always be distinguished from either form by the summation of the various distinctive

¹ Collected by the writer to determine the inter-relationships of *affinis* and *littoralis*.

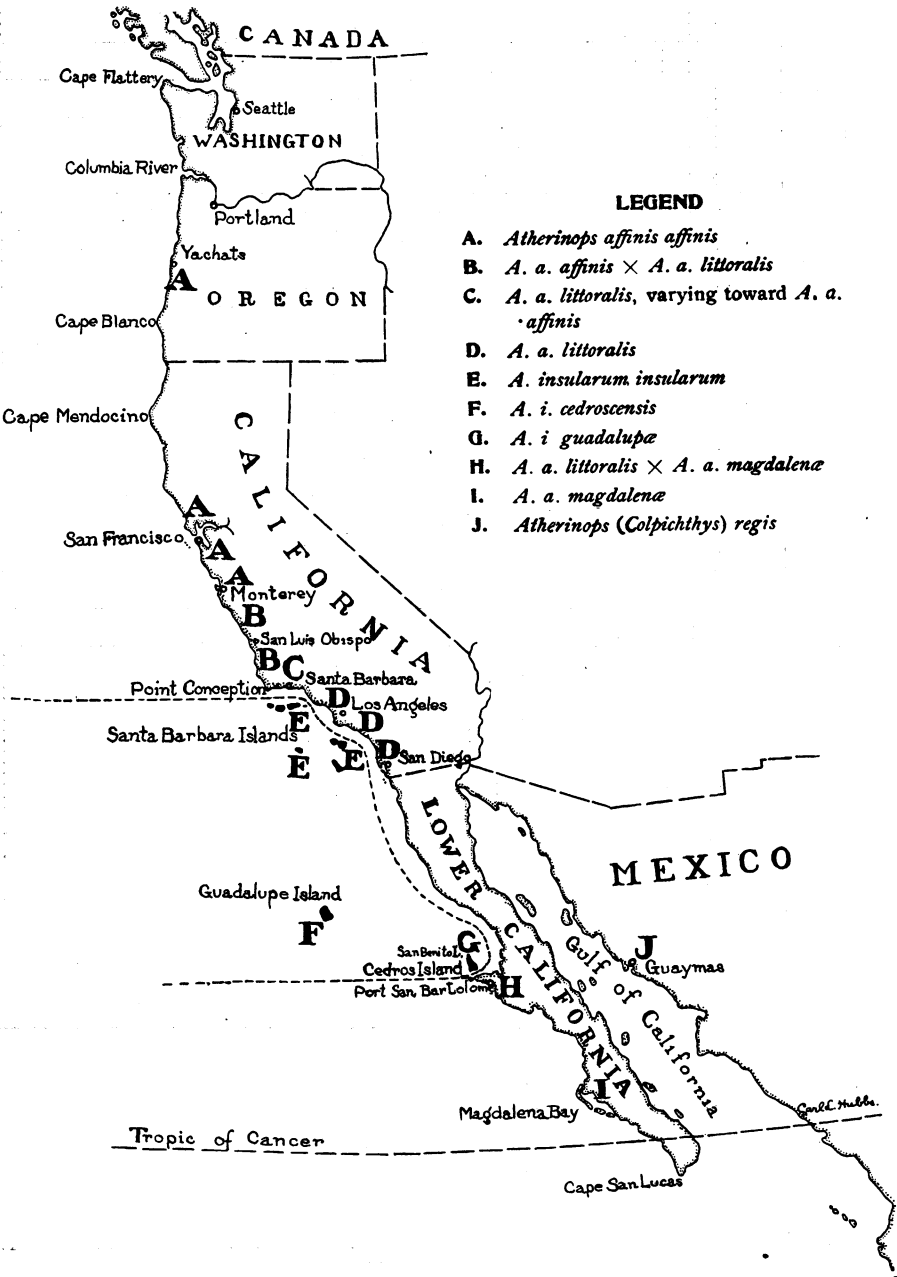


TABLE II.—THE GEOGRAPHICAL VARIATION IN THE NUMBER OF TRANSVERSE SCALE-ROWS IN THE SUBSPECIES OF *Atherinops affinis* (COMPARE WITH TABLE I)

Transverse Scale-rows		52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68
<i>affinis</i>	OREGON south to MONTEREY BAY																	
	Yachats R., Oregon.....																1	
	Drakes Bay, Cal.....															1		
	San Francisco Market.....							1	6	2	4	4	3	2	2			1
	Santa Cruz, Cal.....									1				2	1			
<i>affinis</i> × <i>littoralis</i>	CENTRAL CALIFORNIA (south of Monterey Bay)																	
	Near Piedras Blancas.....									2								
	Morro Bay.....					1	2	2	2	4	6			1	1			1
	Avila, near Port San Luis.....			1		3	3	5	5	3	2	4	2					
	Lagoon at Surf (Lompoc Junction).....					1	1	1		2	2	2		1				
<i>littoralis</i> varying toward <i>affinis</i>	SANTA BARBARA CHANNEL																	
	Estero at Goleta.....	1				1	5	1	2		1	1	1	1	1			
	Santa Barbara.....																	
	Estero at Carpinteria.....			1	3	1	3	3	3	1		1						
<i>littoralis</i>	SOUTHERN CALIFORNIA																	
	Ventura.....					1												
	Alamitos Bay.....	1				1												
	San Diego Bay.....	1	3	2	5	6		4										
<i>littoralis</i> × <i>magdalena</i>	CENTRAL LOWER CALIFORNIA																	
	San Bartolomé Bay.....				2		4	1										
<i>magdalena</i>	SOUTHWESTERN LOWER CALIFORNIA																	
	Magdalena Bay.....	5	2	4	5	4	2	2										

Number of Specimens

characters. Most of the specimens combine in various ways the characters of the two contrasted forms.¹ Thus, some specimens have scales fully as large as in typical *littoralis*, but resemble *affinis* in the wide interorbital and deep caudal peduncle. In the mode of their variation, however, most of the characters of these intergrades are intermediate between those of *affinis* and those of *littoralis*. As an example, the size of the scales may be taken (see Table II). Other characters in which these intergrades are notably intermediate are: the interorbital width (Table XV); the length of the pectoral fin (Table XIX); the depth of the caudal peduncle (Table III); the length of the eye (Table XVII); the length of the head (Tables XIII and XIV); and, finally, the size (Table VIII) and general appearance. In no respect, so far as examined, do the intergrades resemble either *affinis* or *littoralis* exclusively. The intergrades, in fact, are intermediate in all respects; or, expressed more definitely, they may resemble both *affinis* or *littoralis* in the characters in which these forms differ from each other.

In similar fashion, specimens of *Atherinops* from middle Lower California (San Bartolomé Bay) are intermediate between *littoralis*, which is abundant farther north, and *magdalenæ*, known only from the vicinity of Magdalena Bay, farther south. The chief difference apparent between *magdalenæ* and *littoralis* is the depth of the caudal peduncle, in which character the Magdalena Bay form resembles typical *affinis*. In both cases the intergrades are intermediate.

TABLE III.—THE DEPTH OF THE CAUDAL PEDUNCLE (MEASURED INTO THE HEAD), IN THE SUBSPECIES OF *Atherinops affinis*

	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2
<i>A. a. affinis</i>	████████████████									
Intergrades			██							
<i>A. a. littoralis</i>						████████████████████				
Intergrades				██████████████						
<i>A. a. magdalenæ</i>		██████████████								

These intergrades between *littoralis* and *magdalenæ* seem to have rather wider interorbitals, on the average, than typical examples of either form,

¹ A similar situation occurs in the case of *Menidia m. menidia* on the Atlantic Coast (see Kendall, 1901, Rept. U. S. Fish Comm. (1902), pp. 241–267); the writer has been able to confirm this work of Dr. Kendall.

in this respect resembling *A. i. cedroscensis* from the adjacent Cedros Island; in the few other respects by which *littoralis* and *magdalenæ* differ slightly, the intergrades are apparently intermediate, and show no special approach toward *cedroscensis*.

To sum up the interrelationships of the three mainland forms of *Atherinops*, it may be said that specimens from the two areas where the ranges of the forms meet are either intermediate in nearly every character between the subspecies occurring on the two sides; or, more usually, variously combine their characters. Especially in the case of *affinis* and *littoralis* is there evident an actual intergradation of the two forms. In this case the intergradation suggests hybridization rather than uniform blending.

