A DISCUSSION OF THE GEOCHRONOLOGY AND ARCHEOLOGY OF THE CALIFORNIA ISLANDS

Carl L. Hubbs

University of California, San Diego

It is the privilege of old men to forget, and I just can not remember if it was the summer of 1913 or 1914 when I started what little research I have done, off and on through many years, on the California Islands. I visited Avalon and found there a little research station, which was being operated in connection with a public aquarium. The guiding light was Charles Frederick Holder, who founded the Tuna Club at Avalon and was one of the most famous of the big-game-fish anglers of his day. I went through the collection and found a very distinct species of bathypelagic fish of the general sort that Dr. Ebeling spoke about. I described it in one of my first papers, which was published by the University of California in 1916.

I am going to devote most of my remarks to the preceding papers, but will venture into some discussion of other problems in the biology of the California Islands and northwestern Baja California.

First, I will present a few ideas on the general oceanographic and marine-faunal relations of the islands off California, subjects which have not been given quite adequate treatment in this symposium. These subjects need much more data, particularly for the inshore oceanography and for the marine life along the shore, both of which have been neglected in the very extensive Marine Life Research program of Scripps Institution. Such data are particularly important for the present consideration. During the much interrupted work I have done on the islands since the date I mentioned, several oceanographic and faunal features have become evident. The first of these is the California Current, the cold water of which comes down from the north, passing by Point Arguello and Point Conception, then along San Miguel Island, and on to San Nicolas Island and farther south. This water is cold because of the very extensive upwelling of cold water along the central and particularly along the northern coast of California (the coldest temperatures south of British Columbia occur in the Cape Mendocino region). Then there is the Davidson Counter-

rrent at certain seasons of the year when, on the contrary, a ırm current flows up from the south, sometimes not only along e southern California coast but also as far north as central ılifornia and farther.

A predominant feature of the southern California region where e islands under discussion are located is a gyre. As the Cali-rnia Current moves south outside the continental borderland, arm swings around counterclockwise to the southern part of e coast and moves up to the Northern Channel Islands, bathing ɜm in considerably warmer water.

There is a marked temperature gradient between the western-st and easternmost islands of the northern group. Once on an ɜanographic survey along the north side of the islands I found 8°C. (close to 15°F.) increase in the surface temperature be-ɜen the west end of the Santa Cruz and the Anacapa region. I .ieve that differences as great as 12°C. may occur between the st end of San Miguel Island and Anacapa Island.

This very great temperature gradient bears a close relation to fauna. On San Miguel we find invertebrates and fishes of the ɜe that occur along the Monterey coast. Dr. John S. Garth .ted at this in connection with the invertebrates in which he ɜ specialized. An example may be cited among the abalones they occur intertidally: The red abalone predominates in the stern end of the chain and the black abalone, which takes to rmer water, occurs toward the eastern end. And a very inter-ing point that we have found in examining the middens is that ɜ same pattern has existed in the past for a long time. As we to essentially cold water, the prime cold-water index fossil, *ptochiton stelleri*, is very abundant at Point Bennett on the ɜtern end of San Miguel and is replaced by warmer-water shells we go to the eastward. There has been, therefore, a con-tency in time in the temperature-related distributional pattern. .s is true along the entire coast of southern California and, ɜicularly, of Baja California.

There have, however, been very considerable fluctuations in peratures and in faunas, some of which were mentioned by Mr. l C. Orr. There is much evidence of a very considerable warm-of the oceans soon after the close of the Ice Age. Along our st this change was effected more than 7,000 years ago. About)00 years ago there was a rather abrupt change in the temper-·e of the ocean, although the trend had started about 18,000 rs ago. At about the same time the many lakes in the Great in suddenly dried up, and their dust is still blowing. A num-of these lakes were several hundred feet deep during the consin period.

have found indications that relatively warm waters persisted ıg our coasts for most of Postglacial time, but that cooler con-ɔns existed during the period of approximately 1,600 to 600 years ago. Much of this evidence stems from analysis of shell-fish in the Indian middens over the past nine millenia. Faunal changes are indicated, and paleotemperatures have been measured by analyzing the oxygen isotopes in the shells. I am hopeful that we may be able to expand the paleotemperature studies to date shell remains from various parts of the California Islands.

Changes in moisture are also significant. Orr has indicated that moist conditions obviously prevailed when cypress grew on the northwest coast of Santa Rosa Island about 15,000 years ago. This conclusion conforms with all we have learned through the west, and with what Dr. Daniel I. Axelrod said last night.

