

THE RAPANUIAN FAUNAL DISTRICT
(EASTER AND SALA Y GÓMEZ):
IN SEARCH OF ANCIENT ARCHIPELAGOS

William A. Newman and Brian A. Foster

ABSTRACT

The shore fauna of Easter and Sala y Gómez Islands displays a remarkably high degree of endemism, primarily at the specific level and recently estimated at 42% for marine mollusks. It is difficult to explain how such high endemism could have evolved in situ because of the relatively high rate of extinction expected on small, isolated islands. The islands are also very young (2.5 and 2 million years [My], respectively), so high rates of speciation for marine forms would have been required. By contrast, the Hawaiian Archipelago, where marine mollusk endemism is estimated at 20%, is at least 20 My old. Furthermore, some of the endemics of Easter-Sala y Gómez are relicts stemming from older Indo-West Pacific groups, which are likely older than these islands. An alternative explanation seems to be required to account for the origin of the endemics.

A parsimonious hypothesis for the origin of the endemics of Easter-Sala y Gómez is that most if not all were acquired from elsewhere in the region. An analysis of the numerous seamounts of the Sala y Gómez and Nazca Ridges, which extend from Easter to near South America, shows that most were once likely islands. It also indicates that there could have been a chronological continuity of shores among these islands for at least the past 29 My, shores upon which the endemics of the region could have evolved and been perpetuated up to present times. This hypothesis can be tested by dredging the guyots of the region.

Easter and Sala y Gómez, separated by 415 km at approximately 27°S, lie in relative isolation in the subtropical southeast Pacific. The small island of Pitcairn and some nearby atolls about 2,200 km to the west are the nearest shores, followed by the first group of large islands, the Gambiers, 400 km still further west. In the opposite direction are the Galápagos, on the equator, 3,480 km to the northeast, the Juan Fernandez at 33.5°S, 3,000 km to the east-southeast, and the small islands of San Felix and San Ambrosio encountered 2,860 km due east. The coast of Peru is 3,800 km east of Easter.

Not only are the closest shores presently to the west of Easter, but they are climatically more similar than those to the east, and concomitantly the primary faunal affinities of Easter-Sala y Gómez are Polynesian (Thorne, 1963). Notable however is the remarkably high degree of endemism, at the specific level. Rehder (1980) estimates endemism at 42% for the marine mollusks, corroborating the view that these islands represent a distinct district, the Rapanuian. He attributes the endemism to (1) peripheral isolation and speciation (Mayr, 1963) from islands to the west and (2) replacement of ancestral species in the west by more modern Indo-West Pacific invaders. In addition to the usual data, this model is nicely supported by the peripheral distribution of such forms as the marine gastropod *Neothais* (Rehder, 1980), and in part by the terrestrial gastropod mollusk *Tornatellides* (Peake, 1981). Thus it would seem that a vicariance model for the origin of the Easter-Sala y Gómez shore fauna could be applied (Rehder, 1980).

However, Carlquist (1981) notes that for the Hawaiian Archipelago, long-range dispersal must also have been involved. This also seems to be the case for Easter-Sala y Gómez. Southern Ocean components of the fauna include the decapod crustacean *Rhynchocinetes*, also known from Australia, Lord Howe, New Zealand,

Chile, and South Africa (Holthuis, 1972). Rehder (1980) also shows Southern Ocean affinities on one hand (Kermadecs, New Zealand and Australia), and on the other, with the Eastern Pacific. We have been studying the shore barnacles of Easter and Pitcairn and, while most have Indo-West Pacific affinities, one chtham- alid occurring on both islands belongs to a group having its principal diversity in the Southern Ocean (S.E. Australia, New Zealand and southern Chile); a detailed account is to be published elsewhere. Yet, Rehder (1980) takes a skeptical or conservative approach and for the most part dismisses evidence for contemporary dispersal of gastropod mollusks from South America and/or Juan Fernandez to Easter. But considering the evidence for dispersal in this direction in the past, it is difficult to imagine that it is not going on to a greater or lesser extent today. As Carlquist (1981), McDowall (1978) and Newman (1979) have noted, the fact of long-range dispersal as well as the possibility of vicariance must be taken into account where oceanic islands are concerned.

An apparent problem with the Easter-Sala y Gómez situation is that the islands are not only very young (2.5 My and less), but rather small. Could such a high degree of endemism among marine invertebrates develop in such a short time when the probability of extinction is so great? Furthermore, many of the endemics are relicts, stemming from older Indo-Pacific groups. They are therefore potentially older than the islands themselves.