III.—PHYLOGENY

In the foregoing sections an outline of the distribution and relationships of the species and subspecies of *Atherinops* was presented. Some rather anomalous features were indicated, which call for an explanation. The main question to answer is, why does the form (*A. i. insularum*) living about the Santa Barbara Islands, close off southern California, resemble more closely a form (*A. a. affinis*) of the northern California coast than the form found along the mainland near-by. The similarity of *A. a. affinis* and *A. i. insularum* is so close that one is justified in postulating that their separation has been shorter than that of *A. i. insularum* and *A. a. littoralis* of the adjacent mainland. *A. a. littoralis* is separable only by very minor characters from *magdalenæ* of the Lower California mainland coast. The differences which distinguish *insularum* from *littoralis* are mostly paralleled by those distinguishing *cedroscensis* from *magdalenæ*; and *cedroscensis* in its distinctive characters differs only in the mode of its variation from *insularum*. *A. i. guadalupæ* approaches the southern mainland type (*littoralis*) in several of its characters, but the small size of its scales, the breadth of its head, its form, color, etc., seem fully to justify its inclusion in the island series. The *Atherinops* of all the southern islands, therefore, are apparently related most closely to *A. a. affinis* of the mainland to the north and have probably been separated from it by no long period of time. Since the island forms have become isolated from *affinis*, however, considerable differences in each have developed. Three island varieties have become differentiated, but all three have retained certain features by which they differ from *A. a. affinis*; hence, the northern mainland form appears also to have become modified. How the southern islands, now separated from one another by wider distances and deeper channels than those which separate some of the islands from the mainland, could become populated by the northern, rather

than the southern, mainland form is not at first apparent. One might postulate that the young of the northern form, swept out of the bays by the tidal currents, were carried south by the prevalent southward surface drift and by this means reached the islands; or that the adults, contrary to their present habits, at one time forsook the northern coasts and swam southward to the islands. Had such a transfer been made, the original stock would have come, in all probability, from the coastline not far north or east of Point Conception (see map), but the races of *Atherinops* in those districts are not *A. a. affinis*, as such a theory would demand, but intergrades between that form and the dissimilar *A. a. littoralis*. The fact that the southern island form has remained distinct from the southern mainland forms, while the widely separated islands are populated by the same species (of three varieties, one of which inhabits all of the Santa Barbara Islands), would further indicate that some other means of species dissemination has taken place.

A study of the diastrophic movements to which the California coast has been subject seems to afford a plausible explanation of the distribution of the forms of *Atherinops*. During the so-called post-Miocene uplift, the California coast south of San Francisco was elevated to a great height above its present level. At Monterey the elevation probably amounted to not less than one mile, for the great submerged valley of Monterey may be traced out to a depth of about 1000 fathoms. As the 500 fathom contour line is found to enter sharply a number of such submerged valleys, where the soundings have been extensive (in Monterey Bay, off San Diego, etc.), it may safely be concluded that this coast region as a whole was elevated to a greater height than 3000 feet.¹ The 500 fathom contour probably represents the approximate location of the shore-line of the coast at some post-Miocene period, although differential diastrophic movements, particularly of the islands, may introduce a considerable error. The present islands were then apparently peninsulas surrounding large arms of the sea.

The time of the uplift just referred to has been given by several geologists² as Pliocene, but Branner,³ by synchronizing this elevation with the glaciation of the Sierra Nevada Mountains, more recently considers the uplift of Pleistocene age. The occurrence of *Mastodon* remains on the Santa Barbara Islands points to the same conclusion, namely, that the Santa Barbara Islands were connected with the mainland during a cold period of Pleistocene times. A more southern distribution of most of the cen-

¹ The Coast Survey Charts of California, on which many additional soundings by the *Albatross* and by the Scripps Institution for Biological Research were located, formed the basis for the construction of a map, upon which these statements are based.

² See for example Lawson, Bull. Dept. Geol., Univ. Cal. (several papers, Vols. I-III).

³ 1907, Journ. Geol., XV, pp. 1-10, fig.

tral California fishes was probably a feature of that period. *Atherinops affinis*, or rather its immediate ancestor, may then be supposed to have ranged farther southward than at present. Under such conditions it would have occurred around the shores of what are now the southern islands (except Guadalupe). The great inclosed bays between the mountain ranges, which then represented the present Santa Barbara Islands, may well have teemed with this *Atherinops* — the ancestor of *A. a. affinis* and of the three varieties of *A. i. insularum*. The channel between Guadalupe Island and the mainland to the north, at the time of the great uplift, about one-half or one-third narrower than at present, was probably crossed by this ancestral *Atherinops*.

This fine-scaled ancestor of *A. a. affinis* and of the varieties of *Atherinops insularum* during this cold period would have occupied the mainland parallel to that now inhabited by the two large-scaled forms. Now, subsequent to this great elevation there occurred a depression which carried the coast line of the southern half of California downward to a depth of from 800 to 1500 feet¹ below the present level. This depression was obviously accompanied by a warmer climate, approximating that of the present. This warmer climate presumably acted as a stimulus for a northern migration of the finer-scaled type of *Atherinops* to its present range along the coast of Oregon and the northern half of California. During the subsidence the present islands were detached from the mainland, and it may be supposed that a population of the finer-scaled *Atherinops* was thus trapped about each island. Since their separation, probably in Pleistocene but possibly in Pliocene times, the four forms of this finer-scaled group, thus isolated, have become differentiated sufficiently so as to be distinguishable from one another.

We have now accounted, apparently quite plausibly, for the past history of the finer-scaled forms of *Atherinops* and for their present distribution on the northern mainland and the southern islands. We have yet to consider the coarser-scaled or southern-mainland forms, *magdalenæ* and *littoralis*. To account for the differences between these forms and typical *affinis* of the mainland farther north on the assumption that their differentiation has been synchronal with that of the island forms does not adequately explain the present relationships of the island and mainland forms and, particularly, does not explain satisfactorily the nature of the intergradation between *littoralis* of the southern mainland and *affinis* of the northern mainland. These intergrades, as already explained, usually show the characters of both forms in various combinations: a specimen with scales as large as in typical *littoralis* has the interorbital as wide, and the caudal

¹ As indicated by the height of the marine terraces, as given by Lawson (*loc. cit.*).

peduncle as deep, as in typical *affinis*, etc. The intergradation, in fact, suggests hybridization, rather than the differentiation of a previous unit in the two extremes of distribution.

It seems probable, on the basis of the full evidence available, that the coarser-scaled type of *Atherinops*, subsequent to the northward migration of the finer-scaled type and to the separation of the southern islands from the mainland, has likewise moved northward, meeting the finer-scaled type on the central coast of California. By the interbreeding of the two forms in this region the peculiar hybrid-like intergrades have probably arisen. Now, if this intergradation should spread more widely, or if the typical form on either side should become extinct or differentiated, then, according to the above explanation, we should have a *synthetic species* produced not by divergence but rather by the fusion of two species which were formerly distinct.

IV.—NOTES ON, AND DESCRIPTIONS OF, THE SPECIES

The genus *Atherinops* is distinguished from all other atherinids by its bifid or Y-shaped teeth; in other characters it closely resembles *Atherinopsis*, another genus of the western coast of North America. *Atherinops* is divisible into two subgenera, *Colpichthys* and *Atherinops*.

Subgenus **COLPICHTHYS** Hubbs

Colpichthys HUBBS, 1918, Proc. Acad. Nat. Sci. Phila., LXIX, p. 305.

This subgenus, which with its single species represents *Atherinops* in the Gulf of California, has recently been described in sufficient detail.

1. *Atherinops regis* Jenkins and Evermann

Atherinops regis JENKINS AND EVERMANN, 1888, Proc. U. S. Nat. Mus., XI, p. 138 (Guaymas). EVERMANN AND JENKINS, 1891, idem, XIV, p. 137 (Guaymas). JORDAN AND EVERMANN, 1898, Bull. U. S. Nat. Mus., XLVII, part 2, p. 807 (Gulf of California).

Range.—Gulf of California.

Record-station.—Guaymas, Sonora, Mexico.

Relationships.—The only species of the subgenus *Colpichthys*.

Habits.—Unrecorded.

Measurements and Counts (taken from five of the type specimens, varying in length to caudal from 95 to 150 mm.).—Length of head into total length to caudal, 4.0 to 4.55; depth of body, 4.0 to 4.5; depth of caudal peduncle into length of head, 2.25 to 2.5; length of snout, 3.4 to 3.5; length

of upper jaw, 3.3 to 3.85; diameter of eye, 3.5 to 3.8; least width of interorbital, 2.9 to 3.1; length of head into distance from isthmus to anus, 1.8 to 1.95. Measurements in hundredths of length to caudal base: head, 22.2 to 24.5; depth of body, 22.5 to 25; depth of caudal peduncle, 10; length of snout, 6.7 to 7.5; upper jaw, 6 to 7.6; eye, 6 to 7; interorbital, 7.8 to 8.2; isthmus to pelvic fin, 29.6 to 32.6; tip of snout to dorsal fin, 53 to 57; snout to pelvic fin, 44 to 48.5; pelvic fin to anus, 12.3 to 12.7; anus to base of caudal, 42 to 44; length of first dorsal fin when depressed, 9.3 to 11; distance between origins of dorsal fins, 15.3 to 18.4; base of second dorsal, 10 to 12; height of second dorsal, 12; base of anal, 21.5 to 23; end of anal base to base of caudal, 17 to 18.5; pectoral fin, 26; pelvic fin, 12. Number of spines in first dorsal, 5 to 7; soft rays of second dorsal, 10 or 11; soft rays of anal, 20 to 22; rays of pectoral, 14 or 15; transverse scale-rows, 47 to 51.

