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Salinity Variations in Sea Water in the Vicinity of Bimini, Bahamas, British West Indies¹

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INTRODUCTION

During the late spring and early summer of 1955 a series of geologic and geochemical investigations was initiated in the vicinity of Bimini in the western Bahamas under the leadership of N. D. Newell. One phase of the program was an extensive study of salinities and salinity variations as they might relate to investigations in the ecology and geochemistry of marine environs. The present paper reports the results to date.

All determinations on salinity were performed at the Lerner Marine Laboratory at Bimini. The water samples were collected in glass bottles, and within two days after collection the salinity titrations were made. This eliminated temporal variations resulting from evaporation. The technique employed was the classic Mohr method, with the use of silver nitrate as the standard titrating solution. This technique is described in most general works on quantitative chemical analysis.

For convenience a volumetric rather than a gravimetric sampling was made; hence the results were obtained in terms of chlorosity. To get chlorinities it is necessary to consider the specific gravity of sea water. This was taken as 1.03. After conversion to chlorinity an additional fac-

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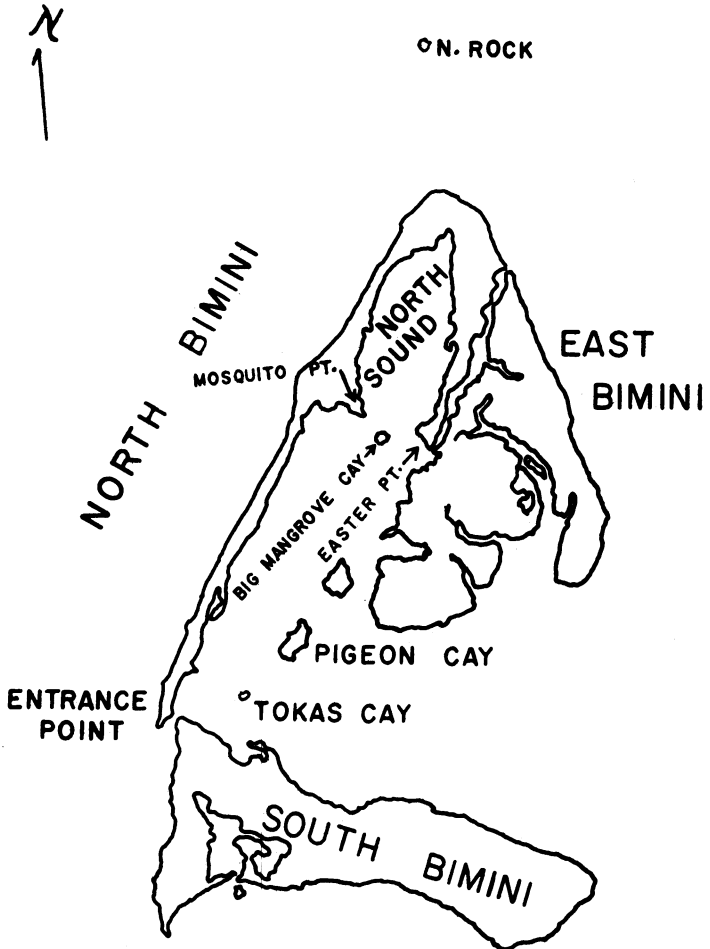


FIG. 1. Index map of the Bimini Islands, British West Indies.

tor is necessary to convert to salinity. Sverdrup *et alii* (1942) report that salinity = chlorinity/0.55, and this relationship was used to obtain the salinity values in the present paper.

DISCUSSION OF RESULTS

The discussion of salinity variations around Bimini (see fig. 1) can best be treated in a consideration of three major areas: (1) the Florida Straits and the marginal platform; (2) the Great Bahama Bank proper; and (3) Bimini lagoon. The interaction of these water masses with one