The same difficulty, relative youth, has been noted for the Hawaiian Archipelago. Zimmerman (1963) concluded that the endemics there had descended from ancient archipelagos now worn away. Menard and Hamilton (1963) looked to the Mid-Pacific Mountains as a possible source for the older elements of the Hawaiian biota, but it is now recognized that these guyots are too old (~70 My), and were drowned before the Hawaiian Archipelago began to form (Ladd et al., 1974). It has since been suggested (Rosen, 1978) that the Hawaiian Archipelago may have received some of its biota from the now drowned islands of the Emperor Seamounts extending north-northwest in an almost continuous series of increasing age to more than 70 My. But this hypothesis ignores the same late Cretaceous extinctions and drownings that afflicted the Mid-Pacific Mountains. Only the Tertiary islands of the Emperor and other nearby chains could have been involved.

Rotondo et al. (1981) suggest the integration of ancient islands into the Hawaiian Archipelago as the plate carrying them passed over the Hawaiian Hotspot. But the two examples, Wentworth and Necker, are not only too old and therefore subject to the same extinctions noted above, but the former apparently never reached the sea surface (Ladd et al., 1974)¹ and the latter may have been elevated to its present depth by the activity of the Hawaiian Hotspot (Winterer, pers. comm.). Since the first Hawaiian Islands could not have received their shallow-water biota from the older, drowned Emperor and Mid-Pacific Mountains, it had to have come from elsewhere, by long-range dispersal². For the Hawaiian Archipelago there has been certainly 20 My, and perhaps as much as 50 My (Jarrard and Clague, 1977; Rotondo et al., 1981) if some of the youngest Emperors were

¹ Rotondo et al., 1981: 17 state that the summit of Wentworth is 329 m, and this is the depth given in the Bathymetric Atlas of the North Pacific (Menard and Chase, 1971, et seq.: 1805N). However, this depth may be in error: A contour chart (Project C-91, Sheet No. 306058) resulting from the detailed survey of the Midway Exploration of May, 1959, a portion of which was published by Ladd et al. (1974), places the depth of Wentworth at 1,818 m, and this is approximately the depth we dredged the now-dated basalt from in 1968 (SIO, Styx-leg 7). Thus, while the evidence for the integration of Cretaceous islands into the Hawaiian Archipelago is wanting, it is clear that there has been an integration of seamounts (Rotondo et al., 1981). This fact has important implications relevant to the seamount stepping-stone hypotheses of Allison et al. (1967) and Grigg and Bayer (1976), concerning the origin of seamount and oceanic, deep-water insular faunas, respectively.

² For recent evidence for long-range dispersal capabilities, in hermatypic corals, see Grigg (1981) and Richmond (1981).

at the sea surface when the Hawaiian Chain began to appear, for the development of the endemism found there today, which, for the marine mollusks is estimated to be about 20% (Kay, 1967).

It follows that the extreme youth of Easter and Sala y Gómez, relative to the high degree of endemism, poses a problem unless there were older islands in the region from which their biota could have been acquired. As noted by Rehder (1980), Easter and Sala y Gómez reside on or very near the ridge crest of the East Pacific Rise. They are late Pliocene and Pleistocene productions resulting from a hotspot in that region (Pilger and Handschumacher, 1981; Gordon and Izmirian, in prep.)³. With plate movement away from the rise crest and concomitant cooling, these islands will eventually sink beneath the sea surface, causing extinction of their shallow-water endemics (Fig. 1). However, if new islands appear in the vicinity, before the drownings, the endemics could populate them and so on through time. Such relatively local island hopping from previous islands of the region could explain the origin of the endemics that presently populate Easter and Sala y Gómez; such were noted but not commented upon by Durham (1963, fig. 3). This model could provide tens of millions rather than but 2.5 My for the ancestors of the endemics to have arrived and evolved into the endemics. What is the likelihood that such a sequence of islands existed?

PAST AND PRESENT ISLANDS IN THE VICINITY OF EASTER-SALA Y GÓMEZ

Methods

The data on the bathymetry of seamounts of the Sala y Gómez Ridge and vicinity are from GEBCO 5.11 (Mammerickx and Smith, 1980). The seamounts, numbered from 1 to 45 in Table 1, are also identified by numbers corresponding to their approximate latitude and longitude, following Hamilton (1956). For example, seamount No. 10, known as Shoal Guyot, is located at approximately 25.7°S, 85.4°W and therefore can be designated as 25.7-85.4. This system is useful in reorganizing data as well as in locating a seamount in question, but for ease of discussion the arbitrary, consecutive numbers used in Table 1 and Figures 2 and 3 are used here.