Subgenus **ATHERINOPS** Steindachner

Atherinops STEINDACHNER, 1875, Sitzb. Akad. Wiss. Wien, LXXII, part 1, p. 89 (1875, Ichth. Beit., III, p. 61). JORDAN AND EVERMANN, 1898, Bull. U. S. Nat. Mus., XLVII, part 2, p. 807.

The typical subgenus includes six species, subspecies, and island varieties, occurring along or off the coast of Oregon, California, and Lower California.

2. **Atherinops affinis affinis** (Ayres)

Atherinopsis affinis AYRES, 1860, Proc. Cal. Acad. Nat. Sci., p. 63 (San Francisco).

Chiostoma affine GILL, 1862, Proc. Acad. Nat. Sci. Phila., p. 280 (after Ayres).

Atherinops affinis STEINDACHNER, 1875, Sitzb. Akad. Wiss., Wien, LXXII, p. 89. JORDAN AND GILBERT, 1880, Proc. U. S. Nat. Mus., III, (1881), p. 456 (San Francisco; Monterey Bay). JORDAN AND JOUY, 1881, idem, IV, p. 13 (San Francisco). JORDAN AND GILBERT, 1881, idem, IV, p. 43 (in part; "Cape Mendocino southward"); 1883, Bull. U. S. Nat. Mus., XVI, p. 409 (in part; "Pacific Coast"). EIGENMANN AND EIGENMANN, 1892, Ann. N. Y. Acad. Sci., VI, p. 352 (Monterey; San Francisco). GILBERT, 1893, Rept. U. S. Fish Comm., (1896), p. 465 (Drake Bay). JORDAN AND EVERMANN, 1898, Bull. U. S. Nat. Mus., XLVII, part 2, p. 807 (in part; "Coast of California"). GILBERT, 1898, Rept. U. S. Fish Comm., (1899), p. 25 (Monterey). STARKS AND MORRIS, 1907, Univ. Cal. Publ. Zool., III, p. 187 (in part; "San Francisco to Magdalena Bay"). EVERMANN AND LATIMER, 1910, Proc. Biol. Soc. Wash., XXIII, p. 136 (Tomas Bay).

Atherinops insularum GILBERT, 1893, Rept. U. S. Fish Comm., (1896), p. 465 (Drake Bay). Not *Atherinops insularum* GILBERT, 1891.

Atherinops regis EVERMANN AND LATIMER, 1910, Proc. Biol. Soc. Wash., XXIII, p. 136 (Tomas Bay). Not *Atherinops regis* JENKINS AND EVERMANN, 1891.

Atherinops oregonia JORDAN AND SNYDER, 1913, Proc. U. S. Nat. Mus., XLV, p. 575, Pl. XLVI (Yachats River, Oregon).

Range.—Coast of Oregon, and of California, south to Monterey.

Record-stations.—Yachats River (near mouth), Lincoln County, Oregon: Jordan and Snyder, as *Atherinops oregonia*. Tomales Bay, California: young recorded by Evermann and Latimer as *Atherinops affinis* and *Atherinops regis*. San Francisco: recorded by Ayres, and by authors in general (usually from the market). Monterey Bay: recorded by Jordan and Gilbert. Santa Cruz: specimens collected by Dr. C. H. Gilbert. Monterey: recorded by Gilbert.

Habits.—*A. a. affinis* is a common fish in the bays and is recorded as entering fresh water (Yachats River, Oregon) in the spawning season.

Nomenclature.—*Atherinops affinis* (Ayres) is the type species of its genus and was the first to be described. Although a common market fish at San Francisco, it seems not to have been well represented in collections, a condition which has led to considerable confusion. Thus, *Atherinops insularum* Gilbert was distinguished in the original description from *A. a. littoralis*, on the assumption that the specimens of that subspecies examined were typical of *A. affinis*, whereas in reality *insularum* is less distinct from typical *affinis* than *littoralis* is; subsequently, typical specimens of *A. a. affinis* were recorded by Dr. Gilbert as *insularum*, and doubt was then expressed as to the validity of the island form. In somewhat similar fashion, the type of *Atherinops oregonia* was contrasted with *A. a. littoralis*, and the identity of *oregonia* with true *affinis* was consequently not appreciated.

The type description of *Atherinopsis californiensis* by Girard¹ agrees better with *Atherinops affinis* than with the species currently known under Girard's name; and, as both species are common in the San Francisco markets, a difficult nomenclatural problem is suggested. Fortunately, however, Mr. Fowler² has redescribed the type of *Atherinopsis californiensis*, showing that there has been no error in the current application of that name.

TABLE IV.—MEASUREMENTS AND COUNTS OF *Atherinops affinis affinis*

	Yachats River ^a	Drakes Bay ^b	San Francisco Markets ^c	Santa Cruz
Number of specimens examined.....	1	1.	14	4
Length to base of caudal, mm.....	227	164	130 to 156	105 to 134
Length of head in body.....	...	5.33	4.8 to 5.6	4.75 to 5.0
Depth of body.....	...	5.25	... to 5.33	4.4 to 4.9
Depth of caudal peduncle in head...	...	2.6	2.33 to 2.7	2.5 to 2.6
Length of snout.....	...	3.3	3.4 to 3.7	3.4 to 3.7

¹ 1854, Proc. Acad. Nat. Sci. Phila., VII, p. 134.

² 1903, idem, (1904), p. 739.

^a Measurements from type description or type figure of *A. oregonia*.

^b Specimen recorded by Gilbert as *A. insularum*.

^c Measurements made from the entire series only in the case of the critical characters.

TABLE IV (continued)

	Yachats River ^a	Drakes Bay ^b	San Francisco Markets ^c	Santa Cruz
Length of upper jaw.....	...	3.75	3.6 to 4.0	3.4 to 3.7
Length of eye.....	...	4.4	3.9 to 4.4	3.7 to 4.1
Width of interorbital.....	...	3.25	2.95 to 3.2	3.0 to 3.25
Length of postorbital.....	...	2.18	2.15 to 2.2	2.15 to 2.25
Length of head in distance from isthmus to anus.....	2.7	2.4	2.4 to 2.8	2.35 to 2.55
<i>Measurements in hundredths of length to caudal base</i>				
Length of head.....	18	19	17.8 to 20.5	20.2 to 21.8
Depth of body.....	22	20	.....	21 to 23
Depth of caudal peduncle.....	8	7.8	7.8	7.8 to 8.3
Length of snout.....	5	6	5.3 to 5.6	5.8 to 6
Length of upper jaw.....	...	5.3	4.8 to 5.2	5.6 to 6
Length of eye.....	4	4.4	4.6	5 to 6
Width of interorbital.....	...	6.2	6.1 to 6.2	6.5 to 7.3
Length of postorbital.....	...	9	8.2 to 9.2	9 to 9.8
Distance, snout to dorsal fin.....	...	62	57.7 to 59.3	57.7 to 61
“ snout to pelvic fin.....	40	42.3	45.3	45.5 to 46.7
“ isthmus to pelvic fin.....	...	28.6	31.7 to 34.7	32.5 to 33.3
“ anus to pelvic fin.....	18	16.8	15.7 to 18.5	15.5 to 17.5
“ anus to base of caudal... ..	42.3	40	42	39.4 to 42
Length of first dorsal, depressed.....	8	7.2	6.6 to 8.2	6.6 to 7.8
Distance between origins of dorsals..	14.8	12	12.8 to 16.2	12 to 13.4
Length of second dorsal base.....	11.4	10.5	9.2 to 10.2	10 to 10.8
Height of second dorsal fin.....	...	...	9.8 to 10.2	10.2
Length of base of anal fin.....	...	19	18.4 to 20.8	19.3 to 21.2
Length of caudal peduncle.....	...	18	17.8 to 19	16.5 to 18
Length of lower caudal lobe.....	...	...	19.4 to 24	.....
Length of pectoral fin.....	...	19	18 to 21	19.5 to 20.2
Length of pelvic fin.....	...	9.3	8.7 to 9.6	9.5 to 11
Number of rays: first dorsal.....	VI	V	V to VII	V or VI
“ “ “ second dorsal.....	12	I, 11	I, 9 to I, 12	I, 10 to I, 12
“ “ “ anal.....	24	I, 19	I, 19 to I, 24	I, 20 to I, 23
“ “ “ pectoral.....	...	14	13 to 15	13 or 14
Number of transverse scale-rows....	67	66	59 to 68	61 to 65

2a. Intergrades between *A. affinis affinis* and *A. affinis littoralis*

Atherinops affinis JORDAN AND GILBERT, 1880, Proc. U. S. Nat. Mus., III, (1881), p. 456 (San Luis Obispo, i. e., Port San Luis, then called Port Hartford). EIGENMANN AND EIGENMANN, 1892, Ann. N. Y. Acad. Sci., VI, p. 352 (Port Hartford). Records only.

