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**PRELIMINARY HYDROGRAPHIC SURVEYS OF SOME PONDS IN THE
PELICAN CAYS, BELIZE**

BY

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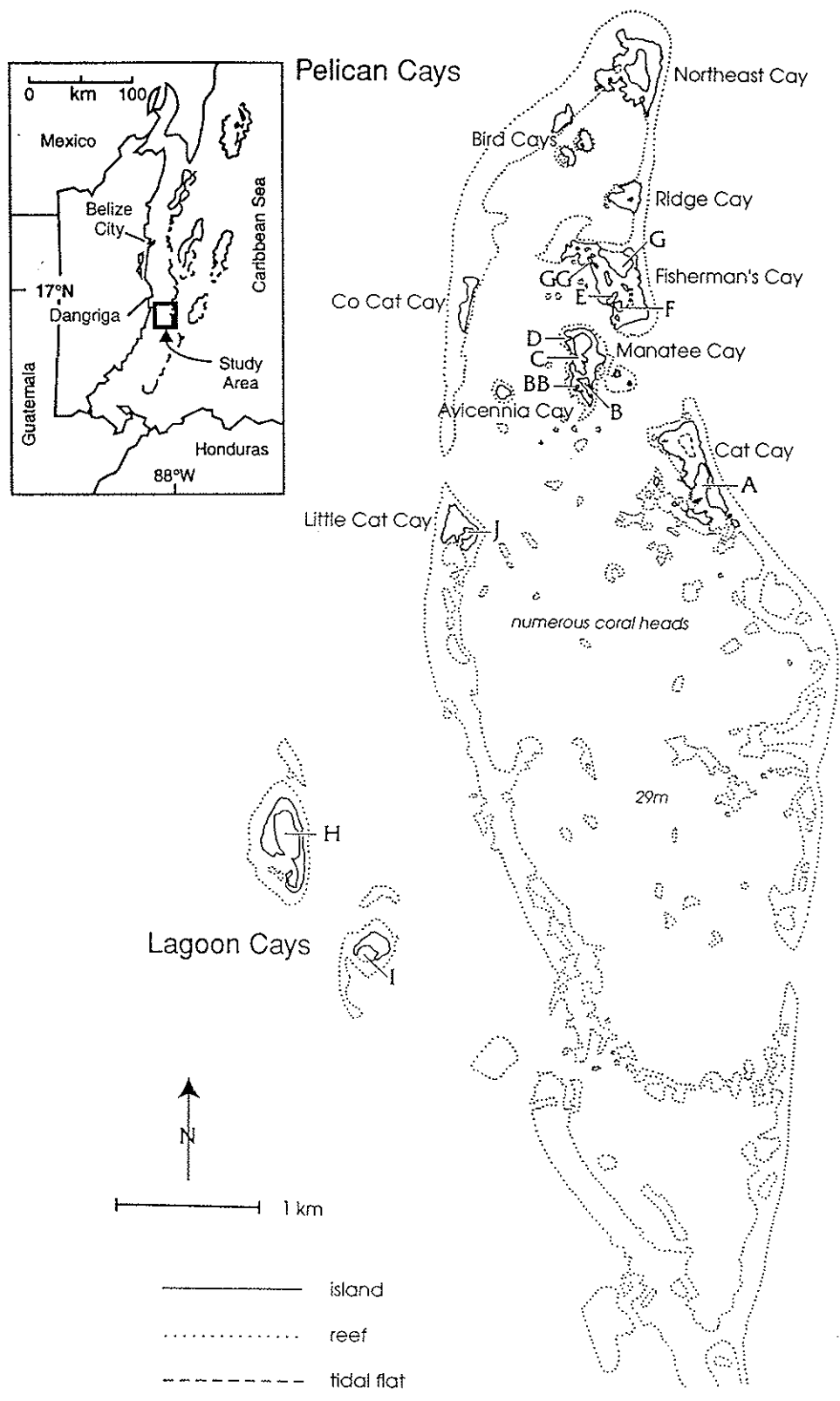


Figure 1. Map of Pelican Cays, Belize, Central America and pond identifications.

PRELIMINARY HYDROGRAPHIC SURVEYS OF SOME PONDS IN THE PELICAN CAYS, BELIZE, CENTRAL AMERICA

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ABSTRACT

Hydrographic and hydrologic surveys of three ponds in the Pelican Cays Group were carried out using hand-held sonar, pressure transducer tide loggers, and YSI temperature-salinity probes. These ponds characteristically have a circular pattern with steeply sloping sides. The pond depths range from 4.6 m in a small pond with a diameter of 100 m to 15.2 m in a large pond with a diameter of 840 m; in general, depth increases with increasing pond size. Depths ranged from 15.2 m for a distance of 100 m between cays to 28.7 m for a distance of 1,150 m. Pond salinities averaged 35.3 ppt with a range of 1.5 ppt, and temperatures averaged 31.4° C with surface temperatures about 1° C higher than bottom temperatures.

INTRODUCTION

The Pelican Cays lie some 13 km east of the coast of Belize on the Belize Barrier Reef (Fig. 1). The submerged limestone shelf on which the cays are located have the characteristics of submerged karst limestone topography (Purdy, 1974; Stoddart et al., 1982). These cays are believed to have been formed on an ancient subaerially eroded limestone plateau that was submerged during the Holocene Transgression some 6,000–8,000 years B.P. According to Macintyre et al. (this volume), the circular pattern of the ponds in these cays is related to a combination of karst control and differential reef growth.