Whether or not a particular seamount is flat-topped cannot be determined from an examination of GEBCO 5.11. Therefore Mammerickx was consulted concerning the original digitized echo sounding tracks used in the construction of GEBCO 5.11. Following Mammerickx's criterion, if several consecutive soundings at the same depth were recorded after reaching the apparent crest of a poorly surveyed seamount, it was scored as a guyot (G) in Table 1. If there were insufficient soundings at the presumed crest, but the seamount was comparable in depth to nearby guyots, it was scored as a likely guyot (G?) in Table 1.

Without empirical data from the seamounts themselves, dating the seafloor along the Sala y Gómez Ridge, between the rise crest and South America, is fraught with difficulties. The possible effect of recent vulcanism at the eastern, older end of the ridge will be taken up shortly. Then, the position of the hotspot is in doubt; it may be west of Easter, or beneath or east of Sala y Gómez (Pilger and Handschumacher, 1981; Gordon and Izmirian, in prep.). Furthermore, a fossil spreading center apparently bisects the ridge in the vicinity of 90-95°W (Mammerickx et al., 1980) and there is mounting evidence that the ridge itself is in good part the production of a hot line rather than a hotspot (Bonatti et al., 1977). These complications cannot presently be resolved and an effort to unravel the history of the seamounts of the ridge may be an empty exercise. However, a partial analysis may be better than none in attempting to gain insights into what past shores may have been available for the evolution of the numerous endemics presently residing on Easter and Sala y Gómez.

A parsimonious approach is to ignore the complications involved in the structure of the Sala y Gómez and Nazca Ridges, and apply a simple, hotspot model. It follows that islands formed at or near the rise crest were carried east, to be leveled by stream and marine erosion before being drowned (Fig. 1) and that these should now be identifiable as guyots. Beginning at time zero in the vicinity of Easter and progressing to approximately 35 million years before present (Mybp) near the Peru-Chile

³ Gordon, R. G. and D. S. Izmirian (in prep.). The Nazca Plate's 25 Ma change in plate boundary and motion with respect to the hotspots.

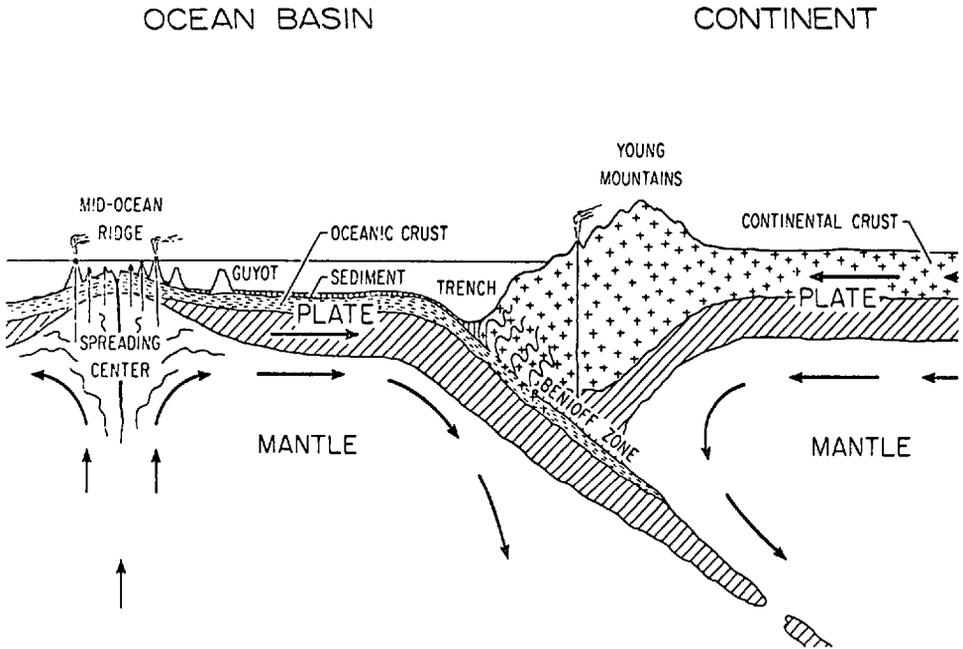


Figure 1. Schematic illustration of plate tectonics representative of a section from the East Pacific Rise into South America (from Inman and Nordstrom, 1971).

Trench, as inferred from magnetic anomalies, the seamounts can be aged by assuming that they were formed at the same time as the adjacent seafloor.