^a Measurements from type description or type figure of *A. oregonia*.

^b Specimen recorded by Gilbert as *A. insularum*.

^c Measurements made from the entire series only in the case of the critical characters.

Range.—Coast of central California (San Luis Obispo County, and Santa Barbara County north of Point Arguello).

Record-stations.—Near Piedras Blancas, between that point and San Simeon: young specimens caught in a rock-pool at low tide, on June 2. Morro Bay: spawning adults seined from sand-bar at mouth of Morro Creek, on June 8. Port Hartford: Jordan and Gilbert, as *Atherinops affinis*. Avila, near Port San Luis, which is the present designation of "Port Hartford": spawning adults seined in the brackish water lagoon, and in the fresh water of San Luis Creek near its mouth; May 25–26. Surf (Lompoc Junction): adults seined in the brackish water lagoon at the mouth of Santa Inez River.

Relationships.—The intergradation of *affinis* and *littoralis* has already been discussed (see p. 412): in this connection there need only be added the following series of measurements and counts.

Habits.—This intermediate race of *A. a. affinis* is very abundant, close inshore, along the coast of central California. It is said by the fishermen to enter the bays and estuaries in large numbers in the spring. It spawns in spring or early summer, in or near the mouths of streams. Thus, it was found in Morro Bay spawning on a sand-bar at the mouth of Morro Creek; it was found at Avila to be excessively abundant in the lagoon at the mouth of San Luis Creek, where many hundreds of specimens, including breeding adults, were caught in a single pull of a small minnow-seine; breeding adults were also taken in the fresh water of this creek near its mouth, but not above tide-water; other adults were taken in the brackish water lagoon at the mouth of Santa Inez River. This fish has no great tenacity of life, many of those caught in the minnow-seine dying in the bag while the seine was being drawn a short distance to shore.

Measurements and Counts of ten specimens, 101 to 166 mm. long to caudal, from the mouth of San Luis Creek.—Length of head into total length without caudal, 4.7 to 5.0; depth of body, 4.4 to 5.1; depth of caudal peduncle into head, 2.6 to 3.1; length of snout, 3.4 to 3.6; length of upper jaw, 3.4 to 4.0; diameter of eye, 3.65 to 4.1; width of interorbital, 3.1 to 3.5; length of postorbital, 2.2 to 2.5; length of head into distance from isthmus to anus, 2.1 to 2.4. Measurements in hundredths of length to caudal base: length of head, 20 to 21; depth of body, 20.5 to 22.5; depth of caudal peduncle, 7.2 to 7.8; length of snout, 5.6 to 6.1; upper jaw, 5 to 6.2; eye, 4.8 to 6; interorbital, 6.2 to 6.7; postorbital, 8 to 9.5; distance from snout to dorsal fin, 55 to 61; snout to pelvic fin, 43 to 46.5; isthmus to pelvic fin, 30 to 32.5; anus to pelvic fin, 14.5 to 18; anus to base of caudal, 39 to 41.5; length of first dorsal when depressed, 6 to 7.7; distance between origins of dorsal fins, 12.5 to 17; base of second dorsal, 8 to 11.5; height of second dorsal, 7.8 to 10; base of anal, 17.5 to 21.6; length of pec-

TABLE V.—MEASUREMENTS AND COUNTS OF INTERGRADES BETWEEN *A. a. affinis* AND *A. a. littoralis*

	Morro Bay			Surf		Mouth of San Luis Creek				
Length to base caudal, mm.....	148	135	115	135	128	126	166	166	156	132 101
Length of head in length to base of caudal	4.9	4.85	4.45	4.75	4.8	4.8	5.0	5.0	4.9	4.9 4.7 4.8
Length of eye in hundredths of length to base of caudal.....	5.5	5.4	6.0	5.6	5.6	5.6	5.5	4.8	5.5	5.6 5.7 6.0 6.0
Interorbital width in head.....	3.5	3.2	3.35	3.2	3.5	3.1	3.2	3.35	3.2	3.35 3.25 3.1 3.5
Depth of caudal peduncle in head.....	2.9	2.7	3.0	2.8	2.8	2.7	2.6	2.7	2.7	2.8 2.7 2.7 3.1
Length of head in distance from isthmus to anus.....	2.3	2.35	2.0	2.2	2.25	2.2	2.35	2.3	2.35	2.25 2.1 2.3 2.2
Length of pectoral fin.....	21.5	20.3	20.7	22.5	22	21	19	21	22	18 21 18 ...
Transverse scale-rows.....	64	68	61	57	62	61	56	64	63	57 63 59 61

toral fin, 17.8 to 22; length of pelvic, 8.5 to 10.5. Number of spines in first dorsal, 5 to 7; soft rays in second dorsal, 9 to 13; soft rays in anal, 18 to 23; pectoral rays, 13 to 15; number of transverse scale-rows, 56 to 64.

The following table gives typical examples of the combining, in single specimens of these intergrades, of the contrasted characters of both *A. a. affinis* and *A. a. littoralis*. The measurements and scale counts printed with bold-faced type are typical of, or most like, those of *affinis*, while the measurements and scale counts in light-faced type are like those characteristic of *littoralis*.

2b.—*A. affinis littoralis* varying toward *A. affinis affinis*

Atherinops affinis JORDAN AND GILBERT, 1880, Proc. U. S. Nat. Mus., III, (1881), p. 456 (Santa Barbara). JORDAN AND JOUY, 1881, idem, IV, p. 13 (Santa Barbara). EIGENMANN AND EIGENMANN, 1892, Ann. N. Y. Acad. Sci., VI, p. 352 (Santa Barbara). GILBERT, 1893, Rept. U. S. Fish Comm., (1896), p. 465 (Santa Barbara).

Range.—Mainland shore of the Santa Barbara Channel, southern California.

Record-stations.—Near Goleta: in channel forming outlet and inlet of estero; abundant; breeding; July 5. Santa Barbara: recorded by Jordan and Gilbert, and others, as *A. affinis*. Near Carpenteria: abundant in the muddy water of El Estero; breeding; July 4.

Relationships.—This race of *Atherinops*, while fairly typical of *littoralis*, shows a definite approach toward *affinis* in the size of the scales (see Table II, p. 414) and in other characters indicated below. As in the case of the last race, those items, in which each specimen listed in the following table resembles typical *affinis*, are emphasized by bold-faced type.

TABLE VI.—MEASUREMENTS AND COUNTS OF SPECIMENS OF *A. a. littoralis*
VARYING TOWARD *A. a. affinis*

	Near Goleta			Santa Barbara	El Estero, near Carpenteria			
Length to base caudal, mm.....	110	101	94	115	137	113	123	120
Length of head in length to base of caudal	4.3	4.65	4.5	4.4	4.65	4.8	4.6	4.5
Length of eye in hundredths of length to caudal base.....	7.3	6.3	6.6	6.2	6.3	6.3	6.3	6.2
Interorbital width in head.....	3.5	3.2	2.9	3.6	3.4	3.45	3.4	3.35
Depth of caudal peduncle in head.....	3.0	2.8	2.7	2.95	3.1	3.0	2.85	2.8
Length of head in distance from isthmus to anus.....	1.9	2.0	1.9	2.2	2.3	2.1	2.2	2.3
Length of pectoral fin.....	22.7	21	21.5	21	21.5	20	19.5	21.5
Transverse scale-rows.....	57	64	61	57	58	58	55	57

3.—*Atherinops affinis littoralis*, new subspecies

Atherinops affinis STEINDACHNER, 1875, Sitzb. Akad. Wiss. Wien, LXXII, p. 89 (San Diego record). JORDAN AND GILBERT, 1880, Proc. U. S. Nat. Mus., III, p. 29 (San Diego). ROSA SMITH, 1880, A List of the Fishes of San Diego (San Diego). JORDAN AND GILBERT, 1880, Proc. U. S. Nat. Mus., III, (1881), p. 456 (San Pedro; San Diego). JORDAN AND JOUY, 1881, idem, IV, p. 13 (Wilmington). JORDAN AND GILBERT, idem, p. 43 (in part; "Cape Mendocino southward"); 1883, Bull. U. S. Nat. Mus., XVI, p. 409 (in part; "Pacific Coast"). GILBERT, 1891, Proc. U. S. Nat. Mus., XIV, p. 549 (locality not given; probably San Diego). EIGENMANN, 1891, Amer. Nat., XXV, p. 579 (San Diego); 1892, Proc. U. S. Nat. Mus., XV, pp. 129, 146 (San Diego). EIGENMANN AND EIGENMANN, 1892, Ann. N. Y. Acad. Sci., VI, p. 352 (San Diego; San Pedro). JORDAN AND EVERMANN, 1898, Bull. U. S. Nat. Mus., XLVII, part 2, p. 807 (in part; "Coast of California"). STARKS AND MORRIS, 1907, Univ. Cal. Publ. Zool., III, p. 187 (in part; "San Francisco to Magdalena Bay"). METZ, 1912, Ann. Rept. Laguna Mar. Lab. (Pomona College), I, p. 31 (Newport Bay; Laguna Beach). JORDAN AND SNYDER, 1913, Proc. U. S. Nat. Mus., XLV, p. 576 (locality not given; probably San Diego).