Orr indicated that there were drier periods 7,000, 5,000, and 4,000 years ago. These were periods of dune formation, yet he mentions that during the early period there were also considerable forests there. It is possible that the dunes may have formed because more sand was available and more wind blew. Conditions may have been more moist than at present. There is considerable evidence that most of Postglacial time was more moist than the present along our coast. Aboriginal populations seem to have been much too large for any amount of water that exists here today. In the La Jollan middens, which we now date around 7,500 – 4,000 B.P., we recently have found pond snails, *Helisoma amnon*, where a pond could not possibly exist under the present climatic regime.

Dr. Charles Rozaire's paper stressed the cultural chronology very nicely and interestingly, and he mentioned three very broad subsistance patterns; namely, gathering, hunting, and fishing, which appeared in about this order.

I notice that Orr found fishhooks earlier than I thought they existed. We have found fish remains in the La Jollan culture, including barracuda and tuna, which could not have been caught without use of a boat; so way back about 6,000 years ago our predecessors had some way of getting out to sea. They had some way of catching these fish although we have found no artifacts to show how they caught them, whether by fishline, net, or hooks (if the hooks were made of abalone, they may have disintegrated). Indians must have had boats or rafts of some kind to get out onto the islands.

Now I offer some remarks on Guadalupe Island, particularly because it is one of my favorite haunts. My remarks will be largely limited to points that bear on our present discussions. Dr. Albert E. J. Engel has obtained a date of about 7,000,000 years for what he regards as the oldest lava flow on the island. He has indications that this lava was formed above water and no indications that the island has been extensively submerged since that time. Hence, there has been ample time for biotic invasions and for speciation.

Around the island along about two-thirds of the eastern shoreline (for about 12 miles) and up the west coast about 2 miles, we have discovered a Pleistocene formation. It is a warm-water deposit, indicated as of the Sangamon (last) Interglacial age through ionium-thorium dating at about 120,000 years. The deposit contains reef coral and tropical shells mixed with Californian types. It occurs consistently from one to five meters above sea level, indicating that Guadalupe Island has been very stable for a long time.

From the bottom of the deep sea, Guadalupe rises about 15,000 feet – one of the great peaks of the west. There is no reason to believe there ever was any land connection between it and the mainland.

There has been considerable discussion about relictual origins of many island endemics. Much confirmatory evidence seems to me to stem from Guadalupe, where many now endemic forms are quite distinct. Most of these are probably not forms that arose there. Rather, most of these distinct forms, in all probability, persist on Guadalupe because its biota is so unsaturated that they have been able to hold out. The slug-like snail that was mentioned occurs, I understand, on one of the Southern California Islands as well as on Guadalupe. Similarly, a considerable number of the distinctive plants appear merely to be remnants of a flora that was widely distributed long ago.

On the other hand, I would like to mention briefly the high variability in some of the island forms. Some of the marine fishes are quite variable there; a few are endemic. Some of these show ecologically differentiated races, especially deep-water and shallow-water ones, that apparently have arisen there in recent time. Because of the unsaturated fauna the possibility of speciation seems to have been much greater than in a normal saturated environment.

One of the most distinctive among Guadalupe plants is *Talinum guadalupense*, of which Dr. Reid Moran showed such a beautiful picture. Among 100 or more plants that we are growing in La Jolla, I find in all the stems, leaf, and floral structures tremendous variation. In several other Guadalupe plants we have found much variability. I think that intraspecific variation is one of the distinctive features of island biotas that has not been mentioned here. In an unsaturated environment, variant genetic types seem to have a greater chance to become established.

One of the speakers brought up a point about the lack of dispersibility of some of the island plants. This is still more dramatically shown by some island birds that have lost their power of flight. The reason may very well be that individuals having good enough wings to fly far off the island often fail to come back to breed.

Another point perhaps not adequately emphasized in the discussions is that many forms which have reached the California Islands have not maintained a population – either did not gain a foothold at all or did so for a very short time. One probable reason why the small islands have so few species is not that the animals or plants did not get there, but that the chance for extinction in a small area is much greater. Some disease or unfavorable environmental condition may wipe out the population, with no opportunity for repopulation from an adjacent area. At Guadalupe, which I know much better than any of the rest, I have noted intrusions of tropical and of temperate fish species, which had presumably arrived in larval stage when the appropriate warm-water or cool-water current impinged on the island. In one instance the larvae of a tropical wrasse, *Pseudojulis* sp., developed in massive numbers to the half-grown stage but did not survive the winter. The southern spiny lobster, *Panulirus gracilis*, occasionally comes in, and at one time seems to have replaced the California lobster, *Panulirus interruptus*, but was not able to maintain itself. On islands, intruding species are no doubt very commonly eliminated.