BULLETIN OF THE SOUTHERN CALIFORNIA ACADEMY OF SCIENCES

Vol. 66 April-June, 1967 No. 2

OTOLITHS AND OTHER FISH REMAINS FROM A LONG BEACH, CALIFORNIA, PLIOCENE DEPOSIT

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Historically, southern California has been blessed with rich outcrops of Pliocene and Pleistocene fossil assemblages, but the ever-increasing press of human encroachment is making rapid inroads toward the ultimate destruction of this heritage. Almost daily, long-standing fossil deposits are buried, carried away, or otherwise lost in the process of freeway and other road construction, in the development of vast housing tracts, complex shopping centers and industrial sites, and because of the cut-and-fill techniques employed to dispose of much of the refuse discarded by today's populace. Although all of these activities go hand-in-hand with an expanding human population, and are considered symbolic of progress, most paleontologists would take exception with using the word "progress" to describe the systematic destruction of fossil deposits, including many type localities, and the opportunity to study the past.

One consolation lies in the fact that "new" fossil deposits are exposed by earth-gouging equipment almost as frequently as "old" deposits are destroyed. Unfortunately, because one measure of progress in construction is the amount of earth that can be moved during a given 24-hour period, few of these new deposits are exposed for more than an hour, a day, or perhaps a week. In addition, only a

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small percentage of these are reported to anyone who is interested in sampling them, or in a position to do so.

During construction of the San Diego Freeway (Interstate 405) through Long Beach in 1963, Reimer observed a procession of fast-moving trucks hauling fossiliferous dirt. He traced these vehicles back to their loading area, and found the source of the fossiliferous dirt was the bottom of a 37-foot deep pit on the south side of the San Diego Freeway where it was crossed by Cherry Avenue. At the time of discovery (July 26), only the south portion of the pit remained undisturbed, and it was from this exposure that Reimer removed about a 300-pound field sample on July 26, 27, and 28 after construction crews had departed each day—the only time he was permitted to enter the area.

The sample was presented to the Los Angeles County Museum of Natural History where George P. Kanakoff, Curator of Invertebrate Paleontology, supervised the washing, screening, and removal of fossils. The site was designated LACMIP 423, and according to Kanakoff (*pers. commun.*), the matrix was composed of shells, dark gray sand, and silt. The gray color, from the high biotite content, had been imparted to most of the otoliths and other fossils. The presence of *Tresus paharoanus* (Conrad) among the mollusks, as well as other invertebrate species that never have been known to occur in Pleistocene deposits, indicated the material was of Pliocene origin—probably representing the top of the Upper Pliocene.

The fish remains found in this deposit were from 32 species (at least) belonging to 19 families. Sharks and rays were identified from 29 teeth and 7 caudal "stings," while teleost remains comprised 1,230 otoliths and 3 miscellaneous bony fragments (Table 1).

Systematic Account

Isuridae—mako sharks

Carcharodon carcharias (Linnaeus)—white shark

The white shark inhabits temperate and subtropical waters of all world seas. It is known in the eastern Pacific from fewer than 100 individuals captured between Alaska and Mazatlan, Mexico. A large specimen for our coast might be 12 to 15 feet long, although white sharks have been reported (unreliably) to attain 35 feet. This species probably is responsible for most of California's unprovoked shark attacks, usually made in relatively shallow water near shore.

Material: one tooth.