Range.—Mainland shores of Ventura, Orange, Los Angeles, and San Diego Counties, in southern California; probably of northern Lower California also, although there are no records from that region.

Record-stations.—Ventura: in brackish water lagoon at mouth of Ventura River. Redondo: abundant about sewer outlet under wharf; a partially protected beach. San Pedro Bay: recorded by Jordan and Gilbert and others as *A. affinis*. Alamitos Bay, Orange County: specimens obtained in sloughs (a mature female 95 mm. long to caudal collected on Juen 6, when no young were observed; many of both sexes, the longest 102 mm. long, seined on August 6, on which date young about an inch long were especially abundant). Sunset Beach: specimens caught from wharf, near surf, on August 6. Newport Bay and Laguna Beach: recorded by Metz as abundant throughout the summer. Near Del Mar: young taken in salt water lagoon just north of town. La Jolla: specimens in the Scripps Institution for Biological Research, collected on April 18. Mission Bay (False Bay): specimens taken near mouth of bay. Point Loma: numerous young specimens, from 43 to 61 mm. long without caudal, collected on December 31, in a rocky tide-pool on the ocean side of the Point; schools of half-grown individuals noted in the summer just off the same rocks. San Diego Bay: recorded by authors in general, as *A. affinis*; common throughout the year, congregating in especial abundance about the sewer outlet; breeding in spring and early summer (May and June, according to Eigenmann; one of the type lot, taken April 2, has matured ova); larvæ recorded by Eigenmann as abundant in the bay.

Habits.—In addition to the notes just given, a few other details of the habits of *littoralis* may be added: like *Mugil*, it feeds largely on mud, with which the alimentary canal is often distended; it swims in rather large groups near the surface; it tolerates both muddy and clear water; it seems to remain close inshore everywhere and may be taken in abundance in seines. Like the other species of the genus, all of which have been examined in this respect, *littoralis* breeds first at the age of two years; the larger adults are three or four years old. The age-determinations upon which these conclusions are based were made on several specimens of each of the several forms in the genus. The seasonal marks, checks, or annuli, on the scales, supposedly formed during the winter, are well developed in *Atherinops*. The first annulus is often indistinct and sometimes is not apparent in the first year group among schools of fishes taken at the beginning of the breeding season.

Atherinops affinis littoralis is a food fish of good quality, though rather bony. It is usually found in the markets, being known, along with *Atherinopsis californiensis*, as "Smelt." The fishermen, it is true, frequently distinguish it from that species under the name of "Top-smelt," or "Little Smelt" (in allusion to its swimming habits or its small size), while they refer to the larger species as the "Jack-smelt" or "Blue-smelt."¹

Nomenclature.—*Atherinops affinis littoralis* is well differentiated from *A. a. affinis*, but is regarded as a subspecies because of the intergradation of the two forms. The fact that the intergradation is interpreted as probably the result of the thorough hybridization of two formerly distinct species can not alter the situation from a nomenclatural point of view, because of the difficulties surrounding the general application or testing of such an interpretation.

Despite the obvious nature of the differences which distinguish the two, *littoralis* has not previously been separated from *affinis*; they have probably never been directly compared. The types of *insularum* and *oregonia* were contrasted with specimens of *littoralis* on the erroneous assumption that the latter were typical of *affinis*.

Holotype.—A female with ripening ova, 143 mm. long to caudal base; Cat. No. 2064, Field Museum of Natural History; collected by the Bureau of Fisheries' Steamer *Albatross*, at North Island, San Diego Bay, California, April 2, 1894.

Description and Comparisons.—*A. a. littoralis* is a more trimly built fish than *A. a. affinis*: the dorsal contour is not elevated at the occiput, as it is in that form, and the caudal peduncle is decidedly more slender (Table

¹ These fishes are known to the Latin fishermen chiefly as *Pescado del Rey*, or similar names signifying "Fish of the King."

III, p. 415). The tip of the premaxillaries are on a level with the middle of the pupil, instead of its lower border. The head is relatively longer (Tables XIII and XIV) but proportionately narrower (Table XV). The larger comparative size of the eye (Table XVII) is accentuated by the lesser development of adipose tissue about it. The paired fins are longer, the difference in the case of the pectoral being noteworthy (Table XIX); the first dorsal is also, on the average, a little higher, its length, when depressed, being constantly less than half the distance between the two dorsals (Table XVIII). The scales (Table II) in *littoralis* are constantly larger than in *affinis*, and they seem to be more regularly arranged anteriorly. The smaller size of *littoralis* (Table VIII) and its general darker tone of color serve further to distinguish it from *affinis*. Otherwise, the two forms are apparently similar.

A. a. littoralis differs from the three island forms of *Atherinops* in various characters, as outlined in the comparative tables referred to above. It is distinguished from all by the greater compression of the body and by the larger size of the scales. When compared with these island forms, *littoralis* is found to resemble *insularum*, of the adjacent islands, the least. It differs from that form in the following characters: scales larger; dorsal spines on the average more numerous; pectoral fin longer; first dorsal higher; head narrower and comparatively longer; snout shorter; eye longer; body more robust; size smaller.

Measurements and Counts of the holotype, supplemented by those of eleven paratypes from San Diego Bay, Alamitos Bay, and Ventura.—Length to base of caudal, 143 mm. (91 to 148 mm.); length of head into length of body to caudal, 4.6 (4.2 to 4.85); depth of body, 4.75 (4.15 to 5.15); least depth of caudal peduncle into length of head, 2.83 (2.8 to 3.15); length of snout, 3.4 (3.35 to 3.85); least interorbital width, 3.35 (3.35 to 3.8); postorbital length of head, 2.25 (2.2 to 2.45); length of head into distance from isthmus to anus, 2.05 (2.0 to 2.3). Measurements in hundredths of length to caudal base: length of head, 21.5 (20.5 to 23.3); depth of body, 21 (20 to 23.3); depth of caudal peduncle, 8 (7.5 to 8); length of snout, 6.5 (5.7 to 7); length of upper jaw, 6.5 (6 to 7); diameter of eye, 6.3 (5.7 to 7); interorbital width, 6.6 (6 to 7); length of postorbital, 10 (9 to 10.2); distance from snout to dorsal fin, 61.5 (58 to 62); snout to pelvic fin, 43.3 (43 to 47.5); isthmus to pelvic fin, 27.5 (28 to 32.5); anus to pelvic fin, 17.3 (14.5 to 17); anus to base of caudal, 40.5 (40 to 43.5); length of first dorsal when depressed, 8 (6.7 to 8.2); distance between origins of dorsal fins, 12.8 (11.2 to 14.3); base of second dorsal, 8.7 (8 to 10); height of second dorsal, — (9 to 10.5); base of anal, 19.7 (18 to 21.5); distance between bases of anal and caudal fins (length of caudal peduncle), 17.5 (16.5 to 19); length of

lower caudal lobe, — (21.5 to 26.5); length of pectoral fin, 22 (21.7 to 24.8); length of pelvic fin, 10.7 (10 to 11). Number of spines in first dorsal fin, 7 (5 to 7); number of soft rays in second dorsal, 10 (8 to 11); soft rays in anal, 22 (17 to 24); pectoral rays, 14 (13 or 14); number of transverse scale-rows, 56 (53 to 58).

3a.—Intergrades between *A. affinis littoralis* and *A. affinis magdalenæ*.

Atherinops affinis OSBURN AND NICHOLS, 1916, Bull. Amer. Mus. Nat. Hist., XXXV, p. 156 (Port San Bartolomé).

Range.—Mainland shore on the ocean side of central Lower California.

Record-station.—Port San Bartolomé, San Bartolomé Bay, central Lower California; specimens seined on March 13, the smallest 32 mm. long to caudal; others taken April 23.

Comparisons.—These intergrades have been discussed in some detail in a former connection (see p. 415). Further comparison between them and *littoralis* on the one hand, and *magdalenæ* on the other, is made in the comparative tables (II, p. 414; III, p. 415; VIII-XIX, pp. 437-440).