Most of the seamounts of less than 1,000-m depth in Table 1 are likely guyots, according to the criterion set forth above. Thus, it appears that there were many more islands east of Easter in the past than there are today. The question now is, was there a continuity of islands upon which the shore fauna of the region persisted for millions of years, or were there times at which there were no shores, and the previously existing shore fauna became extinct?

The seafloor to the north of the Sala y Gómez Ridge extends from approximately 3,000 m of depth at the rise crest to approximately 4,500 m of depth before descending into the Peru-Chile Trench. By picking intermediate depths off GEBCO 5.11 between these two extremes, the curve plotted beneath the seamounts in Figure 2 can be drawn. By running each guyot back to the left along this curve, until its summit reaches the present sea surface, the duration at the sea surface since leaving the rise crest can be estimated (Table 1).

The empirically derived seafloor subsidence curve indicated above is initially (between 0 and 5 Mybp) somewhat steeper than that given for the North Atlantic, and considerably steeper than that given for the North Pacific, by Parsons and Sclater (1977). If the data points selected in making the present curve have resulted in an initially exaggerated rate of subsidence, the estimates of the time the seamounts involved were at the sea surface could be minimal.

RESULTS

Western Sector

The first surface features to the west of Easter include the Gambier Islands and the Pitcairn Group. The latter constitutes the closest stepping stones to the Indo-West Pacific. Jarrard and Clague (1977) give an average age for the Gambiers of 7 My, and for Pitcairn itself, a little less than 1 My. However, there are three atolls in the Pitcairn Group (Ducie, Henderson and Oeno), and they may have been slightly elevated by the Pitcairn Hotspot (Menard, pers. comm.). They are

Table 1. Islands and select seamounts extending along the Nazca-Sala y Gómez Ridges to the Gambiers, numbered consecutively from 1 to 45, and identified by approximate latitude and longitude as proposed by Hamilton (1956). Depths in meters are from Mammerickx and Smith (1980) unless otherwise noted. Information on seamounts assumed to be guyots (G) or likely guyots (G?) was provided by Mammerickx (pers. comm.). Approximate ages in millions of years before present (Mybp) are inferred from magnetic anomalies (Pilger and Handschumacher, 1981) without regard for the complicated history of the region. Duration of seamounts at the sea surface was inferred, in conjunction with Fig. 2, by the method described in the text

No.	Position °S °W	Depth m	Age Mybp	Duration at Sea Surface	Last Time at Sea Surface	Comments
1.	19.7-80.3	820 G	34.4	5.3	29.1	
2.	21.5-81.7	328 G? 953 G	32.8 32.8	17 2.5	15.8 30.3	Nazca: ?pinnacle + foundation guyot
3.	24.9-82.1	600 G	32.1	9.5	22.6	
4.	25.7-82.5	161 G	31.9	22.5	9.4	?Recent tectonics
5.	25.7-83.2	768 G	31.5	5	26.5	
6.	25.5-84.2	750 G	30.5	5	25.5	
7.	25.8-84.7	262 G	29.5	18	11.5	
8.	24.0-84.7	300 G	29.5	18	11.5	
9.	24.7-85.4	320 G	29.2	16.3	12.9	
10.	25.7-85.4	167 G	29.2	22	7.2	Shoal Guyot; ?recent tectonics
11.	25.6-86.9	423 G	26.4	12.7	13.7	
12.	25.0-88.4	444 G	25.8	11	14.8	
13.	25.2-89.5	1,734 -	24.5	-	-	
14.	25.2-90.2	585 G?	23.7	6.5	17.2	
15.	25.2-91.6	994 G?	22.2	1	21.2	
16.	25.5-93.0	589 G?	20.6	4	16.6	
17.	25.0-94.8	1,374 -	18.2	-	-	
18.	25.7-94.8	1,527 -	18.2	-	-	
19.	24.9-96.3	1,181 ?	16.3	?0.5	15.8	May have reached sea surface
20.	25.7-96.6	1,500 -	16	-	-	
21.	25.0-97.6	412 G	14.5	4.2	10.3	Chart depth emended
22.	25.0-98.2	460 G	14	3.5	10.5	Chart depth emended
23.	25.1-98.5	424 G	13.5	3.5	10	
24.	25.6-99.1	478 G	12.8	2	10.5	
25.	25.8-99.6	1,750 -	12.3	-	-	
26.	26.0-100.7	330 G	10.9	3	7.9	
27.	26.9-100.8	1,051 -	10.9	-	-	
28.	25.2-100.9	600 G	10.4	0.9	9.5	
29.	26.0-102.1	1,762 -	9	-	-	
30.	26.0-103.4	413 G	7.3	1.5	5.8	
31.	26.5-105.4	0 I	2	2	-	Sala y Gómez
32.	26.6-106.3	825 G?	2.5	-	?0.5	Pleistocene?
33.	26.8-107.5	581 G	2.5	-	?0.5	Pleistocene?
34.	28.0-107.4	1,399 -	-	-	-	
35.	27.1-109.4	0 I	2.5	2.5	-	Easter Island
36.	27.1-109.7	613 G	-	-	-	
37.	27.0-110.3	476 G	3	0.5	-	Pleistocene?
38.	26.8-114.6	1,144 G	-	-	-	
39.	25.9-116.3	1,350 G	-	-	-	
40.	25.6-117.6	1,134 G	-	-	-	
41.	24.7-124.8	I	<25.5	-	-	Ducie Atoll
42.	24.3-128.3	I	<25.5	-	-	Henderson Atoll
43.	25.1-130.1	I	<1	-	-	Pitcairn Island
44.	23.9-130.8	I	<25.5	-	-	Oeno Atoll
45.	23.2-134.9	I	7	-	-	Gambiers