The cays are composed of coral and coral rubble covered largely by mangrove forest. They can be characterized as low-lying land masses of coral and peat surrounding central ponds. The coastal margins of the cays are vegetated by the red mangrove *Rhizophora mangle* in the lower tidal washed sections, and some black mangrove, *Avicennia germinans*, in the slightly higher regions. Sand deposits with coconut trees can be found in a few higher areas.

The ponds, which also appear as well-delineated circular bottom configurations in the outside lagoon, have steep walls. Many of the ponds overlap, separated only by articulate ridges. Some ponds are completely enclosed, but most are connected with other ponds by shallow channels.

Tides along the barrier reef are microtidal and of a mixed semidiurnal nature, with a mean range of only about 15 cm, but this, along with windset, is sufficient to cause some interpond currents (Kjerfve et al., 1982). However, because most of the ponds have relatively deep central areas, they are probably poorly flushed, except in the upper water, and are essentially individual

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ecosystems.

There is no direct precipitation record for the region, but extrapolation from mainland records (Walker, 1973) and limited records at Carrie Bow Cay (Rützler and Ferraris, 1982) suggest that annual rainfall averages about 190 cm/yr (75 in/yr). The nearest official weather station is Melinda Forest Station, located on the mainland coast about 45 km to the north. A dry period is common from February through May, when the rainfall averages only about one-third that of other months. Hurricanes during the months of July to October can produce storm surges that completely inundate the low-lying cays. During the periods of study, pond conditions were little affected by precipitation or unusual sea conditions.

During the period May 18–26, 1994, we investigated the ponds of three cays of the Pelican Cays Group: Pond A (Cat Cay), Pond C (Manatee Cay), and Ponds E, F and G (Fisherman's Cay) (Fig. 1). Additional depth measurements and investigations of the broader hydrographic characteristics of the regions between the cays were recorded during the period May 7–10, 1995. The hydrographic surveys were part of a larger scientific field study of the Pelican Cays undertaken by a group of scientists associated with the Smithsonian Institution.

METHODS

Very limited mapping information is available on the Pelican Cays. Some hydrographic mapping of the area can be found in U.S. naval charts based largely on British surveys between 1830 and 1841 (U.S. Navy, 1942). In order to obtain the scale of detail necessary for this study, the island-pond maps (Figs. 3, 6, and 10) were drawn using aerial photographs taken by Tony Rath (Dangriga, Belize) during May 1995. Distances and dimensions were ground-truthed in the field and checked against other published maps.

Pond-bottom depth measurements were made using a Scuba-pro Model hand-held sonar deployed from a small boat. Survey line control across the ponds was established by making runs between prominent shoreline points. Locations of measurements along these lines were determined by "dead reckoning." That is, the measurements were made at regular timed intervals as the boat moved at a steady speed along the survey line. Location and depth in the interpond channels were determined by direct tape measurements. The latitude-longitude location shown on the maps was obtained with a Garmin GPS Model 50 unit.

The tide record was obtained with the aid of pressure transducers and an Enviro-lab Model 120 data logger in the ponds. The data logger was programmed to collect level data at intervals of 15 min. The period of data collection was two and a half days. The vertical reference datum was arbitrary but was selected to keep all readings as positive elevations.

Vertical profile depths were determined with direct tape measurements. Temperature and salinity values for the depth profiles were obtained using a YSI Model 33 instrument. Measurement of temperature and salinity were taken at 0.6-m (5.0-feet) intervals.

RESULTS

A two-and-one-half-day record of tidal fluctuation in Pond E at Fisherman's Cay was obtained (Fig. 2). Pressure transducer probes used to measure water level were located in the mangrove roots on the west side of Pond E of Fisherman's Cay as well as in Pond F. Although channel flow could be observed as the tide changed, there was very little measurable difference

in elevation or lag time. It is believed, however, that such differences can be measured using a shorter data collection interval, such as one minute.

The location of work in Pond C at Cat Cay is shown on Fig. 3. It consisted of two bottom hydrologic profiles (Figs. 4 and 5), and two hydrologic depth profiles (Figs. 24 and 25) in the deeper parts of the ponds.

The location of work in Pond A at Manatee Cay is shown on Fig. 6. It consisted of three hydrographic bottom profiles (Figs. 7–9) and two hydrographic depth profiles (Figs. 26 and 27) in the deeper parts of the pond.

The field work at Fisherman's Cay consisted of pond-bottom profiles and vertical hydrologic profiles in the deep parts of the ponds (Fig. 10). Four interpond channel cross sections (Figs. 11–14) were completed, two at the entrance into Pond E and two between Ponds E and F. Nine hydrographic lagoon bottom profiles (Figs. 15–23) and four hydrologic depth profiles (Figs. 28–31) were made.

The locations of the 16 hydrographic survey runs made in May 1995 between the various cays of the Pelican Cays Group are shown on Fig. 32. Table 1 summarizes the results of these survey runs. Depths of water between cays ranged from 15.2 m for a distance of 100 m between cays to 28.7 m for a distance of 1,150 m.

Table 1. Summary of pond hydrographic and hydrologic characteristics.