TABLE 1

List of Fish Remains Found in a Long Beach, California, Pliocene Deposit (Freeway Cut near Signal Hill)

Scientific name	Common name	*Type and number of remains found* teeth	otoliths	other
	ELASMOBRANCHS			
Carcharhinus spp.	requiem sharks	9		
Carcharodon carcharias	white shark	1		
Galeorhinus zyopterus	soupfin shark	3		
Myliobatis californicus	bat stingray	14		
Sphyrna sp.	hammerhead shark	1		
Triakis semifasciata	leopard shark	1		
Urolophus halleri	round stingray			7*
	TELEOSTS			
Artedius notospilotus	bonehead sculpin		1	
Atherinopsis californiensis	jacksmelt		1	
Citharichthys sordidus	Pacific sanddab		7	
Citharichthys stigmaeus	speckled sanddab		24	
Citharichthys spp.	sanddabs		9†	
Cymatogaster aggregata	shiner perch		10	
Electrona rissoi	chubby flashlightfish		2	
Engraulis mordax	northern anchovy		1	
Genyonemus lineatus	white croaker		687	
Lepidogobius lepidus	bay goby		6	
Lyopsetta exilis	slender sole		1	
Merluccius productus	Pacific hake		8	
Microgadus proximus	Pacific tomcod		1	
Otophidium scrippsae	basketweave cusk-eel		105	
Otophidium taylori	spotted cusk-eel		45	
Otophidium spp.	cusk-eels		12†	
Paralichthys californicus	California halibut		3	
Parophrys vetulus	English sole		1	
Porichthys myriaster	specklefin midshipman		1	
Porichthys notatus	plainfin midshipman		14	
Roncador stearnsi	spotfin croaker		15	
Sebastodes spp.	rockfish		3†	
Seriphus politus	queenfish		271	
	unidentified teleosts		2‡	3**

*stings
**vertebra, skull fragment, and fin spine
†too worn or fragmented to identify to species
‡embiotocid otoliths

Carcharhinidae—requiem sharks

Carcharhinus spp.—requiem sharks, species undetermined.

At least four species of sharks belonging to this genus have been captured off southern California at one time or another during the

past 30 or 40 years, but these and several other species do not occur abundantly north of about Magdalena Bay, Baja California. Some species of requiem sharks may attain lengths of 15 feet, but others may never exceed 5. Because of the confusion among taxonomists regarding speciation, we have not attempted to identify the teeth from this deposit beyond the generic level.

Material: 9 teeth.

Galeorhinus zyopterus Jordan and Gilbert—soupfin shark

Soupfin sharks are abundant between British Columbia and about Magdalena Bay, Baja California. Females occur principally south of Point Conception, and males north of there. They may be caught in water as shallow as 100 feet, but most are found deeper than that. A 6½-foot female (about maximum) may weigh as much as 100 pounds.

Material: 3 teeth.

Triakidae—smoothhounds

Triakis semifasciata Girard—leopard shark

The leopard shark has been caught between Oregon and Cape San Lucas, as well as in the northern Gulf of California. Typically they inhabit shallow areas where the bottom is sandy or sandy-mud. A 5-footer is large, but they may reach 7 feet. The jaws of this species contain approximately 400 teeth.

Material: one tooth.

Sphyrnidae—hammerhead sharks

Sphyrna sp.—hammerhead shark, species undetermined.

Three species of these tropical sharks have been recorded from our waters in modern times, but they are rarely seen north of about Magdalena Bay except during periods of oceanic warming up-coast from there. The largest hammerheads may reach 15 feet, but those observed off California seldom exceed 8. Because of inadequate knowledge of their dentition, we have not attempted to identify the tooth from this deposit to species.

Material: one tooth.

Myliobatidae—eagle rays

Myliobatis californicus Gill—bat stingray

Bat stingrays range from Oregon to Magdalena Bay, occurring in shallow bays, along the mainland coast, and around offshore islands.

A record specimen weighed 209 pounds, but individuals exceeding 50 pounds are rare. Because their heavy, plate-like teeth are large and easily recognized, few escape detection in fossil deposits.

Material: 14 teeth.