Measurements and Counts of eight specimens from Port San Bartolomé.—Length to base of caudal, 107 to 124 mm.; length of head into total length to base of caudal, 4.35 to 4.65; depth of body, 4.5 to 5.2; least depth of caudal peduncle in length of head, 2.6 to 2.9; snout, 3.4 to 3.7; upper jaw, 3.4 to 3.7; eye, 3.35 to 3.7; interorbital, 3.2 to 3.4; postorbital, 2.35 to 2.4; length of head into distance from isthmus to anus, 1.9 to 2.2. Measurements in hundredths of length to base of caudal fin: head, 21.5 to 23; depth of body, 20 to 22; depth of caudal peduncle, 7 to 8.5; snout, 6 to 7.5; upper jaw, 6 to 7.5; eye, 6 to 7.3; interorbital, 6.5 to 7.3; postorbital, 9 to 9.7; snout to dorsal, 59 to 62; snout to pelvic, 44 to 48; isthmus to pelvic, 28 to 32; anus to pelvic, 14.5 to 17; anus to base of caudal, 41 to 44; length of first dorsal when depressed, 7 to 8.2; distance between origins of dorsals, 11.4 to 13.3; base of second dorsal, 8.5 to 10.5; height of second dorsal, 9.2 to 10.3; base of anal, 21.5 to 23; length of pectoral, 21.5 to 24; length of pelvic, 10 to 11. Number of spines in first dorsal fin, 5 or 6; soft rays of second dorsal, 9 or 10; soft rays of anal, 20 or 21; pectoral rays, 13 to 15; number of transverse scale-rows, 55 to 58.

4.—*Atherinops affinis magdalenæ* Fowler

?*Atherinopsis californiensis* LOCKINGTON, 1881, Proc. Acad. Nat. Sci. Phila., p. 114 (? based upon the specimens subsequently serving as the types of *Atherinops magdalenæ*); (Magdalena Bay).

Atherinops magdalenæ FOWLER, 1903, idem, (1904), p. 740, Pl. xlii (Magdalena Bay).

Atherinops affinis STARKS AND MORRIS (after Gilbert MS.), 1907, Univ. Cal. Publ. Zool., III, p. 187 (Magdalena Bay). OSBURN AND NICHOLS, 1916, Bull. Amer. Mus. Nat. Hist., XXXV, p. 156 (Magdalena Bay; Santa Maria Bay).

Range.—Southwestern Lower California.

Record-stations.—Magdalena Bay; Santa Maria Bay. The material reported on here has already been recorded by Starks and Morris, and by Osburn and Nichols. The material of the latter lot was collected by the 1911 expedition of the *Albatross*: on March 18, at Santa Maria Bay; on March 20, on the beach on the outer side of Mangrove Island, Magdalena Bay¹; and on March 21, off Magdalena.

Habits.—Nothing definite concerning the habits of *magdalenæ* has been published. Judging from the size of the series collected by the *Albatross* on two occasions, the species is probably common in Magdalena Bay. In addition to remains of algæ, small gastropod shells and shell fragments were found in the stomachs of large specimens.

Comparisons.—*A. a. magdalenæ* is much more closely related to *A. a. littoralis* than to any other form of the genus. It differs from *littoralis*, and resembles *affinis*, however, in its deeper caudal peduncle, and further approaches *affinis* in its larger size, somewhat smaller eye, and paler coloration. It differs from *affinis* and resembles *littoralis* in the following characters: the dorsal contour is not elevated at the occiput; the tip of the premaxillaries are on a level with the middle of the pupil, rather than its lower border; the head is relatively longer; the interorbital, narrower; the eye, larger; the paired fins, longer; the scales, larger (see comparative tables).

As in related forms, the position of the spinous dorsal is variable, being either over or behind the anus; hence this character, used in the distinction of *magdalenæ* from *affinis* by Fowler, proves to be of little systematic value. The number of transverse scale-rows (52 to 58) is higher in the material examined than that given for the type (47). The peritoneum is not silvery gray as originally described, but black, as in all other species of *Atherinops*.

Measurements and Counts of fourteen topotypes of *Atherinops affinis magdalenæ*.—Length to caudal base, 93 to 172.5 mm.; head in total length to caudal, 4.1 to 4.88; depth of body, 4.88 to 5.17; least depth of caudal peduncle in head, 2.4 to 2.7; snout, 3.45 to 3.6; upper jaw, 3.3 to 3.7; eye, 3.5 to 4.1; interorbital, 3.3 to 3.6; postorbital, 2.2 to 2.35; length of head in distance from isthmus to anus, 1.9 to 2.15. Measurements in hundredths of length to base of caudal fin: head, 21 to 22.7; depth of body, 20 to 21, depth of caudal peduncle, 8.2 to 8.6; snout, 6.2 to 6.7; upper jaw, 6 to 7;

¹ See Townsend, 1916, Bull. Amer. Mus. Nat. Hist., XXXV, p. 417.

eye, 5.5 to 6.5; interorbital, 6.5 to 7; postorbital, 9 to 10.3; distance from snout to dorsal fin, 59 to 62; snout to pelvic fin, 43 to 48; isthmus to pelvic fin, 26.5 to 30.5; anus to pelvic fin, 14 to 16; anus to base of caudal, 42 to 42.5; length of first dorsal when depressed, 7 to 8; distance between origins of dorsal fins, 10.8 to 15.5; base of second dorsal, 10.5 to 11; height of second dorsal, 9.5 to 10.5; base of anal fin, 21 to 22; length of caudal peduncle (base of caudal to end of anal base), 15.5 to 18; length of pectoral fin, 21 to 22.6; length of pelvic fin, 10.2 to 11.5. Number of spines in first dorsal fin, 5 to 7; soft rays of second dorsal, 9 to 12; soft rays of anal, 20 or 21; pectoral rays, 13 or 14; number of transverse scale-rows, 52 to 58.

***Atherinops insularum* Gilbert**

Although the relations of the three island forms of *Atherinops* have already received some attention (pp. 410 to 412), a general comparison between them and three mainland forms of the subgenus may precede the more detailed discussion of each form.

The island races of *Atherinops* are all trimly built fishes, resembling *Atherinopsis californiensis* in form; they are less compressed and usually less robust than the mainland races. In addition to their form, the island races, considered together, differ from those of the mainland in only one character: the pectoral rays on the average are more numerous; in both cases the mode of variation is at fourteen rays, but along the mainland the pectoral fin contains thirteen rays more frequently than fifteen, whereas on the islands the reverse is true:

<i>Pectoral rays</i>	13	14	15	16
Mainland (75 specimens).....	17	54	4	—
Islands (55 specimens).....	1	31	22	1

The island forms of *Atherinops*, as previously discussed, probably are related to *A. a. affinis* of the northern mainland more closely than to *A. a. littoralis* and to *A. a. magdalenæ*: they resemble *affinis* in the small size of the scales (Table I, p. 411); in the width of the head (Table XV, p. 439), and in the shortness of the pectoral (Table XIX). The size of the scales is the most clearly diagnostic among these characters; the width of the interorbital in *cedrosensis* is no greater than that of the intergrades between *littoralis* and *magdalenæ*, which inhabit the adjacent main-shore, although wider than in typical specimens of any of the mainland forms; the pectorals are not much shorter in *guadalupæ* than in *magdalenæ*. The island forms, as a whole, differ from *affinis* proper in the more slender form, particularly of the caudal peduncle (see Table IX, p. 437); in the slightly higher position of the mouth, the tip of the premaxillaries being on a level with the middle

rather than the lower edge of the pupil; and in the greater length of the head as compared with the distance from isthmus to anus. In addition to these general differences, each of the island forms may be distinguished by several characters from each of the mainland forms, considered separately.

Some zoologists would not apply trinominal nomenclature to these island forms, as obviously no actual intergradation can occur between them. Two of the forms, *insularum* and *guadalupæ*, are surely sufficiently differentiated to be contrasted as distinct species, if they alone were known. But *cedroscensis* is intermediate between the other two: the range of its variation overlaps that of both *insularum* and *guadalupæ* in the case of each of the contrasted characters, except the interorbital width. Consequently the relationships of the three forms seem to be well expressed by the use of trinominal names. Those ichthyologists who demand a strict demonstration of intergradation for the recognition of forms as subspecies may use binominal nomenclature in this case.

5.—*Atherinops insularum insularum* Gilbert

Atherinops insularum GILBERT, 1891, Proc. U. S. Nat. Mus., XIV, p. 549 (in part; San Clemente Is.; San Nicholas Is.). JORDAN AND EVERMANN, 1898, Bull. U. S. Nat. Mus., XLVII, part 2, p. 807 (after Gilbert). STARKS AND MORRIS, 1907, Univ. Cal. Publ. Zool., III, p. 187 (in part; Santa Cruz Is.; San Nicholas Is.; San Clemente Is.). JORDAN AND SNYDER, 1913, Proc. U. S. Nat. Mus., XLV, p. 576 (the particular island not mentioned).