TABLE 1

SALINITY (IN PARTS PER THOUSAND) AND TEMPERATURE (IN DEGREES CENTI-
GRADE) DATA ON WATER SAMPLES TAKEN IN 1955

No.	Date	Description	Tem- pera- ture	Salin- ity
1	5/23	"Research" traverses (fig. 3); generally little rain	27.2	35.90
2	5/23	preceding sampling (see table 2)	27.0	36.02
3	5/23		26.8	36.15
4	5/23		27.2	35.90
5	5/23		27.2	36.02
6	5/23		27.5	36.50
7	5/23		27.2	36.02
8	5/23		27.6	36.20
9	5/23		27.2	36.00
10	5/23		—	35.90
11	5/24	East of Big Mangrove Cay	—	36.75
12	5/24	Lagoon area in South Channel in East Bimini	—	37.15
13	5/24	Mangrove flat in Bonefish Hole	—	37.11
14	5/28	Water from shallow (6 inches), isolated basin on northern part of North Bimini	—	58.95
15	5/30	Bimini Lagoon	—	39.23
16	6/1	Easter Point	—	38.80
17	5/27	Mangrove swamp, west of prominent "pond," East Bimini	29.0	37.71
18	6/2	Off northwest corner of Great Isaac, depth 100 feet	28.0	36.23
19	6/2	Large pond on Great Isaac	—	9.44
20	6/3	Series of consecutive samples from northernmost	—	46.50
21	6/3	inlet of North Sound to the constriction at Mos-	—	45.00
22	6/3	quito Point	—	45.80
23	6/3		—	44.60
24	6/3		—	43.20
25	6/3		—	41.25
26	5/24	Research cruise off Picquet Rock, 500 yards, off platform	27.0	35.85
27	5/24	Research cruise off Picquet Rock, 50 yards, on platform	27.0	36.00
28	6/3	Well water from East Wells	—	0.67
29	6/3	Water from "lake" in North Bimini, 100 yards north of Big Creek	—	42.50
30	6/7	Just north of North Point	—	36.60
31	6/7	1 1/2 miles east of Bimini on banks (high tide)	—	38.10
32	6/7	Midway between Bonefish Point and South Bimini	—	38.43
33	6/9	South tip of Alec Cay in mangrove	—	38.10
34	6/10	Traverse 1 (see fig. 3)	28.3	36.00
35	6/10		28.3	36.00

TABLE 1—(Continued)

No.	Date	Description	Temperature	Salinity
36	6/10		28.3	36.00
37	6/10		28.2	36.03
38	6/10		29.2	39.40
39	6/10		29.3	40.40
40	6/10		29.2	40.85
41	6/10		29.2	41.80
42	6/10		29.8	41.90
43	6/10		31.3	40.50
44	6/10	Traverse 2 (see fig. 3)	29.0	36.10
45	6/10		29.2	36.79
46	6/10		28.3	36.60
47	6/10		30.7	37.50
48	6/10		27.9	36.00
49	6/10		29.8	37.20
50	6/10		29.7	37.27
51	6/10		29.2	37.27
52	6/10		29.0	37.20
53	6/10		28.8	37.10
54	6/10		29.3	36.85
55	6/10		29.2	37.20
56	6/10		29.2	37.27
57	6/10		29.2	37.10
58	6/14	Center of Cavelle Pond, South Bimini (low tide)	—	31.52
59	6/22	Point equidistant from Big Mangrove Cay, Easter	27.8	30.81
60	6/22	Point, and Mosquito Point; sample for one-half	28.2	31.22
61	6/22	tidal cycle beginning at 9:00 A.M. (high tide at	28.4	32.75
62	6/22	about 10:30 A.M.); samples taken one hour apart	28.8	32.10
63	6/22		29.2	31.50
65	6/22		29.4	31.02
66	6/22		29.4	30.81
67	6/23	Research cruise from drop off towards banks at	29.3	35.92
68	6/23	Dollar Harbor area on South Cat Cay; samples	28.2	36.00
69	6/23	taken approximately every 500 yards (see table	28.6	36.00
70	6/23	3)	29.0	36.00
71	6/23		29.1	36.00
72	6/23		29.2	35.82
73	6/23		28.8	35.82
74	6/23		28.8	35.82
75	6/23		29.0	35.70
76	6/23	Above oölite bore in Dollar Harbor	—	35.70
86	6/25	Samples taken every 15 minutes at about 9 knots,	28.8	36.18
87	6/25	starting with Round Rock, bearing south-south-	29.0	36.80
88	6/25	east; tide coming in (fig. 2)	29.0	37.00

TABLE 1—(Continued)

No.	Date	Description	Temperature	Salinity
89	6/25		29.0	36.55
90	6/25		29.0	37.20
91	6/25		29.3	37.70

another and the effect on salinity of local meteorological conditions are the main items covered below.