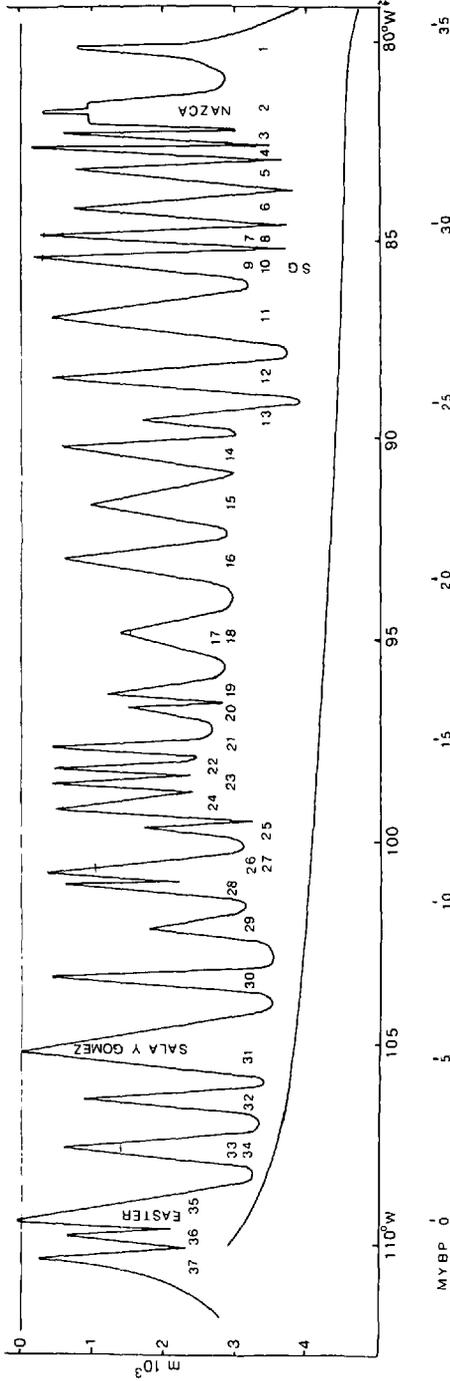


Figure 2. Schematic profile of islands and seamounts of the Nazca-Sala y Gómez Ridges (Nos. 1 to 37, Table 1), and subsidence curve extrapolated from the depths of the adjacent seafloor (Mammerickx and Smith, 1980), assuming a simple hotspot model with the hotspot just east of Easter and ignoring the fossil spreading center (Mammerickx et al., 1980) and other complications in the system.