Atherinops affinis GILBERT, 1898, Rept. U. S. Fish Comm. (1899), p. 25 (Santa Catalina Island).

Range.—Shores of the Santa Barbara (or Channel) Islands, off southern California.

Record-stations.—Santa Cruz Island; recorded by Starks and Morris, after Gilbert, MS. San Nicholas Island: Gilbert. Santa Catalina Island: recorded by Gilbert, as *A. affinis*; two specimens examined from near Avalon, received from the Los Angeles High School. San Clemente Island: Gilbert. Specimens were examined from each of these islands except Santa Cruz.

Habits.—Nothing definite is known concerning the habits of *insularum*. The form of the fish would indicate that it is a stronger swimmer than the mainland species, a characteristic probably correlated with the absence of estuaries about the islands.

Comparisons.—*A. i. insularum* differs from *A. a. littoralis*, and approaches, resembles, or exceeds in its variations, *A. a. affinis* of the mainland farther north, in the following characters: scales smaller; head broader and shorter; fins shorter; eye smaller; size larger (see comparative tables at end of the paper). It differs from both *littoralis* and *affinis* in its longer, sharper snout,

and in its more nearly terete body, in which respects it resembles *Atherinopsis californiensis*, and further, on the average, in the fewer dorsal spines and more numerous pectoral rays.

TABLE VII.—MEASUREMENTS AND COUNTS OF *Atherinops insularum insularum*

	San Clemente	San Nicholas	Santa Catalina
Number of specimens.....	4	4	2
Length to base of caudal, mm.....	100 to 155	147 to 220	120, 135
Head in total length to caudal.....	4.6 to 5.2	4.9 to 5.4	4.7, 4.7
Depth of body.....	5.4 to 5.8	4.9 to 5.6	5.35, 5.4
Depth of caudal peduncle in head...	2.9 to 3.3	2.7 to 3.0	3.0, 3.05
Length of snout.....	3.15 to 3.35	3.15 to 3.4	3.3, 3.35
Length of upper jaw.....	3.2 to 3.6	3.5 to 3.7	3.4, 3.6
Diameter of eye.....	3.6 to 4.0	4.2 to 4.33	4.0, 4.1
Width of interorbital.....	3.05 to 3.25	3.0 to 3.15	3.2, 3.2
Length of postorbital.....	2.25 to 2.4	2.15 to 2.2	2.2, 2.3
Length of head in distance from isthmus to anus.....	1.9 to 2.1	2.25 to 2.4	2.2, 2.3

Measurements in hundredths of length to caudal base

Length of head.....	20.5 to 22	19.5 to 20.5	21, 22
Depth of body.....	17 to 19	18.8 to 20.3	18.6, 19
Depth of caudal peduncle.....	6.7 to 7.8	7 to 7.6	7.3, 7.5
Length of snout.....	6.2 to 7.2	5.7 to 6.5	6.7, 6.7
Length of upper jaw.....	6 to 7.2	5.4 to 6	6.3, 6.6
Diameter of eye.....	5.4 to 6	4.6 to 4.8	5.6, 5.6
Width of interorbital.....	6.5 to 7.2	6.5 to 6.7	7, 7
Length of postorbital.....	8.8 to 9	8.8 to 9.7	9.6, 9.7
Distance, snout to dorsal fin.....	55.7 to 58.2	54 to 57.2	57, 59
“ snout to pelvic fin.....	42.3 to 43.5	42.3 to 45	45, 46
“ isthmus to pelvic fin.....	27.5 to 28.8	28.7 to 32	30, 32
“ anus to pelvic fin.....	13 to 14.8	14.6 to 16.3	15.5, 16
“ anus to base of caudal.....	44 to 45.3	41.5 to 44	41, 43.3
Length of first dorsal when depressed	6 to 6.3	5.6 to 6.4	6, 6.4
Distance between origins of dorsal fins	12.6 to 15.2	13.2 to 17*	12.7, 13.4
Base of second dorsal fin.....	10.2 to 11.8	9.6 to 11	9.5, 10.4
Height of second dorsal fin.....	.....	10	9
Base of anal fin.....	23 to 24	22 to 23.7	20.5, 22.5
Length of caudal peduncle.....	16.8 to 18.8	16.6 to 18.5	17, 18.4
Length of pectoral fin.....	19 to 20.3	18.6 to 20.7	20.3, 20.4
Number of rays: first dorsal.....	V or VI	V	V, VI
“ “ “ second dorsal.....	I, 10 or I, 11	I, 10	I, 9, I, 11
“ “ “ pectoral.....	14 or 15	14	15, 15
“ “ “ anal.....	I, 21 to I, 23	I, 20 or I, 21	I, 20, I, 22
Number of transverse scale-rows....	66 to 72	65 to 70	63, 65

6.—*Atherinops insularum cedroscensis*, new subspecies

Atherinops affinis STARKS AND MORRIS (after Gilbert MS.), 1907, Univ. Cal. Publ. Zool., III, p. 187 (in part; Cedros Island).

Atherinops insularum OSBURN AND NICHOLS, 1916, Bull. Amer. Mus. Nat. Hist., XXXV, p. 156 (Cedros Is.; San Benito Is.).

Range.—Cedros and San Benito Islands, off the coast of central Lower California.

Record-stations.—Cedros Island (also known as Cerros Is.): Starks and Morris, after Gilbert MS, as *Atherinops affinis*; southeast side of island, March 11, 1911 (Osburn and Nichols, as *A. insularum*). West San Benito Island: young specimens, the largest 67 mm. long to caudal, collected March 9, 1911, and recorded by Osburn and Nichols as *A. insularum*. All of the known specimens were collected by the naturalists of the United States Bureau of Fisheries' Steamer *Albatross*, and all have been re-examined.

Atherinops insularum cedroscensis resembles closely both *A. i. guadalupæ* and *insularum* in those respects in which those two forms agree with each other, with the single exception that its head is slightly narrower. In those characters by which *guadalupæ* differs from *insularum*, *cedroscensis* is intermediate, the range of its variation in the case of each distinctive feature overlapping that of the two related forms (see comparative tables at the end of this paper).

Habits.—The Cedros Island *Atherinops* was collected on the southeast and east sides of that island on March 11, 1911, and reported to be of "excellent quality and very abundant."¹ Two specimens obtained at Cedros Island, by the *Albatross* on a former occasion, had their stomachs distended by small crustacea, the one 116 mm. long to caudal containing in addition a myctophid fish 13.5 mm. long.

Nomenclature.—*A. i. cedroscensis* has been recorded under the names of *affinis* and *insularum*, its distinctive features not having been appreciated.

Holotype.—A female specimen with ripening ova, 175 mm. long to caudal (Cat. No. 7144, American Museum of Natural History); collected by the *Albatross* on the southeast side of Cedros Island, off the coast of central Lower California, on March 11, 1911.

Comparisons.—*Atherinops insularum cedroscensis*, like the other island forms, has a gracefully slender and not strongly compressed body; the dorsal contour is scarcely elevated at the occiput; the caudal peduncle is slender. The head is of moderate length, and apparently somewhat narrower than in the other island races. The eye is larger than in *affinis* or

¹ Townsend, 1916, Bull. Amer. Mus. Nat. Hist., XXXV, p. 410, fig. 8.

insularum, being a little shorter than the snout, which is less produced than in *insularum*. The tip of the premaxillaries are on a level with the middle of the pupil; the forked teeth are arranged in a single series on each jaw.

Measurements and Counts of the type of *cedroscensis*, supplemented by those of ten paratypes.—Length to base of caudal fin, 175 mm. (110 to 166 mm.); length of head in total length to caudal, 5.15 (4.5 to 4.9); depth of body, 5.0 (4.6 to 5.5); depth of caudal peduncle into head, 3.0 (2.9 to 3.05); length of snout, 3.5 (3.25 to 3.6); length of upper jaw, 3.6 (3.4 to 3.7); diameter of eye, 3.8 (3.4 to 4.0); width of interorbital, 3.2 (3.2 to 3.4); length of postorbital, 2.15 (2.2 to 2.5); length of head in distance from isthmus to anus, 2.25 (1.9 to 2.35). Measurements in hundredths of length to base of caudal: head, 20.2 (20.7 to 22.2); depth of body, 20.4 (17.5 to 21.5); depth of caudal peduncle, 6.8 (7 to 7.8); distance from snout to origin of dorsal fin, 58.5 (56 to 59); snout to pelvic fin, 46 (43.5 to 46); isthmus to pelvic fin, 31 (27 to 31); anus to pelvic fin, 15 (14 to 16); anus to base of caudal, 41.8 (41 to 43); length of first dorsal fin when depressed,—(6 to 8); distance between origins of dorsal fins, 14 (13.5 to 15.5); base of second dorsal, 10.5 (9.6 to 11); height of second dorsal,—(7.5 to 9); base of anal fin, 22.5 (20.5 to 22.5); length of pectoral fin, 20 (19 to 21.6); length of pelvic fin,—(9 to 10). Number of spines in first dorsal fin, 6 (5 to 7); soft rays in second dorsal, 11 (10 or 11); pectoral rays, 14 (14 or 15); soft rays in anal fin, 24 (18 to 23); number of transverse scale-rows, 63 (61 to 70).