SALINITY OF FLORIDA STRAITS AND MARGINAL PLATFORM

It is readily seen from analyses 1, 4, 10, 26, and 67 in table 1 that the surface waters of the Florida Straits near Bimini remained at a constant value of about 35.9 parts per thousand during the period of study, which is generally more saline than normal oceanic waters. Wüst (1924), according to Sverdrup *et alii* (1942), reports similar values for surface waters of the Florida Straits.

The margins of the platform, on the other hand, are variable, depending apparently on the weather just previous to sampling.

On May 23, 1955, a series of traverses off Bimini across the marginal platform (table 2) show an increase in salinity, though slight, towards the shore. There had been little rain before these traverses, and evidently mixing was not rapid enough to destroy the gradient.

TABLE 2

SALINITY VARIATIONS (IN PARTS PER THOUSAND) IN SAMPLES TAKEN ON TRAVERSES ON MARGINAL PLATFORM BETWEEN BIMINI AND THE FLORIDA STRAITS, MAY 23, 1955

		Florida Straits (West) ^a	Drop Off	Marginal Platform	Bimini (East)
North	Traverse A	35.90		36.02	36.15
	Traverse B	35.90		36.02	—
	Traverse C	35.90		36.00	36.20
South	Traverse D	—		36.02	36.50

^a Distance between east-west stations, about 1000 yards.

On June 23, 1955, a similar traverse was made off South Cat Cay. Here there was a decrease in salinity (table 3) towards shore, which is thought to be a reflection of the heavy rains that fell for two weeks before the observations were made. It is to be noted, however, that the changes were not great.

TABLE 3

SALINITY VARIATIONS (IN PARTS PER THOUSAND) OF SAMPLES TAKEN APPROXIMATELY EVERY 500 YARDS FROM DROP OFF AT DOLLAR HARBOR AREA, SOUTH CAT CAY, TOWARDS GREAT BAHAMA BANK, JUNE 23, 1955

	Salinity
Florida Straits	35.92
	36.00
	36.00
	36.00
	36.00
	35.82
	35.82
	35.82
Off South Cat Cay (east side)	35.70
Above oölite bore in Dollar Harbor (west side of South Cat Cay)	35.70

SALINITY OF THE BANKS

As a traverse is made from the cays inward to the center of the Bank, a small steady increase in salinity is found (fig. 2). This is undoubtedly the consequence of the composite effect of evaporation, rainfall, and degree of mixing with less saline open ocean or Gulf Stream waters (see table 1, analyses 86-91).

The salinity of the Bank proper is probably around 37.7 parts per thousand or higher; hence a marked difference exists between it and the waters of the Florida Straits as well as those of the open ocean.

SALINITY VARIATIONS WITHIN BIMINI LAGOON

Because of the restrictive nature of the lagoon formed by the Bimini Islands, it is expected that large variations will occur not only in different locations within the lagoon but also with variations in the weather. The data in table 1 indicate that these variations are indeed considerable.

Variations with location are qualitatively evident from a consideration of the following analyses: 11-16 and 20-25. It can be seen that the sa-

