The exposed parts of the stumps were partially encrusted with living organisms such as coralline algae, bryozoans, and sponges, but much of the exposed wood surface was barren of organisms. There was no visible evidence of any biological degradation of the wood, that is, no borer holes or indication of decay. The surfaces of the wood appeared to be shaped principally by mechanical weathering or erosion. Unlike new wood exposed in a marine environment, the wood of the stumps appears to have been immune to the usual attacks of wood-boring organisms. During the period of total encasement in the rock substrate, the wood probably underwent chemical changes that resulted in immunity to biodegradation.

As stated earlier and as shown in Figure 4, the substrate in direct contact with the stumps was undisturbed bedrock. Rock samples we obtained from fresh rockfalls along the cliff face containing the stumps were identified as coming from volcanic breccia of the Chitka Point Formation of the Miocene age (L. M. Gard, pers. comm.). The Chitka Point Formation is composed of subaerial lava flows, breccias, tuffs, and conglomerates derived from a volcano which must have been located on western Amchitka and eastern Rat Islands (Carr et al., 1971; L. M. Gard, pers. comm.). Potassium-argon dates obtained on lavas of the upper part of the Chitka Point Formation indicated an age of at least 12.4 ± 1.1 million yr (Carr et al., 1971).

Amchitka and all of the Aleutian Islands are now devoid of naturally occurring trees. Evidence that trees once grew on Amchitka does exist, however. During Miocene time, trees and other carbonaceous material were often incorporated into volcanic mudflows and debris flows of the Chitka Point Formation, as evident by the presence of this material in many of the outcrops of breccias, tuffs, and conglomerates along the Bering coast of Amchitka (Powers, Coats, and Nelson, 1960; L. M. Gard, pers. comm.).

The significance of the tree stumps reported in this paper derives from their in situ location 23 m below present sea level. Because of the offshore and submerged location of these stumps, they represent a time when the island was not only forested but larger and at least 23 m higher in relation to sea level.

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ESTIMATION OF RATES OF TAG SHEDDING BY NORTHWEST ATLANTIC BLUEFIN TUNA[1]

A joint experiment was initiated by the Fisheries Research Board of Canada (FRBC), the National Marine Fisheries Service, and the Woods Hole Oceanographic Institution (WHOI) in 1971 under the leadership of F. Mather to estimate the rates of tag shedding by bluefin tuna. Five hundred and eighty bluefin tuna were double tagged with one of four types of dart tags off the east coast of the U.S. during the 1971 fishing season. Two types of darts, metal and plastic, were used and tags supplied by FRBC were slightly different from tags supplied by WHOI. Tags and tagging procedures

[1] Contribution No. 3010, Woods Hole Oceanographic Institution, Woods Hole, MA 02543.

TABLE 1.—Tag releases and returns from east coast of U.S. bluefin tuna double tag study.

Agency and tag type	1971 Double tag releases	1971 First year returns			1972 Second year returns		
		n_{dd1}	n_{ds1}	t_1 (days)	n_{dd2}	n_{ds2}	t_2 (days)
FRBC							
Plastic dart	140	16	1	24.4	7	8	369.8
Metal dart	128	9	1	19.4	9	11	376.0
WHOI							
Plastic dart	150	4	0	7.2	20	9	349.9
Metal dart	162	4	1	18.6	10	9	371.1
Total							
Plastic dart	290	20	1	19.8	27	17	357.3
Metal dart	290	13	2	19.1	19	20	373.7
Total	580	33	3	19.5	46	37	364.7

were those described by the Food and Agriculture Organization (1972). The 1971 releases and returns in 1971 and 1972 are shown in Table 1 by tagging agency and dart type.