Dasyatidae—stingrays

Urolophus halleri Cooper—round stingray

Round stingrays have been captured between Humboldt Bay, California, and Panama, but they are not abundant north of about Ventura, California. They are especially fond of shallow bays, sloughs, and estuaries, but also abound on the outer coast where the bottom is not rocky. Although it is difficult, if not impossible, to distinguish the caudal sting of *Urolophus* from that of *Myliobatis californicus* or a juvenile *Dasyatis*, we are identifying the stings from this deposit as being from round stingrays because they are so much more abundant in a shallow, sandy habitat than the others. Round stingray teeth are minute, and will not be retained by 20-mesh screens (the smallest used for this deposit), so the absence of their teeth was not unexpected.

Material: 7 "stings."

Engraulidae—anchovies

Engraulis mordax Girard—northern anchovy

Northern anchovies range from British Columbia to Magdalena Bay and from the surf zone offshore for 100 miles or more. They usually are seen in schools at or near the surface, but there is evidence that great quantities of large, adult anchovies live at depths of 600 to 800 feet. Individuals are reported to attain lengths of 9 inches, but a 7-inch fish could be considered quite large.

Material: one otolith (Fig. 4), 4.0 mm long, showing two winter annuli and a wide summer zone at the margin.

Myctophidae—lanternfishes

Electrona rissoi (Cocco)—chubby flashlightfish

The chubby flashlightfish is a bathypelagic species that apparently lives 1,000 feet or more beneath the surface. It has rarely been caught off California, although a great deal of midwater trawling has been done in areas where it should occur. There is some question regarding the validity of the name *rissoi* for the form that inhabits the eastern Pacific, but the otoliths from this deposit match perfectly those removed from an inch-long individual caught off our coast.

Material: two otoliths (Fig. 11), the largest being 3.5 mm long.

Gadidae—cods

Microgadus proximus (Girard)—Pacific tomcod

The Pacific tomcod ranges from about Morro Bay north to Alaska. It seems to prefer depths of 200 feet or more, but at times pier and skiff fishermen catch great quantities in shallow water. They are reported to reach lengths of 12 inches, but no weights are available for such a fish. A 10¼-inch female weighed just a bit under 6 ounces. This is the only species found in this deposit whose range during modern times fails to extend south to the latitude of Long Beach.

Material: one broken otolith 3.5 mm long (Fig. 9).

Merlucciidae—hakes

Merluccius productus (Ayres)—Pacific hake

Pacific hake range from Alaska to the southern tip of Baja California, and offshore for 350 miles or more. Sometimes they are found in shallow water near shore, but mostly they travel in dense schools near the bottom in water deeper than 600 feet. They are said to reach lengths of 3 feet, but a 30-inch fish is rare; a 26-inch female weighed slightly more than 4 pounds.

Material: eight badly worn otoliths (Fig. 12), the largest fragment being 7.3 mm long.

Bothidae—lefteyed flounders

Paralichthys californicus (Ayres)—California halibut

California halibut have been captured between Alsea, Oregon, and Magdalena Bay, but they are not abundant north of San Francisco. They live on the bottom, usually in water shallower than 200 feet, often in the surf zone and in coastal bays and estuaries. A 5-foot, 72-pound female seems to be a record size.

Material: 3 otoliths, the largest being 9.3 mm long (Fig. 20).

Citharichthys sordidus (Girard)—Pacific sanddab

Pacific sanddabs are said to range from southern Alaska to about Magdalena Bay, but reports of the species in central and southern Baja California need to be verified. The maximum size reported for the Pacific sanddab (16 inches and 2 pounds) also is subject to question; a 12-inch female, the largest of several thousand recently examined, weighed less than 10 ounces. The otoliths of *C. sordidus* are

easily distinguished from those of the other two Californian sanddabs because of a sharp notch in the antero-dorsal margin.
Material: 7 otoliths, 4.4 to 6.6 mm long (Fig. 17).

Citharichthys stigmaeus Jordan and Gilbert—speckled sanddab

Speckled sanddabs range along the coast from southeastern Alaska to Sebastian Viscaino Bay, Baja California, usually in water shallower than 200 feet, and often just outside the surf zone. A large individual might be 5 inches long and weigh less than an ounce. Their otoliths are easily distinguished (if in good condition) from those of the other two Californian sanddabs because of their straight margins.
Material: 24 otoliths, 1.9 to 3.4 mm long (Fig. 14).