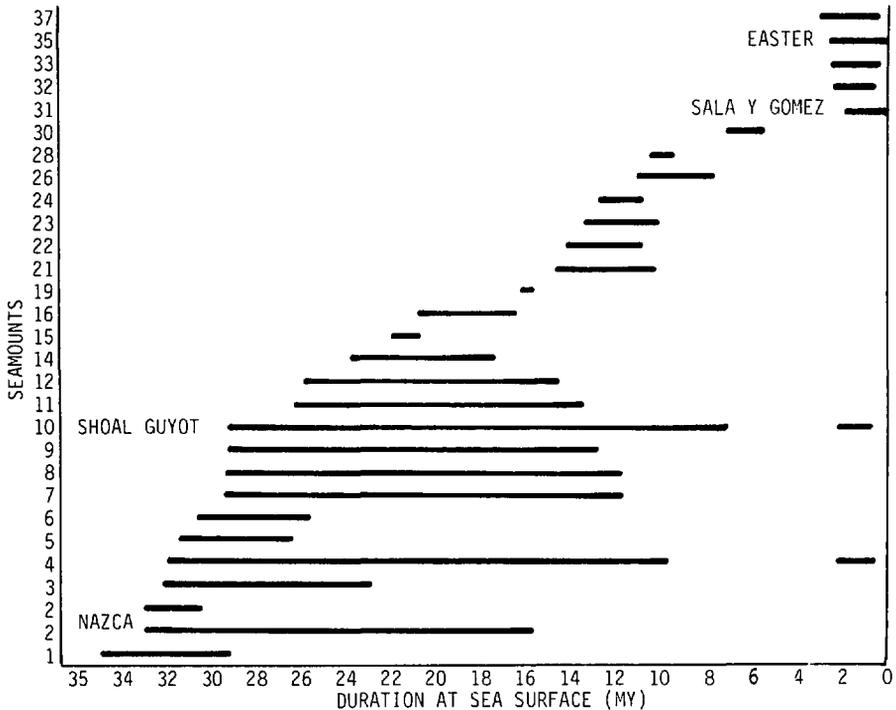


Figure 3. Durations at the sea surface of seamounts of the Nazca-Sala y Gómez Ridges since the time of their inferred appearance at the rise crest, in millions of years (My); from data presented in Table 1, and the method applied to Figure 2 described in the text.

considerably older than Pitcairn and the seafloor of the region dates at approximately 25.5 My by magnetic anomalies (Pilger and Handschumacher, 1981), but the depths and ages of the basalt underlying the reefs are unknown. In any event, Pitcairn and Easter while separated by more than 2,000 km, share some endemics, so the greater ages of the nearby atolls and their role as stepping stones is likely important.

There are few data on subsurface features between Easter and Pitcairn. Three substantial seamounts are known (Table 1, Nos. 38, 39 and 40) at depths between 1,134 and 1,350 m, and they are likely guyots (Mammerickx, pers. comm.). They are apparently too deep to have been at the sea surface when Easter appeared, and if once sea surface features, they must have subsided rather rapidly. Nonetheless, they could have been involved in speciation events with older islands to the east and/or west.

Immediately west of Easter there are two guyots (Table 1, Nos. 36 and 37) at 613 and 476 m, respectively. As we shall see, the latter was probably at the sea surface when Easter was formed.

Eastern Sector

The eastern sea surface features, the volcanic islands of San Felix and San Ambrosio, like Pitcairn, are young. They lie in line with two remarkably shallow guyots (Table 1, Nos. 4 and 10, at 161 and 167 m, respectively) at the eastern and presumably older end of the Sala y Gómez Ridge. The extreme shallowness

of these guyots and their proximity to the young volcanic islands to the east suggest that they are either relatively recent features, or old guyots elevated by tectonics associated with the adjacent vulcanism. These guyots are presently shallow enough to have been at the sea surface during the Pleistocene, an exposure that would have masked Tertiary exposures if they had been at comparable depths during the Oligocene and Miocene eustatic low stands of the sea elaborated upon by Vail et al. (1977).

Nazca Ridge, trending to the northeast from the shallow guyots just mentioned, supports a guyot at 953 m of depth (No. 2) which in turn supports a pinnacle reaching to within 328 m of the surface (Mammerickx, pers. comm.). This feature, and the curiously shallow guyots (Nos. 4 and 10) of the Sala y Gómez Ridge, are included among the ancient islands of the southeast Pacific by Durham (1963, fig. 3). They represent a significant and essential part of the present hypothesis. However, it is the numerous and previously unreported guyots between this region and Easter-Sala y Gómez that are likely more significant, and they can now be brought under consideration.

It will be noted in Figure 3, according to the assumptions made and the method applied, that there have been seamounts at the sea surface between the rise crest and the Peru-Chile Trench for at least the past 34 My, except for the hiatus between guyot No. 30 and the Easter-Sala y Gómez Group. This hiatus is critical because if it is real, there may have been no nearby shores to the east along the ridge from which the islands of Easter-Sala y Gómez Group could have acquired their shore faunas. The hiatus, however, may be due to an exaggerated subsidence curve (Fig. 2) noted earlier as well as to insufficient data. The region is sparsely surveyed and perhaps less than half of the guyots have been discovered (Mammerickx, pers. comm.). When more guyots in the region have been identified, the apparent hiatus will likely disappear. Assuming this to be the case, it will be noted that guyots to the east of the hiatus (Nos. 21-24, 26, 28 and 30) provide shores between 7 and 15 Mybp. And still further east, another group of guyots (Nos. 7-9, 11, 12, 14 and 16) provide shores between 12 and 29 Mybp. Thus, there is ample evidence for a continuity of shores east of Easter for the past 29 My or so, if one applies a simple hotspot model. This is comparable to the minimum time available for the development of the endemics of the Hawaiian Archipelago.