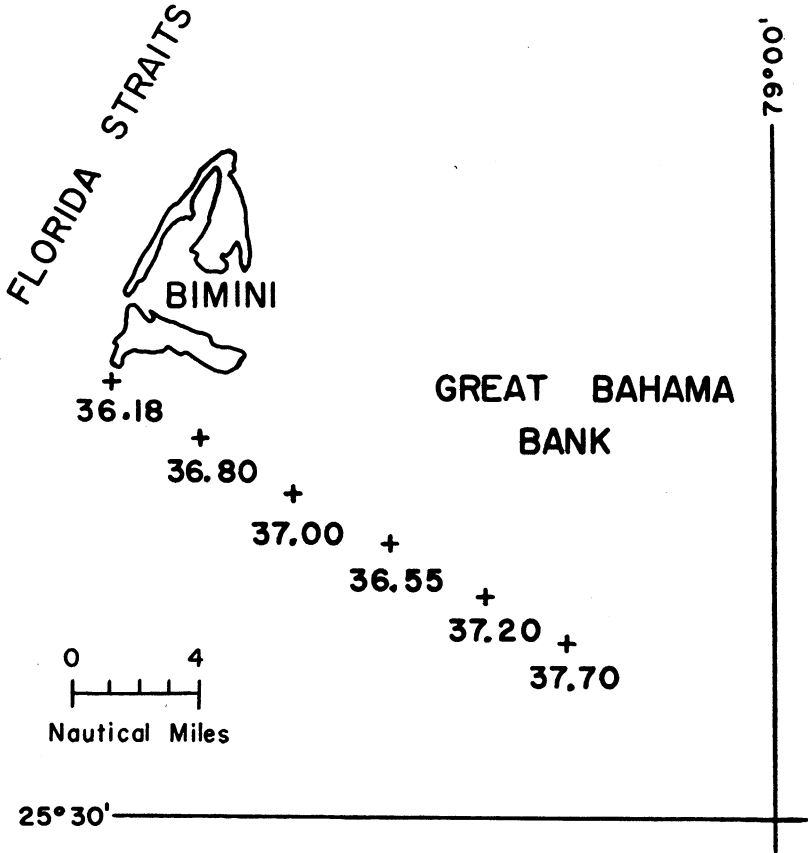


FIG. 2. Salinity gradient from the margin of the Great Bahama Bank in towards the center of the Bank, showing increase in salinity.

linity of the lagoon varies from a value about the same as for the Gulf Stream, through values in some localities characteristic of the Bank, to other values ranging up to 46.50 parts per thousand in the most saline areas.

To check the variations possible in a very short span of time for a given tide condition, a suite of samples was taken simultaneously at high tide along two traverses in the lagoon. Traverse 1 was made from Tokas Cay north to the northernmost part of North Sound. Traverse 2 started at Pigeon Cay and went east to the Bank. These data are shown in figure 3.

It is evident that three separate water masses are present in Bimini lagoon: (1) water from the Florida Straits entering through the en-

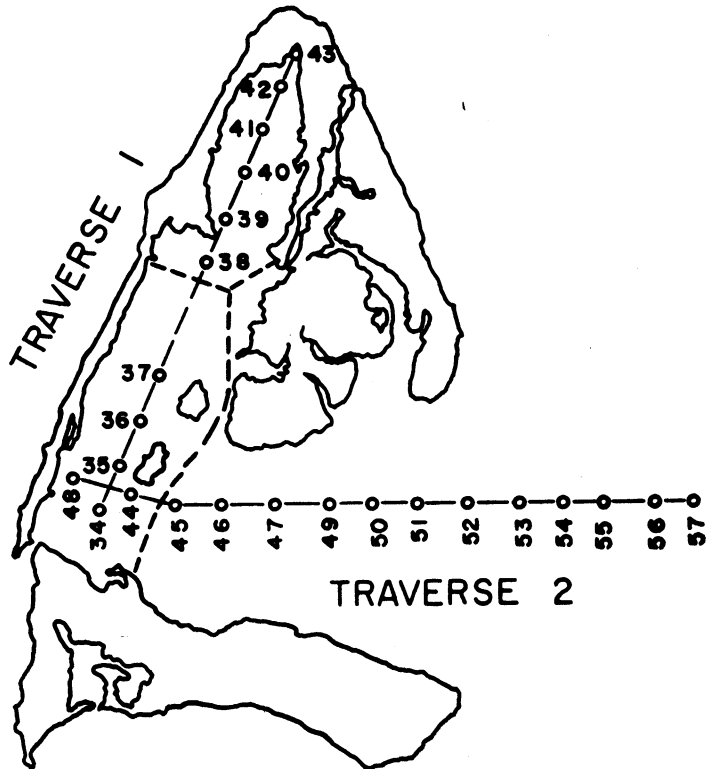


FIG. 3. Simultaneous traverses in Bimini lagoon at high tide, showing the presence of three water masses. See table 1 for the salinities and temperatures corresponding to the numbers in the figure.

trance; (2) water from the Bank entering across the inlet between East Bimini and South Bimini and also through the diverse waterways of East Bimini; and (3) water that is restricted to the lagoon, essentially moving in and out of North Sound.