Citharichthys spp.—sanddabs, species undetermined.

Several sanddab otoliths were too badly worn or fragmented to identify beyond the generic level.
Material: 9 otoliths identifiable to genus but not to species.

Pleuronectidae—righteyed flounders

Lyopsetta exilis (Jordan and Gilbert)—slender sole

Slender soles are abundant in depths of 400 to 800 feet or more between Alaska and Cedros Island, Baja California. They are less abundant in shallower water, but sometimes they do occur in 150 feet or less. A large individual might exceed 12 inches in length, but probably would not weigh more than 3 or 4 ounces.
Material: one otolith 2.9 mm long (Fig. 21).

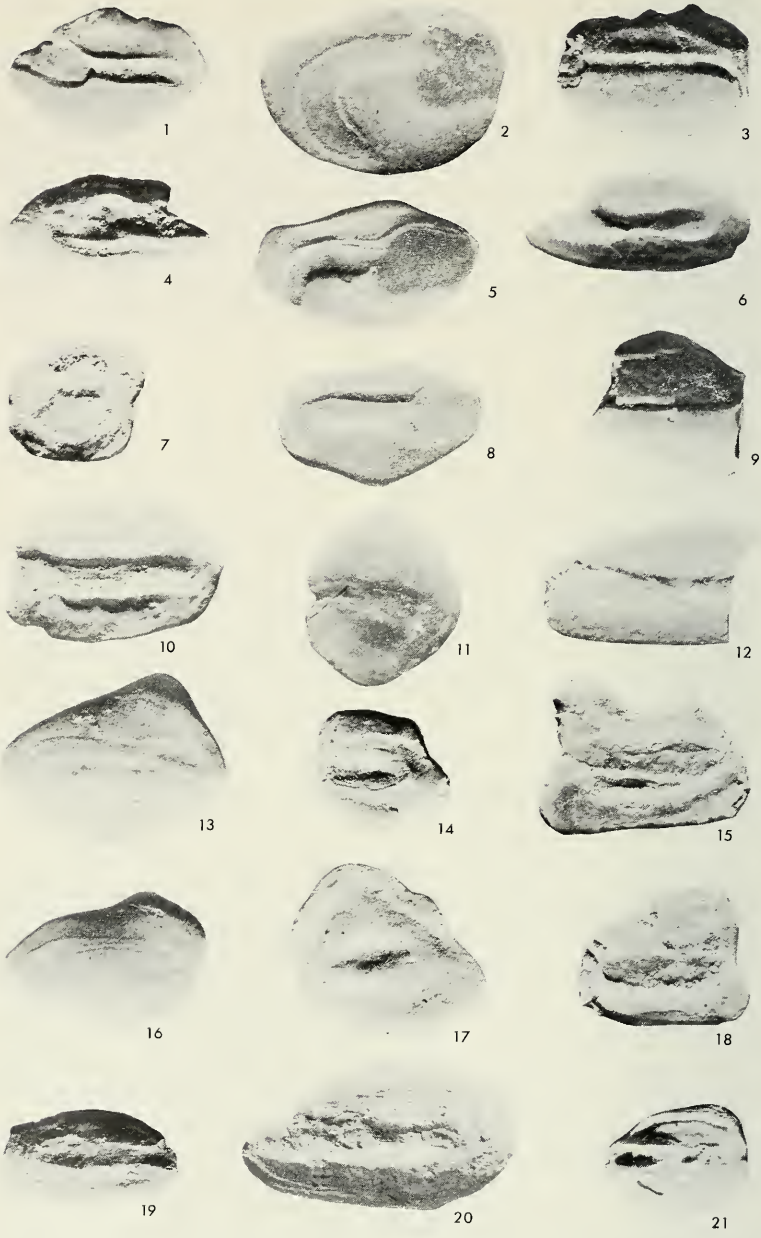
Parophrys vetulus Girard—English sole

The English sole ranges from Alaska to Cedros Island, Baja California, usually migrating inshore to spawn but living in deep water most of the remaining time. They prefer sandy mud or muddy bottom areas, and off southern California are most abundant at depths greater than 30 fathoms. A large English sole might reach 21 inches and 2 pounds or slightly more. The otoliths of *P. vetulus* are difficult to distinguish from those of two other flatfishes, *Eopsetta jordani* and *Lepidopsetta bilineata*, without a careful comparison.
Material: one otolith 4.8 mm long (Fig. 19).

Atherinidae—silversides

Atherinopsis californiensis Girard—jacksmelt

Jacksmelt are found between northern Oregon and about Magda-



lena Bay, usually near the surface in relatively shallow water both in bays and along the outer coast. They are reported to reach 22 inches but no weight is available for such a fish; a 16½-inch female weighed about 1 pound 3 ounces.

Material: one otolith 5.2 mm long (Fig. 3).

Sciaenidae—croakers

Genyonemus lineatus (Ayres)—white croaker

White croakers are abundant on sandy or sandy-mud bottoms between Vancouver Island and Magdalena Bay. They usually travel in loose aggregations just above the bottom, and are equally at home in shallow water or in 600 feet. A 14½-inch fish, which is large for a white croaker, weighed 1.4 pounds. Their otoliths were the most abundantly found fish remains in this deposit.