Location	Depth Profile	Maximum		Maximum Salinity		Temperature	
		Length (m)	Depth (m)	Upper (ppt)	Lower (ppt)	Upper (°C)	Lower (°C)
Cat Cay							
Pond A	A1	250	15.2	35.1	34.9	31.0	29.0
Manatee Cay							
Pond C	C1	130	14.0	35.7	35.4	31.0	29.6
	C2	200	10.7	35.6	35.1	31.5	30.0
Fisherman's Cay							
Pond E	E1	100	4.6	35.1	34.7	31.2	31.5
Pond F	F1	80	5.2	35.1	36.2	31.0	30.0
Pond G	G1	265	13.4	35.1	35.2	31.8	29.8

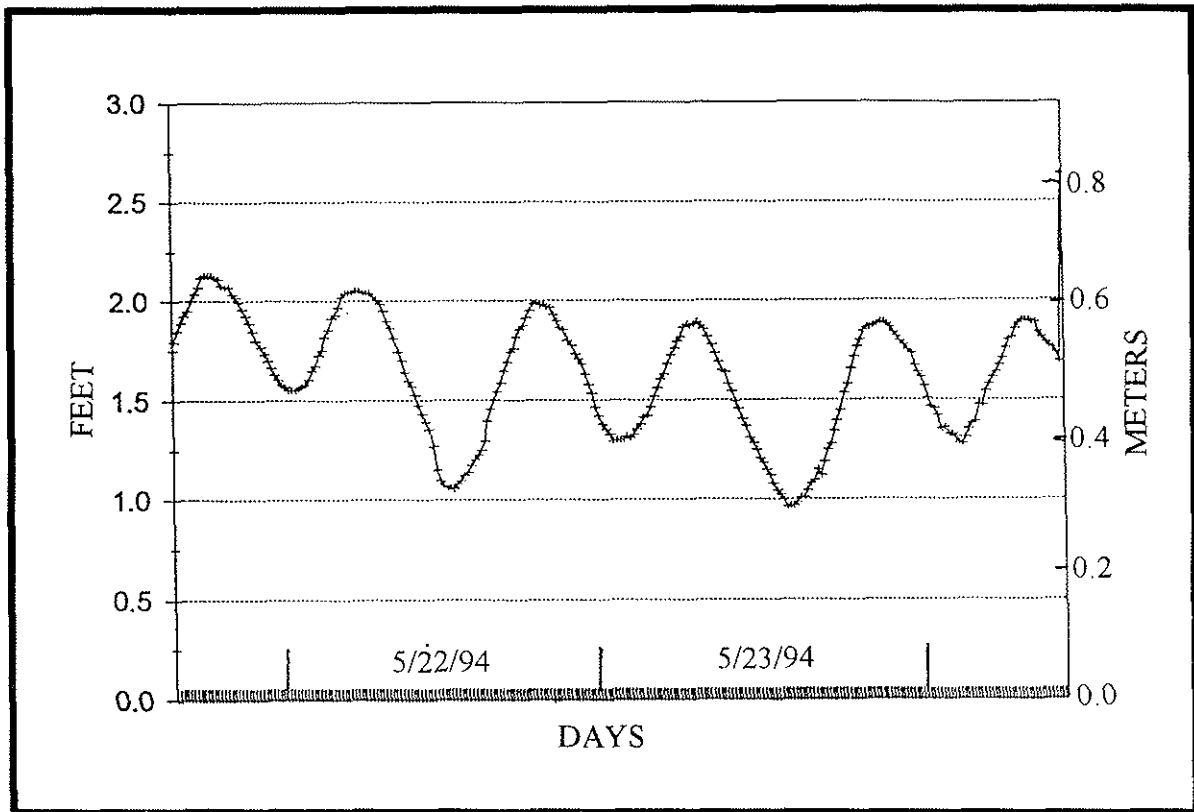


Figure 2. Plot of tidal fluctuations in Pond E, Fisherman's Cay during period of May 21-23 1994.