From the above discussion it is seen that there is definite localization of salinities in the lagoon. The waterways of East Bimini seem to be fed from the banks, as they consistently have the same salinity. The drainage must be continuous and more or less complete.

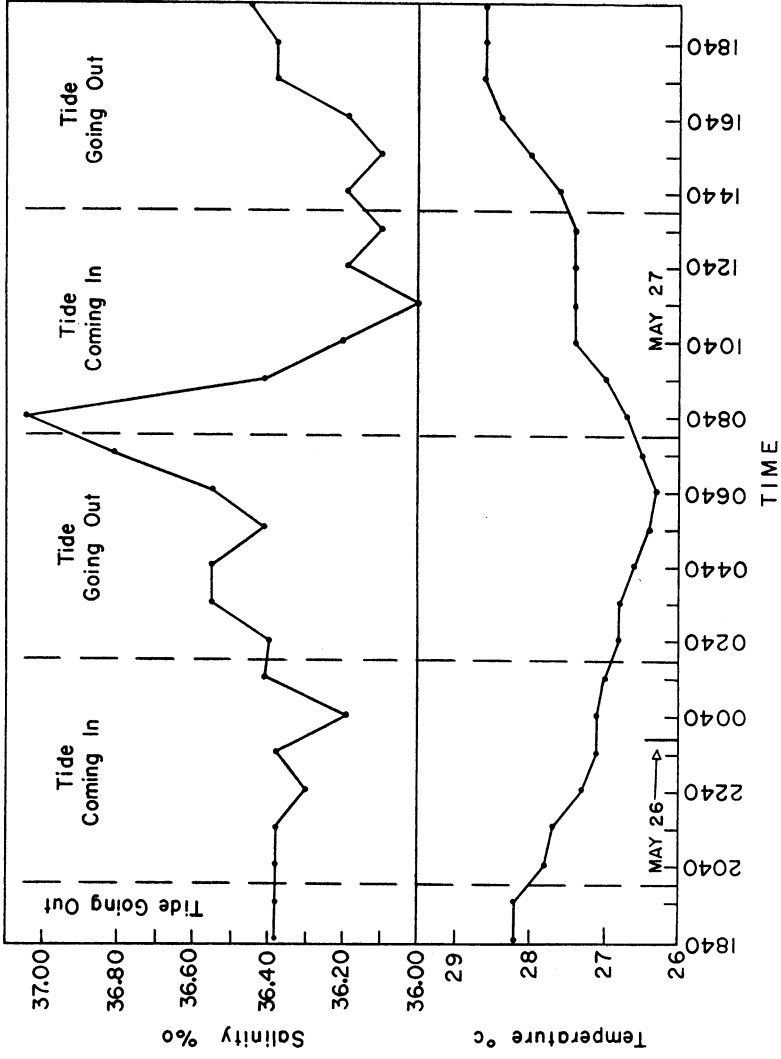


FIG. 4. Variations in temperature and salinity at Till's Pier, Entrance Point, during a 24-hour period.