Material: 687 otoliths 2.4 to 10.5 mm long (Fig. 5).

Seriphus politus Ayres—queenfish

Queenfish have been reported between Yaquina Bay, Oregon, and San Juanico Bay, Baja California, in much the same habitat as the white croaker, except that they seem to prefer staying above the bottom instead of on it. A 12-inch fish, about as large as they grow,

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Figure 1. Inner face, right sagitta of *Cymatogaster aggregata*, 5.4 mm long.
Figure 2. Inner face, left sagitta of *Roncador stearnsi*, 5.7 mm long.
Figure 3. Inner face, right sagitta of *Atherinopsis californiensis*, 5.2 mm long.
Figure 4. Inner face, left sagitta of *Engraulis mordax*, 4.0 mm long.
Figure 5. Inner face, left sagitta of *Genyonemus lineatus*, 7.3 mm long.
Figure 6. Inner face, right sagitta of *Artedius notospilotus*, 6.0 mm long.
Figure 7. Inner face, left sagitta of *Lepidogobius lepidus*, 3.1 mm long.
Figure 8. Inner face, left sagitta of *Seriphus politus*, 6.8 mm long.
Figure 9. Inner face, left sagitta (central part) of *Microgadus proximus*, 3.5 mm segment.
Figure 10. Inner face, right sagitta (rostrum missing) of *Sebastodes* sp., 7.5 mm long.
Figure 11. Inner face, right sagitta of *Electrona rissoi*, 3.5 mm long.
Figure 12. Inner face, left sagitta (posterior half) of *Merluccius productus*, 7.3 mm long.
Figure 13. Inner face, left saggita of *Otophidium scrippsae*, 6.0 mm long.
Figure 14. Inner face, left sagitta of *Citharichthys stigmaeus*, 3.4 mm long.
Figure 15. Inner face, left sagitta of *Porichthys myriaster*, 5.7 mm long.
Figure 16. Inner face, left sagitta of *Otophidium taylori*, 6.9 mm long.
Figure 17. Inner face, left sagitta of *Citharichthys sordidus*, 5.5 mm long.
Figure 18. Inner face, right sagitta of *Porichthys notatus*, 4.6 mm long.
Figure 19. Inner face, left sagitta of *Parophrys vetulus*, 4.8 mm long.
Figure 20. Inner face, right sagitta of *Paralichthys californicus*, 9.3 mm long.
Figure 21. Inner face, right sagitta of *Lyopsetta exilis*, 2.9 mm long.