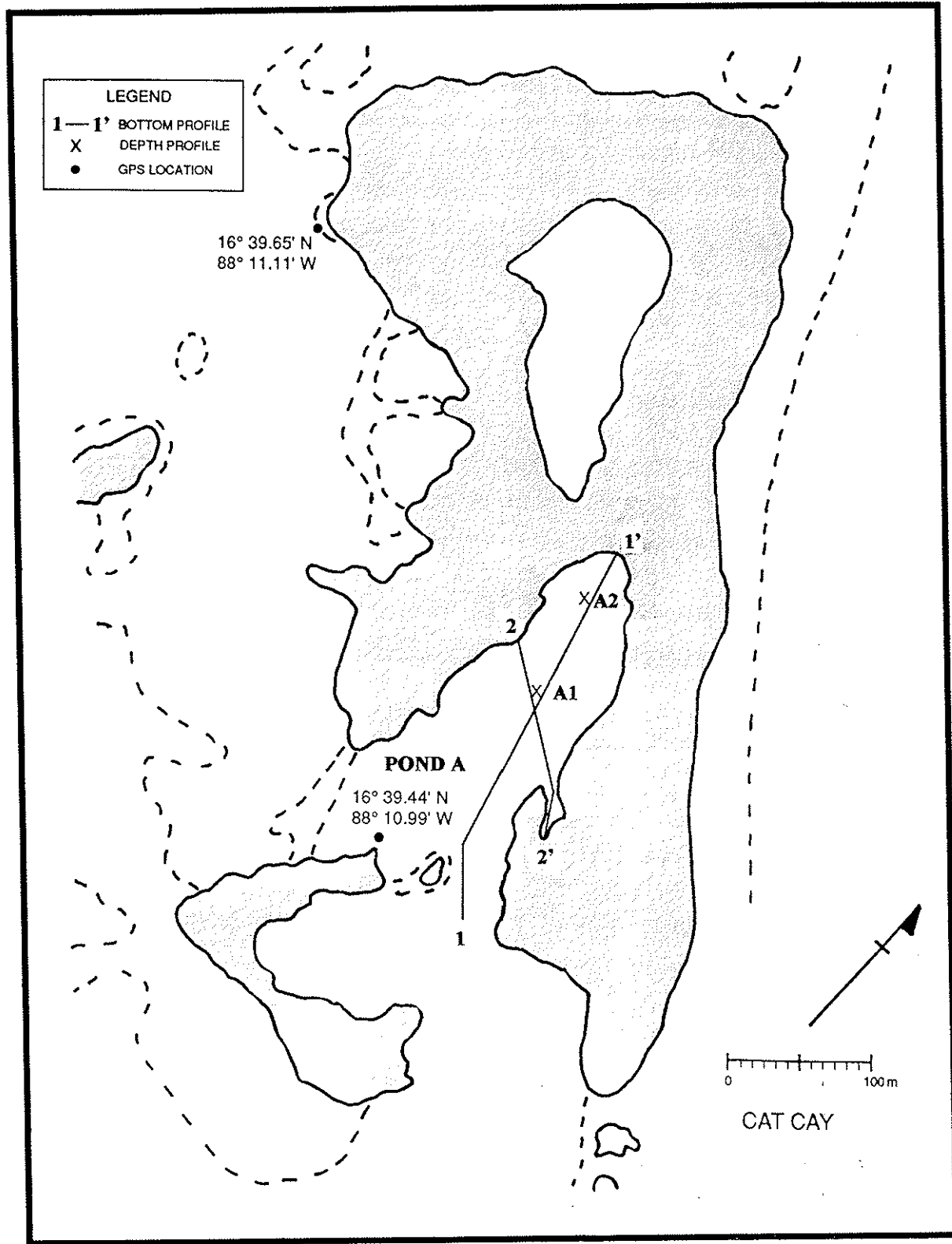


Figure 3. Map of Cat Cay showing locations of bottom profiles and depth profiles for Pond A.

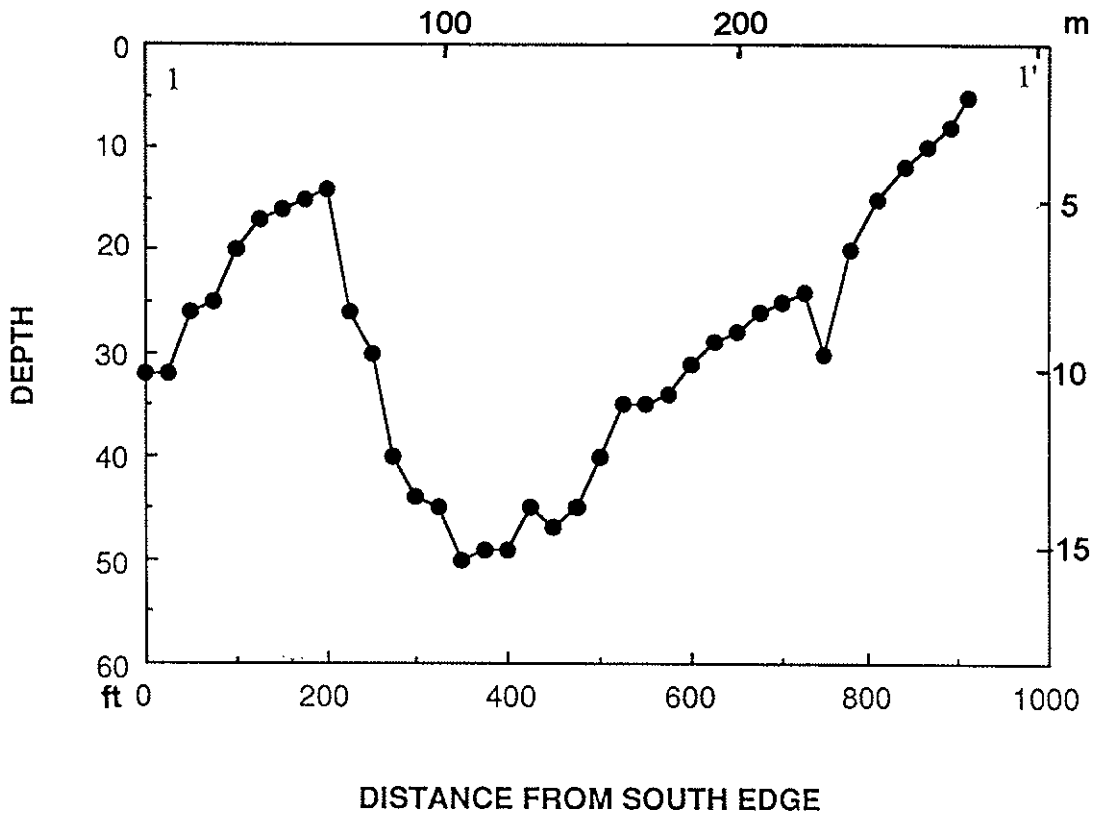


Figure 4. Pond A - Cat Cay Bottom Profile 1-1'.