DISCUSSION

As already noted there are difficulties with the fixed hotspot model, when applied to the Sala y Gómez Ridge. There seem to be four: (1) the present location of the hotspot, (2) the fossil spreading center bisecting the ridge, (3) the recent vulcanism near the junction of the Sala y Gómez and Nazca Ridges and (4) the lack of relative uniformity in the depths of the guyots along the ridge.

1. Location of the hotspot has serious implications because if it is in the vicinity of Sala y Gómez, rather than Easter as indicated in Figure 1, the seafloor curve would begin at approximately 105°W rather than 110°W. This could reduce the ages of guyots Nos. 21-24, 26, 28 and 30 by as much as 5 My. Because of the steepness of the seafloor subsidence curve in the vicinity of the rise crest, these guyots would then have drowned between 2.9 and 5 rather than 7.9 and 10.5 Mybp. Thus some would have been contemporaneous with such guyots as Nos. 33 and 37 near Easter, obliterating the hiatus noted above and yielding a continuity of shores back to at least 10 Mybp. Unfortunately, for the general hypothesis, this creates a new hiatus between this newly formed group and the guyots further east.

Yet not all the guyots of the region are known. Thus this minor hiatus may not be a difficulty when the area has been more fully surveyed.

2. If the fossil spreading center that bisects the Sala y Gómez Ridge were presently at approximately 95°W, the group of guyots Nos. 21–24 just discussed could belong to its western flank. These guyots then would be older rather than younger, as suggested by the shift of the present hotspot east. If older, the apparent hiatus between them and the Easter-Sala y Gómez Group seen in Figure 3 is significantly increased. The greater the hiatus, the less the likelihood that it is a sampling artifact that would disappear with the discovery of more guyots in the region.

3. The recent vulcanism at the eastern end of the Sala y Gómez Ridge, as indicated by San Felix and Sam Ambrosio, may explain the remarkably shallow guyots (Nos. 4 and 10), thus alleviating the remarkably long duration these guyots were islands indicated in Figure 3. It is notable that the chain so formed by these two guyots and islands is similar in length and alignment, and therefore possible age, to the Juan Fernandez Archipelago lying less than 10° further south. This may be important because there are faunal connections between the Juan Fernandez and Easter (Holthuis, 1972; Rehder, 1980 in part).

Knowledge of the bathymetry of these remarkably shallow guyots has improved since the work of Allison et al. (1967) in which Shoal Guyot (No. 10) was believed to have been between 205 and 230 m of the surface. They inferred that this would have been too deep for most if not all of the hermatypic corals found there to be young, and too deep for the guyot to have been at the sea surface during Pleistocene lowstands of 100 to 150 m below present level. But we now know that these guyots are as shallow as 161 m. Therefore it is entirely possible that the fresh appearing fossil corals found there are Pleistocene rather than Tertiary, and this could be important considering the faunal connections with Juan Fernandez to the south and with Easter. Furthermore, Zullo and Newman (1964) noted that the living barnacles from Shoal Guyot were primarily Indo-West Pacific rather than Eastern Pacific in their affinities. Thus, despite the difficulties in the fixed hotspot model these guyots present, it is not only possible but highly probable that they have had some involvement in the origin of the endemism now found at Easter-Sala y Gómez.

4. A relatively uniform gradient in guyot depth might be expected if a fixed hotspot model applied, or at least relatively uniform depths if well away from the source, assuming that each seamount followed a similar subsidence pattern upon leaving the ridge crest. Such a gradient or trend is not evident in the present situation, as has already been noted. Some of the discrepancies probably relate to the uncertainty surrounding the position of the hotspot itself, to the apparent recent vulcanism at the eastern end, and to the likelihood that a fossil spreading center bisects the Sala y Gómez Ridge. A fourth possibility is that there has been vulcanism along the ridge, as well as at both ends; that is, the ridge is, in good part, a hot line, rather than the production of a hotspot (Bonatti and Harrison, 1976; Bonatti et al., 1977).