Photographs by Jack W. Schott

weighed just over 10 ounces. Their otoliths were the second most abundantly found fish remains in this deposit.

Material: 271 otoliths, 3.0 to 9.3 mm long (Fig. 8).

Roncador stearnsi (Steindachner)—spotfin croaker

Spotfin croakers range from about Point Conception to San Juanico Bay, usually along sandy beaches and in coastal bays and estuaries where depths do not exceed about 60 feet. A 26⅝-inch spotfin caught at Ensenada in 1959 weighed 10¼ pounds, a near record size for the species.

Material: 15 otoliths, 3.9 to 11.1 mm long (Fig. 2).

Embiotocidae—surfperches

Cymatogaster aggregata Gibbons—shiner perch

Shiner perch are extremely abundant in shallow water throughout much of their known range: Port Wrangel, Alaska, to Santo Tomas Point, Baja California. They have been trawled from 400 feet of water, but are most abundant at depths shallower than 50 feet. They apparently are restricted to the mainland coast; those around the offshore islands have been given the name *C. gracilis*. A 7-inch long pregnant female weighing about 3 ounces contained 16 young which were almost 2 inches long each; no larger shiner perch has been reported.

Material: 10 otoliths, 3.2 to 5.5 mm long (Fig. 1).

Embiotocid perch not identified to species.

Two otoliths, unmistakably from embiotocids, were too badly worn to be identified to species. The "wear" appeared to be the result of digestive action from being in the stomach of some predator, rather than from abrasion.

Scorpaenidae—rockfishes

Sebastodes spp.—rockfish, species undetermined.

Fifty-two members of the genus *Sebastodes* inhabit the waters of California. Some of these live exclusively over rocky bottoms, others inhabit areas of sandy or sandy-mud bottom. Some live out their entire adult lives in relatively shallow water near shore, but others remain in deep water offshore. Some attain lengths of 36 inches and weights in excess of 35 pounds, while others never reach 8 inches and 4 ounces. The otoliths of most of these species can be distinguished one from the other if they are from adult fish and if they are not

worn or broken. Such characters as length and shape of rostrum, configuration of posterior end, angle of taper, depth of sulcus, and number of growth zones (annuli) for otolith size are helpful for determining species or species-complex. All of the rockfish otoliths from this deposit were too worn and fragmentary to identify to species.

Material: 3 otoliths, probably representing three species (Fig. 10).

Cottidae—sculpins

Artedius notospilotus Girard—bonehead sculpin

The bonehead sculpin ranges from about Puget Sound to Ensenada, usually at depths shallower than 150 feet where the bottom is sand or sandy mud. A large female taken in Santa Monica Bay in 1961 was slightly shorter than 7 inches and weighed about 3½ ounces. Otoliths of cottids usually are abundant in fossil deposits (Fitch, unpublished data), but because of their small size they are difficult to find without the aid of a microscope. Unless in near-perfect condition, identification to species is impossible.

Material: one otolith 6.0 mm long (Fig. 6).

Gobiidae—gobies

Lepidogobius lepidus (Girard)—bay goby

This small fish is fairly common in quiet, shallow waters between northern Vancouver Island and about Ensenada. They seem to prefer areas shallower than 60 feet but occasional individuals are trawled in 250 to 300 feet. A large specimen might be 5 inches long and weigh one ounce.

Material: 6 otoliths, 2.0 to 3.1 mm long (Fig. 7).

Batrachoididae—toadfishes

Porichthys myriaster Hubbs and Schultz—specklefin midshipman

Specklefin midshipmen range from about Point Conception to Magdalena Bay. They often seek out rocky intertidal areas for spawning, but at other times they can be found in 300 feet or more. They prefer firm mud or muddy bottoms to other habitat types except during spawning and "nesting." A 19-inch male weighed slightly less than 4 pounds, possibly a record length and weight.