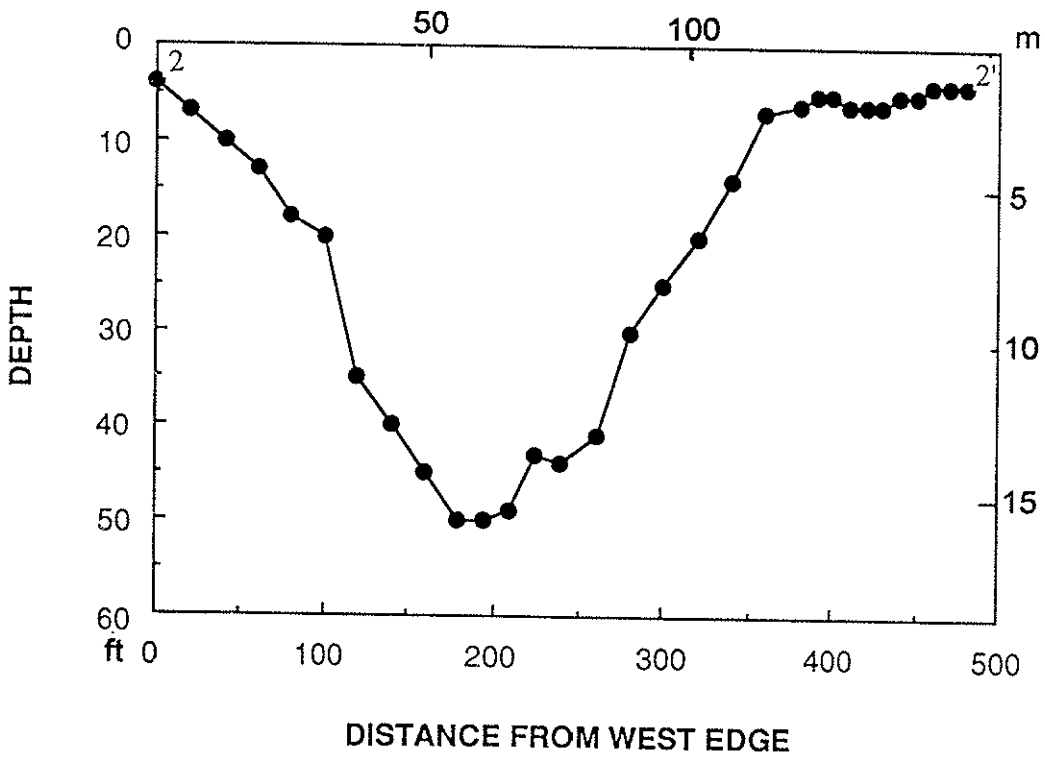


Figure 5. Pond A - Cat Cay Bottom Profile 2-2'.