7.—*Atherinops insularum guadalupæ*, new subspecies

Atherinops insularum GILBERT, 1891, Proc. U. S. Nat. Mus., XIV, p. 549 (in part; Guadalupe Island). JORDAN AND EVERMANN, 1898, Bull. U. S. Nat. Mus., XLVII, part 2, p. 807 (in part; after Gilbert). STARKS AND MORRIS, 1907, Univ. Cal. Publ. Zool., III, p. 187 (in part; after Gilbert). OSBURN AND NICHOLS, 1916, Bull. Amer. Mus. Nat. Hist., XXXV, p. 156 (in part; Guadalupe Is.).

Range and Record-station.—Guadalupe Island, off Lower California (see Map, opposite p. 412); first obtained by the *Albatross* on February 28, 1889, and recorded by Dr. Gilbert as *Atherinops insularum*, in the type description of that form; again collected by the *Albatross*, with the use of dynamite, on March 2, 1911, and recorded by Osburn and Nichols as *A. insularum*.

Habits.—Almost wholly unknown. It seems to spawn earlier, and perhaps longer, than the mainland forms, a female 147 mm. long to caudal (Cat. No. 46667, U. S. N. M.), taken February 28, being mature, while another of the same length (the type specimen), taken March 2, has ripening ova.

Nomenclature.—Recorded twice as *Atherinops insularum*, this form has remained without a distinctive name.

Holotype.—A female with ripening ova, 147 mm. long to base of caudal fin; collected by the *Albatross* with the use of dynamite, at Guadalupe Island, March 2, 1911; Cat. No. 7145, American Museum of Natural History.

Comparisons.—The Guadalupe Island *Atherinops* differs widely and unmistakably from *A. i. insularum* of the Santa Barbara Islands, although it resembles that form more closely than it does any of those occurring on the mainland. The body is subterete, being usually more slender than *insularum*, and decidedly more slender and less compressed than the mainland forms; the caudal peduncle is even more slender than in *insularum*. The head averages longer and broader than in any other form of the subgenus; the eye is large, averaging slightly larger than in *littoralis*, and being much larger than in *affinis* or *insularum*; the snout is blunter and usually less pointed than in *insularum*. The position and form of the mouth is like that of *littoralis* and *insularum*; the teeth are bifid like those of the other forms of the subgenus. The first dorsal fin is higher than in *insularum*, extending, when depressed, more than half way to the origin of the second dorsal; the spines are more frequently six than five, while the reverse is true for *insularum*; the pectoral rays average slightly more than in the mainland forms; in its length the pectoral fin of *guadalupe* is intermediate between that of *A. i. insularum* on the one hand, and that of *affinis* or *littoralis* on the other. The Guadalupe subspecies has the scales as small as those of *affinis*, but on the average not so numerous as in *insularum* (see Table I, p. 411). The color is darker than in *affinis* or *magdalenæ*; the size attained seems to be somewhat less than in the case of *affinis* or *insularum*. The measurements and counts serving as the basis for these comparisons are given below; the comparisons are repeated in more graphic form in the following tables.

Measurements and Counts of the type of *A. i. guadalupe*, supplemented by those of fifteen paratypes.—Length to base of caudal, 147 mm. (123 to 147 mm.); length of head in total length to caudal, 4.4 (4.2 to 4.8); depth of body, 5.2 (5.15 to 5.5); depth of caudal peduncle in length of head, 3.35 (3.1 to 3.4); length of snout in head, 3.35 (3.2 to 3.6); length of upper jaw, 3.5 (3.35 to 3.8); diameter of eye, 3.6 (3.2 to 3.6); width of interorbital, 2.95 (2.9 to 3.15); length of postorbital, 2.35 (2.2 to 2.4); length of head in distance from isthmus to anus, 1.85 (1.75 to 2.1). Measurements in hundredths of length to caudal base: length of head, 23 (21 to 24); depth of body, 19.5 (18 to 20); least depth of caudal peduncle, 7 (7 to 7.5); distance from snout to origin of first dorsal fin, 58 (54 to 57.5); snout to pelvic

fin, 43 (42 to 45); isthmus to pelvic fin, 27.5 (27 to 30); anus to pelvic fin, 15 (12.7 to 15); anus to base of caudal, 44 (42.5 to 45); length of first dorsal when depressed, — (7.3 to 8.8); distance between origins of dorsals, 13.3 (13.5 to 16.5); base of second dorsal, 9.5 (9 to 11.5); height of second dorsal, 10.5 (9 to 11); base of anal fin, 21.5 (21 to 23.5); length of pectoral fin, 21 (20 to 22); length of pelvic fin, 10.5 (9.8 to 11). Number of spines in first dorsal fin, 7 (5 to 7); soft rays in second dorsal, 10 (9 to 12); soft rays in anal, — (20 to 24); pectoral rays, 15 (14 or 15); number of transverse scale-rows, 65 (60 to 69).

V.—COMPARATIVE TABLES OF MEASUREMENTS AND COUNTS

In order to compare graphically the differential features of the six forms of the subgenus *Atherinops*, the following comparative tables have been prepared. They supplement those included in the preceding sections of the paper: size of the scales (Table I, p. 411; Table II, p. 414), and depth of the caudal peduncle (Table III, p. 415). The figures forming the basis of these comparative tables are generally given in the tables of measurements and counts for each form, but in certain cases additional figures are included.

TABLE VIII.—LENGTH TO CAUDAL BASE OF THE LARGEST SPECIMEN OF EACH FORM EXAMINED

<i>A. a. affinis</i>	227 mm.
Intergrades	163
<i>A. a. littoralis</i>	148
<i>A. a. magdalenæ</i>	172.5
<i>A. i. insularum</i>	220
<i>A. i. cedroscensis</i>	175
<i>A. i. guadalupæ</i>	147

TABLE IX.—DEPTH OF BODY (EXPRESSED IN HUNDREDTHS OF LENGTH TO CAUDAL BASE)

	17	18	19	20	21	22	23
<i>A. a. affinis</i>							
Intergrades							
<i>A. a. littoralis</i>							
Intergrades							
<i>A. a. magdalenæ</i>							
<i>A. i. insularum</i>							
<i>A. i. cedroscensis</i>							
<i>A. i. guadalupæ</i>							

TABLE X.—DEPTH OF CAUDAL PEDUNCLE (MEASURED INTO HEAD)

	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4
<i>A. a. affinis</i>											
Intergrades											
<i>A. a. littoralis</i>											
Intergrades											
<i>A. a. magdalene</i>											
<i>A. i. insularum</i>											
<i>A. i. cedroscensis</i>											
<i>A. i. guadalupæ</i>											

TABLE XI.—NUMBER OF SPINES IN THE FIRST DORSAL FIN ¹

	4	5	6	7
<i>A. a. affinis</i>	..	7	11	1
Intergrades	..	4	11	5
<i>A. a. littoralis</i>	1	6	10	4
Intergrades	..	2	3	..
<i>A. a. magdalene</i>	..	6	5	4
<i>A. i. insularum</i>	..	8	2	..
<i>A. i. cedroscensis</i>	..	4	6	1
<i>A. i. guadalupæ</i>	..	2	8	6

TABLE XII.—NUMBER OF PECTORAL RAYS ¹

	13	14	15	16
<i>A. a. affinis</i>	4	12	1	..
Intergrades	1	11	2	..
<i>A. a. littoralis</i>	4	9	..	..
Intergrades	1	5	1	..
<i>A. a. magdalene</i>	7	17	..	..
.....				
<i>A. i. insularum</i>	1	6	4	..
<i>A. i. cedroscensis</i>	..	16	11	1
<i>A. i. guadalupæ</i>	..	9	7	..

TABLE XIII.—LENGTH OF HEAD (MEASURED INTO LENGTH TO BASE OF CAUDAL)

	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7
<i>A. a. affinis</i>																
Intergrades																
<i>A. a. littoralis</i>																
Intergrades																
<i>A. a. magdalene</i>																
<i>A. i. insularum</i>																
<i>A. i. cedroscensis</i>																
<i>A. i. guadalupæ</i>																

¹ The number of individuals among those examined, having the given number of fin-rays, are listed in this table.

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