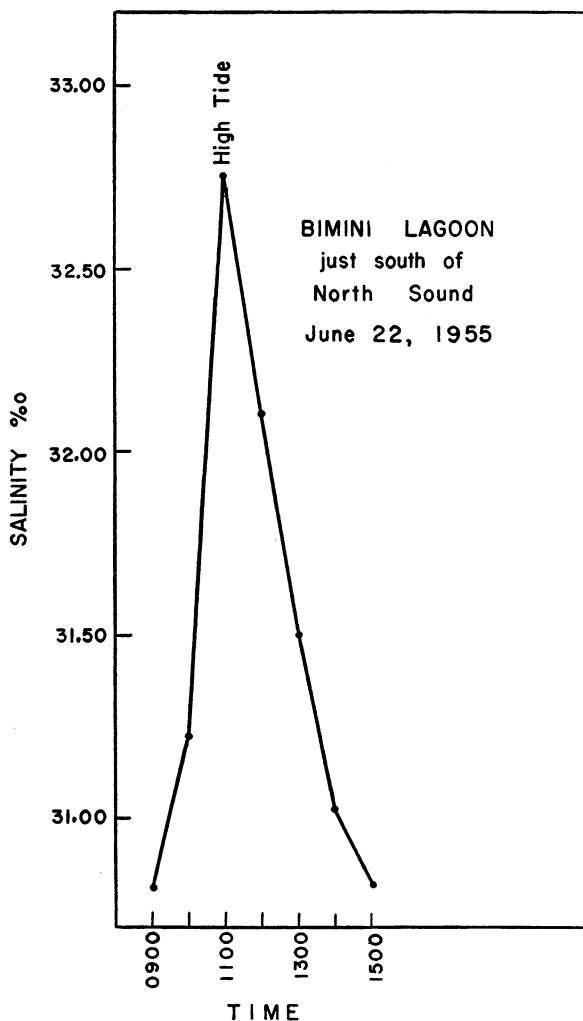


FIG. 5. Variations in salinity during one tidal phase at a point in Bimini lagoon equidistant from Big Mangrove Cay, Mosquito Point, and Easter Point, June 22, 1955.

From the samples of traverse 1 (fig. 3) it is seen that at a point in the lagoon there is a marked change towards the north from an area of lower salinity and lower temperature to a progressively more saline area. The point where this break occurs is probably the limit reached by oceanic water that enters the lagoon during flood tide.

VARIATIONS IN SALINITY ASSOCIATED WITH THE TIDAL CYCLE

Two sets of observations at different stations were made to determine if any marked variation in the salinity occurred during tidal cycles.

A 24-hour vigil at Till's Pier near Entrance Point gave the variations seen graphically in figure 4. It is to be noted that no correlation exists with the temperature of the water. The temperature is a function only of the time of day. The highest value of salinity occurs during a slowly rising peak as the tide goes out. The sudden high value during the rise is most probably attributable to the arrival of Bank waters which made their way to the open sea through Bimini lagoon.

The second check on changes in salinity due to tidal fluctuations was made at a point equidistant from Big Mangrove Cay, Easter Point, and Mosquito Point.

Figure 5 shows that the salinity increases as the tide brings in water from the Florida Straits, and as the tide goes out it again decreases to the value of the indigenous waters. The low salinity of the indigenous water is due to the effect of heavy rains. The fact that the salinity returns to the old value as the tide goes out indicates that mixing of the two water masses within the lagoon is not rapid.

VARIATIONS WITH WEATHER

In a basin with restricted circulation it is evident that the weather will have a strong effect on the variation of the salinity in any one locality.

The effect of extensive rain is clearly seen in the last set of samples discussed. Samples taken in North Sound ranged in salinity from about 31 to 40 parts per thousand, depending on conditions of precipitation and evaporation immediately before the sample was taken.

ECOLOGICAL SIGNIFICANCE

In the case of Bimini lagoon it is seen that there are three different water masses in action. They probably are unlike in regard to plankton and nutrient content, and markedly different life conditions may occur in separate parts of this relatively small area. The effect of substrate may overshadow these effects, but additional work would be necessary to assess the relative contribution of each factor.

Second, it is to be noted that faunal and floral assemblages may be controlled not so much by salinities alone as by their ability to undergo different degrees of salinity change. In North Sound, for instance, the water during periods of low rainfall becomes highly saline (around 40–45‰). After a considerable rainy time the salinity drops to about 31–35 parts

per thousand and maintains this dilution until evaporation again raises the salt concentration. Faunal and floral assemblages in such a locality should reflect this change.

SUMMARY

1. The salinity of the Gulf Stream in Florida Straits just west of the Bahama Bank is 35.9 parts per thousand. The salinity of the Bank proper is probably around 37.7 parts per thousand, although it probably varies considerably.

2. A gradient exists between the Florida Straits and the Bank which increases in salinity towards the Bank generally but with minor fluctuation at the marginal platform due to varying rainfall.

3. Bimini lagoon is host to three distinct water masses: (1) an indigenous mass that moves in and out of North Sound with the tides; (2) a mass entering from the Florida Straits through Entrance Point; and (3) a mass entering from the Bank through the waterways of East Bimini and the inlet between East and South Bimini.

4. The rate of mixing of these water masses is slow.

5. The indigenous water of Bimini lagoon varies considerably in salinity (from 31 to 45‰), depending on the relative amounts of evaporation and precipitation.

6. It is suggested that the above variations in salinity may cause differing ecological conditions in a relatively small area that supplement the effects of bottom environment.

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