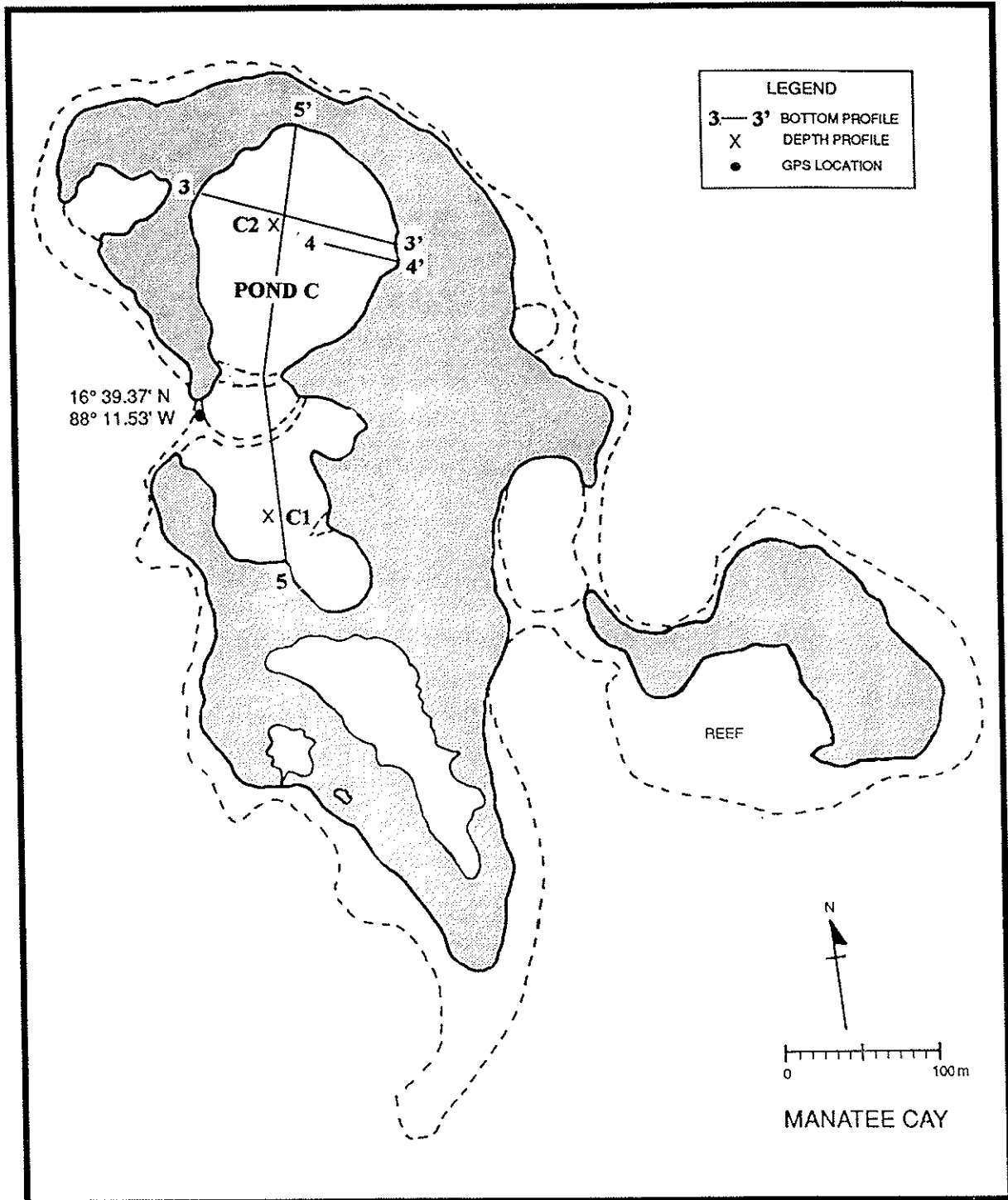


Figure 6. Map of Manatee Cay showing locations of bottom profiles and depth profiles for Pond C.

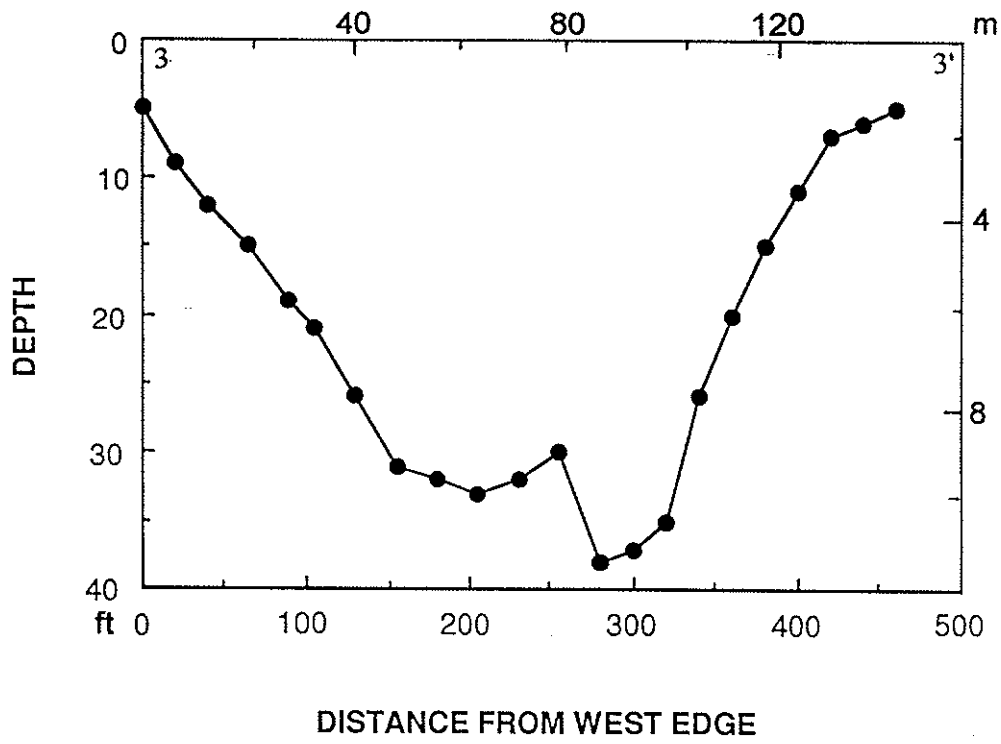


Figure 7. Pond C - Manatee Cay Bottom Profile 3-3'.

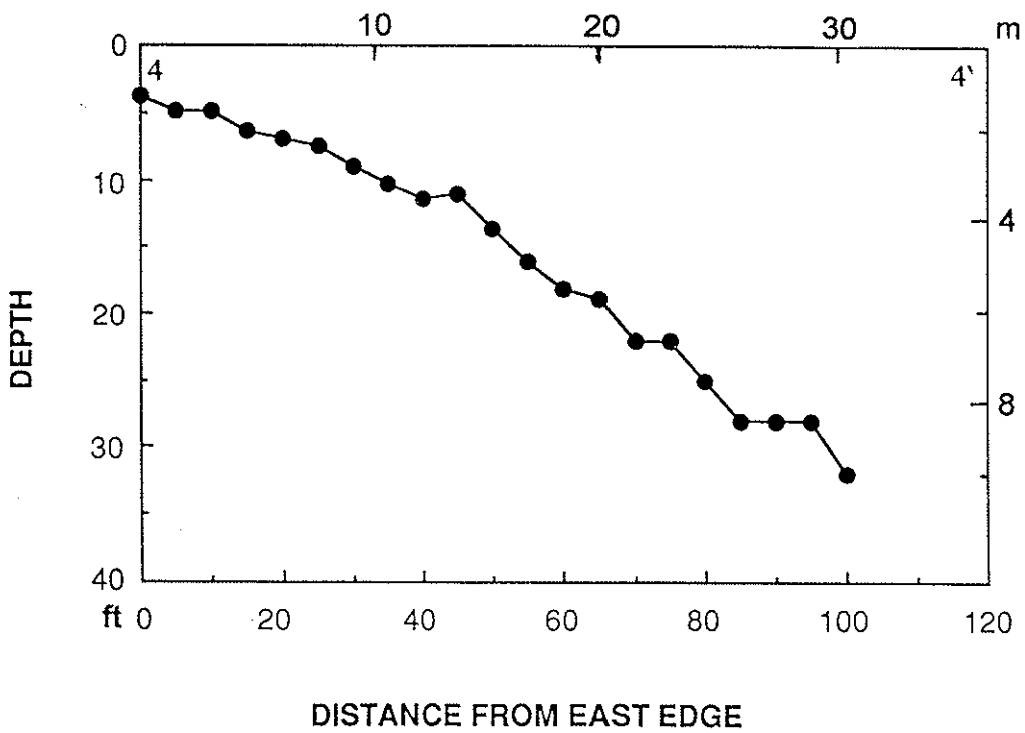


Figure 8. Pond C - Manatee Cay Bottom Profile 4-4'.