There appear to be two or perhaps three groups of guyots, according to depth. Whether they are actually groups or portions of a continuum will become evident as the region is more fully surveyed. They include (1) guyots Nos. 2, 7–9 and 26 between 262 and 330 m; (2) 11, 12, 21–24, 30 and 37 between 413 and 478 m; and (3) 3, 14, 16, 28, 33, and 36 between 581 and 613 m. Since some members of each group are well separated from the others, it is obvious that the groupings are not wholly geographical entities. The first group includes guyots in the vicinity

of the Sala y Gómez-Nazca junction, already suspected of recent vulcanism and/or tectonic uplift. The second contains guyots about equidistant on either side of the possible position of the fossil spreading center, and one outlier west of Easter. It is therefore not worth pursuing either. The third and deepest group has several guyots in the vicinity of Sala y Gómez, two possible ones known between those flanking the fossil spreading center, and one in the region of possible tectonic activity in the east. Thus each group has outlying members. The groups may be related to the foregoing complications of the ridge complex, and their existence further emphasizes the shortcomings in attempting to apply a simple, hotspot model.

SUMMARY AND CONCLUSIONS

The shore fauna of Easter-Sala y Gómez, while almost wholly Indo-West Pacific in origin, displays a remarkably high degree of endemism primarily at the specific level. It is difficult to explain how such high endemism, estimated at 42% for the marine mollusks, could have developed on these two, small islands because of the relatively high rate of extinction one would expect under such conditions. Easter-Sala y Gómez are also very young, 2.5 and less than 2 My, respectively, and therefore unusually high rates of speciation for marine forms would be required to produce the number of endemic species we see there today. By contrast the Hawaiian Archipelago, where marine mollusk endemism is estimated at 20%, is at least 20 My old and the Emperor Seamounts extending to the northwest include Tertiary guyots that are very much older. Furthermore, many of the endemics of Easter-Sala y Gómez are apparently relicts, stemming from older groups of the Indo-West Pacific fauna. Therefore, the endemics of Easter-Sala y Gómez appear older than the islands themselves and some alternative or supplementary explanation for their origin would seem to be required.

The most obvious alternative hypothesis is that most if not all of the endemics of Easter-Sala y Gómez did not evolve *in situ* but were acquired from elsewhere in the region. To test the feasibility of such an hypothesis, the following exercise was carried out.

There are complications in the structure of the Sala y Gómez Ridge, including uncertainty as to the present position of the hotspot, the recent vulcanism at the eastern (older) end, the likelihood of a fossil spreading center bisecting it centrally and the accumulating evidence that it may be better explained by a hot line rather than a hotspot model. The last complication is perhaps the most critical for present purposes, but there is insufficient data for it to be resolved at this time. Therefore, a parsimonious model was adopted; a fixed hotspot producing islands, leveled by erosion and eventually drowned as they were carried east (Fig. 1). Known seamounts along the ridge qualifying as guyots were assumed to be equivalent in age to adjacent seafloor magnetic anomalies (Fig. 2). Their duration at the sea surface was then estimated by comparing present height above the surrounding seafloor to the estimated elevation of the seafloor at the time of drowning (Fig. 2 and Table 1).

From the foregoing analysis it is evident that there were numerous islands near the present position of Easter-Sala y Gómez; some in the immediate vicinity in the Pleistocene and some to the east over at least the past 10 to 29 My or so. It seems likely that there would have been a chronological continuity of shores among these islands over this period (Fig. 3), shores on which the endemics of the region could have evolved and been perpetuated up to present times. While this conclusion rests on numerous assumptions, it is probable that less than half

the guyots occurring in the region are known. This greatly increases the likelihood that there has been a chronological continuity of shores in the region for tens of millions of years.

The hypothesis that, for the most part, the endemics of Easter-Sala y Gómez did not evolve in situ but on now drowned, ancient islands, can be tested by dredging the tops and slopes of guyots of the region. Dating basalts recovered would provide evidence for when fossils of shallow-water origin also recovered had been living at or near the sea surface. If the fossils were not immediately ancestral or identical to the endemics presently inhabiting the shores of Easter-Sala y Gómez, the present hypothesis would have been falsified.

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Note added in proof: It is a pleasure to note that our views, concerning the geologic history of the Sala y Gómez Ridge and the origin of Easter Island shallow-water endemics, corroborate those of Springer (1982: 136-139) whose masterful tome on Pacific Plate Biogeography was received by our library on February 3, 1983. However, for lack of evidence we were compelled to reject *island integration* as part of the explanation for the origin of elements of the Hawaiian shallow-water fauna (p. 634 & footnote 1) and therefore must reject it as an explanation for the shallow-water endemics shared by these islands and Easter-Sala y Gómez (Springer, 1982, p. 139).

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ADDRESSES: (W.A.N.) *Scripps Institution of Oceanography A-002, La Jolla, California 92093, U.S.A.*
and (B.A.F.) *Zoology Department, The University of Auckland, Private Bag, Auckland, New Zealand.*