The notation and methodology in this study follows Bayliff and Mobrand (1972):

$$n_{ddk} = F\tau N_D \pi \rho^2 e^{-(F + X + 2L)t_k}$$

$$n_{dsk} = F\tau N_D \pi \rho (1 - \rho e^{-Lt_k}) e^{-(F + X + L)t_k}$$

where:

t_k = time at the middle of the kth period of length τ (k = 1, 2),

n_{ddk} = number of returns of double-tagged fish retaining both tags during the period centered at t_k,

n_{dsk} = number of returns of double-tagged fish retaining only one tag during the period entered at t_k,

N_D = number of fish released with double tags,

π = portion of tagged fish which remain alive after the Type-I (immediate) mortality has taken place,

ρ = portion of the tags which are retained after Type-I (immediate) shedding has taken place,

F = instantaneous rate of fishing mortality,

X = instantaneous rate of other mortality (other includes natural mortality, Type-II (long-term) tagging mortality and apparent mortality caused by migration from the fishery), and

L = instantaneous rate of shedding of tags.

Bayliff and Mobrand showed that

$$\ln \frac{2n_{ddk}}{n_{dsk} + 2n_{ddk}} = -Lt_k + \ln\rho = Y_k$$

where Y_k is an estimate of the log of the proportion of tags retained up to time t_k.

Estimates of Y_k are shown in Table 2. Estimates of L and ρ are shown in Table 3. Although some differences among categories are indicated, a chi square test for differences in returns among categories was not significant at the 90% level of confidence. Thus the differences do not appear to be large enough to rule out the use of

TABLE 2.—Intermediate results in estimates of shedding rates from 1971 U.S. east coast bluefin double tag study.

Agency and tag type	Y_1	Y_2
FRBC		
Plastic dart	-0.03077	-0.45199
Metal dart	-0.05407	-0.47692
WHOI		
Plastic dart	0	-0.20294
Metal dart	-0.11778	-0.37156
Total		
Plastic dart	-0.02469	-0.27370
Metal dart	-0.07411	-0.42286
Total	-0.04445	-0.33802

TABLE 3.—Estimates of ρ and L from 1971 U.S. east coast bluefin double tagging study.

Agency and tag type	$\ln\rho$	L on daily basis	ρ	L (on annual basis)
FRBC				
Plastic dart	-0.00102	0.0012195	0.999	0.44512
Metal dart	-0.03106	0.0011858	0.969	0.43282
WHOI				
Plastic dart	0.00426	0.0005922	1.004	0.21615
Metal dart	-0.10439	0.0007199	0.901	0.26278
Total				
Plastic dart	-0.01008	0.0007378	0.990	0.26929
Metal dart	-0.05532	0.0009835	0.946	0.35898
Total	-0.02787	0.0008504	0.973	0.31041

the estimates obtained from the combined data. These estimates of $\rho = 0.973$ and $L = 0.31041$ are close to the estimates of Bayliff and Mobrand (1972) of $\rho = 0.913$ and $L = 0.278$ for yellowfin tuna in the eastern Pacific.

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DISTRIBUTION AND ABUNDANCE OF THE SAND DOLLAR, *DENDRASTER EXCENTRICUS*, OFF THE COAST OF OREGON AND WASHINGTON

Dendraster excentricus is one of two known species of Clypeasteroid echinoids occurring along the Pacific coast of North America from British Columbia southward to Mexico. It lives on sandy bottoms from the low water zone to a depth of about 90 m[1] (Raup, 1956). Large beds of these animals have been reported in southern Puget Sound, Monterey Bay, Newport Bay, San Diego Bay, and El Estero de Punta Banda — just south of Ensenada, Mexico (Ricketts and Calvin, 1952). Merrill and Hobson (1970) made detailed observations on the behavior, distribution, and biotic relationships of *D. excentricus* along the Pacific coast of California and Baja California, Mexico. They remarked that relatively little was known about the populations of sand dollars along the exposed outer

[1] Richard J. Merrill, Department of Biological Sciences, University of California, believes this is too deep for *D. excentricus* and may refer to *D. laevis* (pers. comm.).