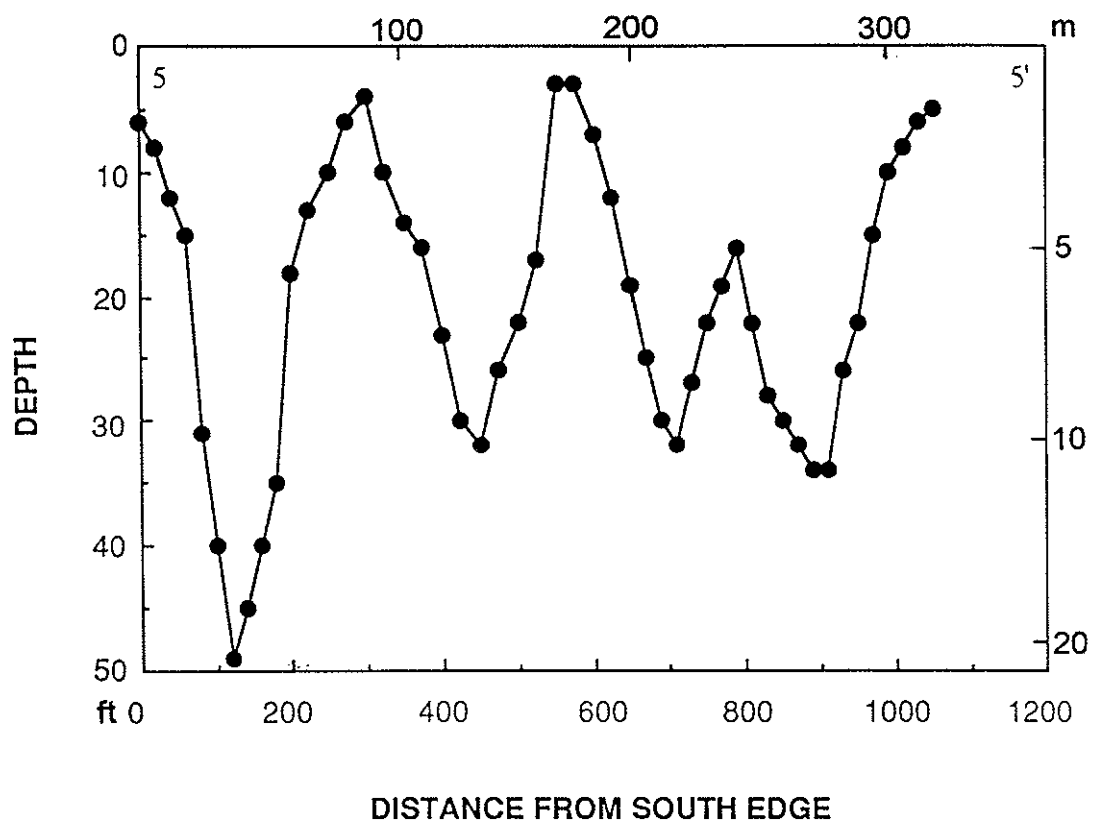


Figure 9. Pond C - Manatee Cay Bottom Profile 5-5'.