Material: one otolith 5.7 mm long (Fig. 15).

Porichthys notatus Girard—plainfin midshipman

Plainfin midshipmen are among the half-dozen most abundant

species in trawl catches made in depths of 300 to 750 feet. They are found in most areas between southeastern Alaska and Cedros Island where the bottom is muddy. During spawning and "nesting" they often move into intertidal areas, but during other periods they may range into 1,200 feet of water.

Material: 14 otoliths 3.3 to 5.2 mm long (Fig. 18).

Ophidiidae—cusk-eels

Otophidium scrippsae Hubbs—basketweave cusk-eel

The range of *O. scrippsae* is relatively restricted compared with other species found in this deposit: Point Conception to about Turtle Bay, Baja California. Divers report that they prefer a habitat of small rocks and cobbles, hiding under and among these during daylight hours and moving out into sandy areas at night. A large individual might be 12 inches long and weigh about 5 ounces. The basketweave cusk-eel typically inhabits shallower depths than the spotted cusk-eel. The otoliths of *O. scrippsae* are easily distinguished from those of *O. taylori*, if they are in good condition, by their expanded anterodorsal margin and their concave to flat inner face anteriorly.

Material: 105 otoliths 3.4 to 6.8 mm long (Fig. 13).

Otophidium taylori (Girard)—spotted cusk-eel

The spotted cusk-eel has habits similar to those of *O. scrippsae*, but seems to prefer living in deeper water: typically 60 to 800 feet. They range from about Humboldt Bay to San Cristobal Bay, Baja California. A large individual caught in deep water off San Pedro in 1960 was 14½ inches long and weighed almost 10 ounces. The otoliths are more tear-drop shaped than those of *O. scrippsae*.

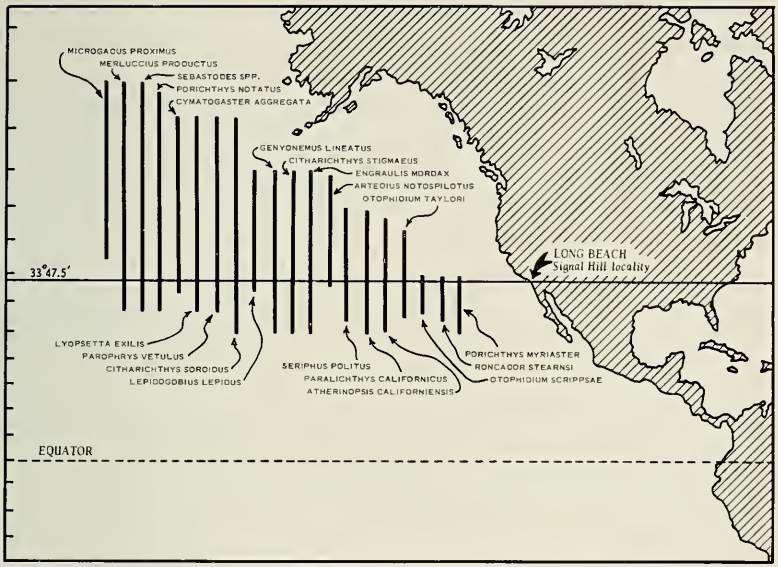
Material: 45 otoliths 2.6 to 8.1 mm long (Fig. 16).

Otophidium spp.—cusk-eels, species undetermined.

Twelve cusk-eel otoliths were too badly fragmented to identify to species.

Discussion

The assortment of fish remains found in this deposit, with but two exceptions, was typical of a shallow-water, coastal fauna similar to what one would find at the same latitude today (Fig. 22). The otoliths of *Electrona rissoi*, a deepwater species, are difficult to explain in a shallow-water deposit, but since they have been found in several other southern California Pliocene and Pleistocene deposits (Fitch,



gure 22. Present-day distributions of the 20 non-bathypelagic teleost fishes iden-ied from the Long Beach, California Pliocene deposit (LACMIP 423, lat. 33° .5′ N.). *Drawing by Walter Thomsen.*

npublished data), they apparently were more abundant during prehistoric" times than today, and may have had different habits so. Another possibility is that the fish were picked up and eaten y gulls or other sea birds working over deep water, and transported ioreward in the digestive tract of the bird. Fish otoliths will pass rough a number of fish-eating birds and suffer little or no damage om digestive action (Martini, 1964), and many lanternfishes, in-uding close relatives of *Electrona rissoi* (*e.g.*, *Electrona subaspera* the Antarctic) undergo diurnal migrations which make them vul-erable to surface-feeding birds. A final possibility is that *Electrona ssoi* suffered a mass mortality and drifted into shallow water before isintegrating; such a lanternfish die-off has been reported for *Tarle-nbeania crenularis* in Monterey Bay (Aughtry, 1953).

The otolith of the tomcod, *Microgadus proximus*, would seem be the only incongruous fish remain in the deposit, but otoliths of is species too have been encountered in several other southern Cali-rnia Pliocene and Pleistocene deposits (Fitch, *unpublished data*). is entirely possible that a foot-thick bed of potential fossils (mol-scan remains, fish otoliths, shark teeth, crustacean parts, etc.) will

accumulate on the floor of the ocean for 100 years or more before some "catastrophe" occurs to cover and preserve the layer. In this case, the fish fauna of a single bed or layer within a deposit would reflect distributional anomalies that had occurred during the period. Fishes are notorious for reflecting short-duration (*e.g.*, weekly, monthly, or annual) temperature changes (Fitch, 1966a; Radovich, 1961) that would not be apparent from an examination of the molluscan fauna, since mollusks are so much less motile than fishes.

Many of the otoliths in this deposit were in poor condition, apparently having been eroded by digestive action while in the stomach of some predatory fish, mammal, or bird. Growth zones were apparent on many of the otoliths that had not been damaged by digestive action, but the margins of these did not indicate that a catastrophe had caused the demise of the fauna. Some otolith margins indicated summer mortality; others indicated fall, winter, or spring as the period of death. Thus, it is assumed that this accumulation of fish remains represented normal deposition over a considerable number of years.

Obviously, the 32 species of fish we have reported did not represent the entire fauna. Additional sampling unquestionably would have yielded a number of additional species and families, but since the site was covered by many tons of dirt three days after its discovery, additional sampling was not possible. Recently Fitch (1966b) has shown that many small otoliths are missed entirely when examining fossiliferous screenings with the naked eye, such as was done with the material from this deposit. Careful examination of the washed screenings under the microscope possibly would have doubled the number of otoliths found and may have added 10 to 15 species, but at this late date one can only speculate. Certainly microscopic examination is warranted for other "lost" deposits where only a small field sample has been salvaged.

Acknowledgments

This study was supported in part by a research grant (GB-1244) from the National Science Foundation. In addition, George P. Kanakoff, as Curator of Invertebrate Paleontology, Los Angeles County Museum of Natural History, supervised the several student volunteers and other Museum personnel who washed, screened, and sorted the sample. Each of these deserves to be thanked by name for his contribution to this study, so if we fail to mention anyone, it is not in-

tentional and we hope we will be forgiven. In alphabetical order they were: John E. Fitch, Jr., Nick Furjanick, Suzanne Grizet, Louis Marinkovich, Peter Oringer, Sherry Parkhurst, Robert Rashkin, William Warner, and Barbara Weeks. Finally, Jack W. Schott, San Pedro, took the excellent otolith photographs; Walter Thomsen, Long Beach, produced the fish distribution map; and Mrs. Loretta Morris, San Pedro, typed the manuscript and its revisions.

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