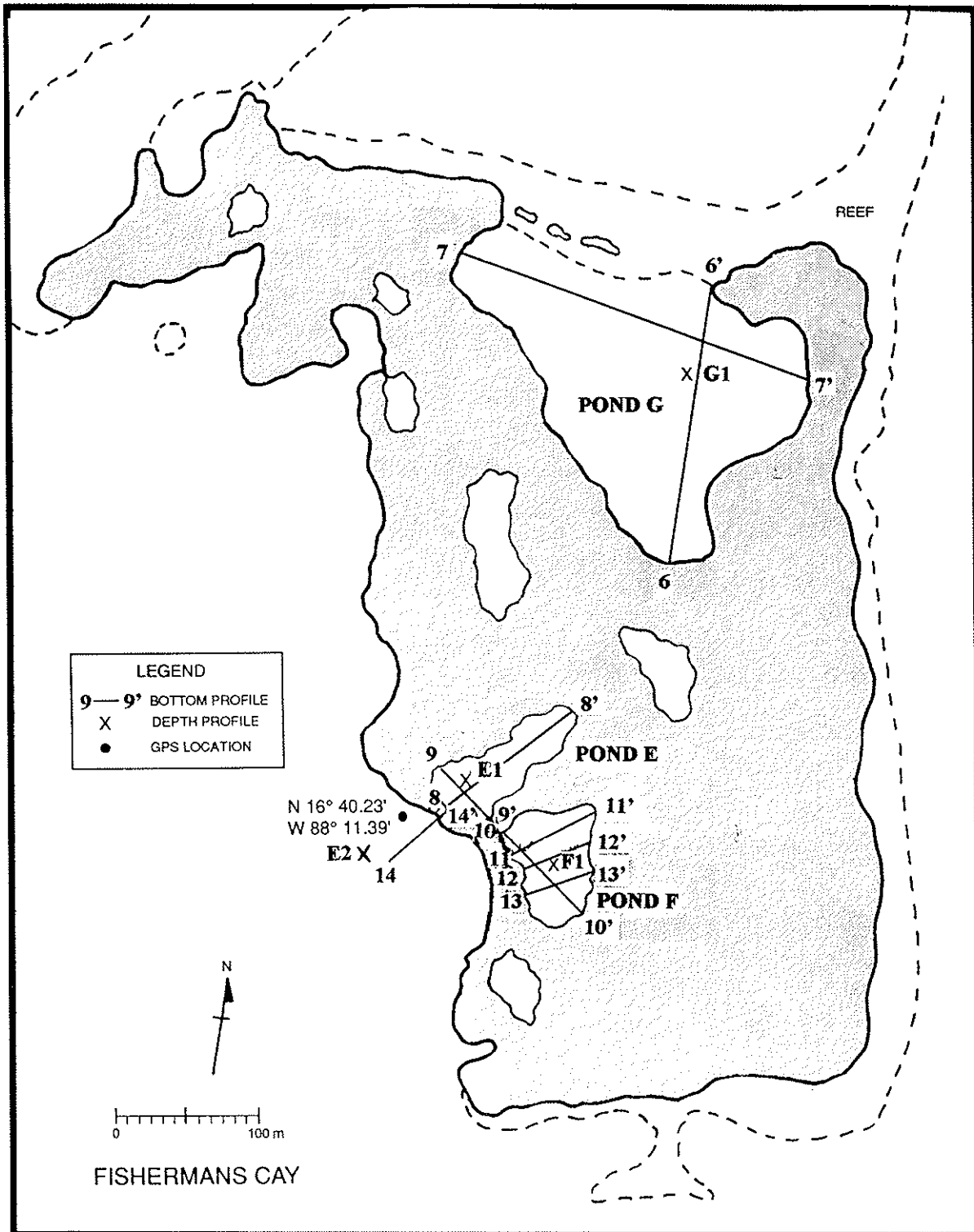


Figure 10. Map of Fisherman's Cay showing locations of bottom profiles and depth profiles for Ponds E, F, and G.

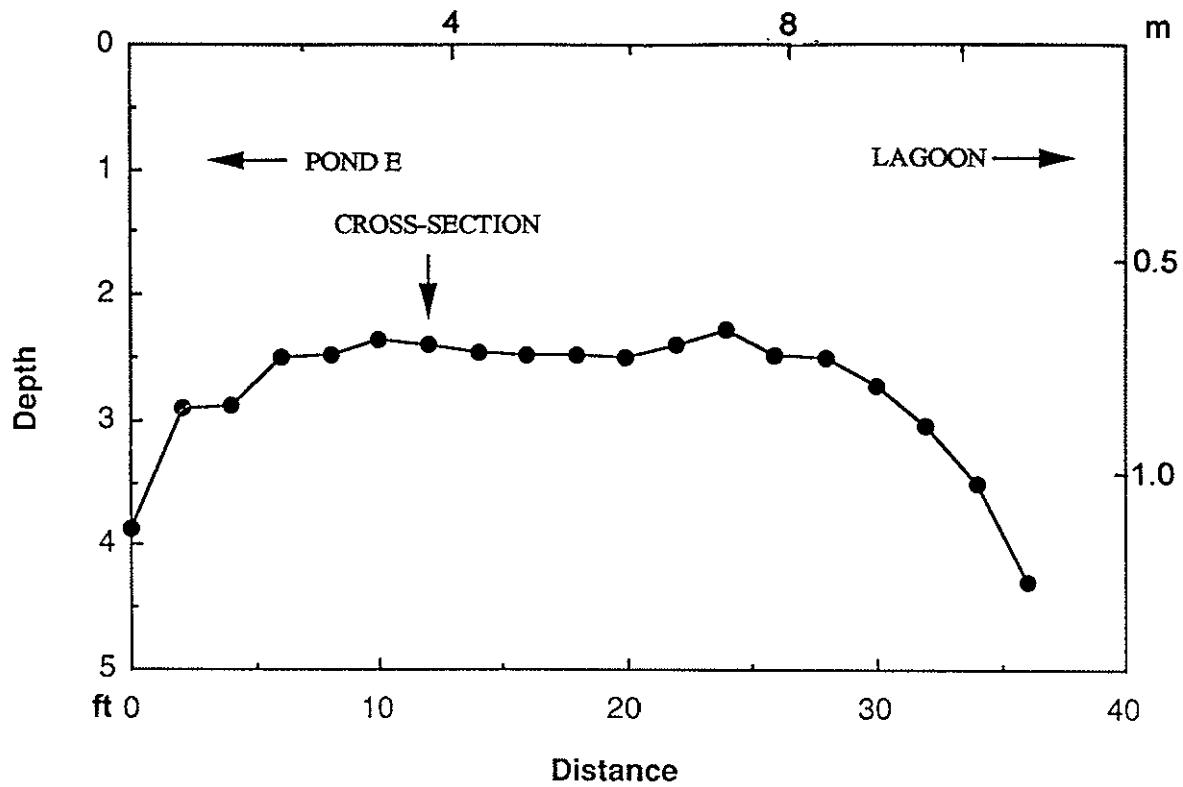


Figure 11. Fisherman's Cay Channel Axial Profile from Pond E to lagoon.

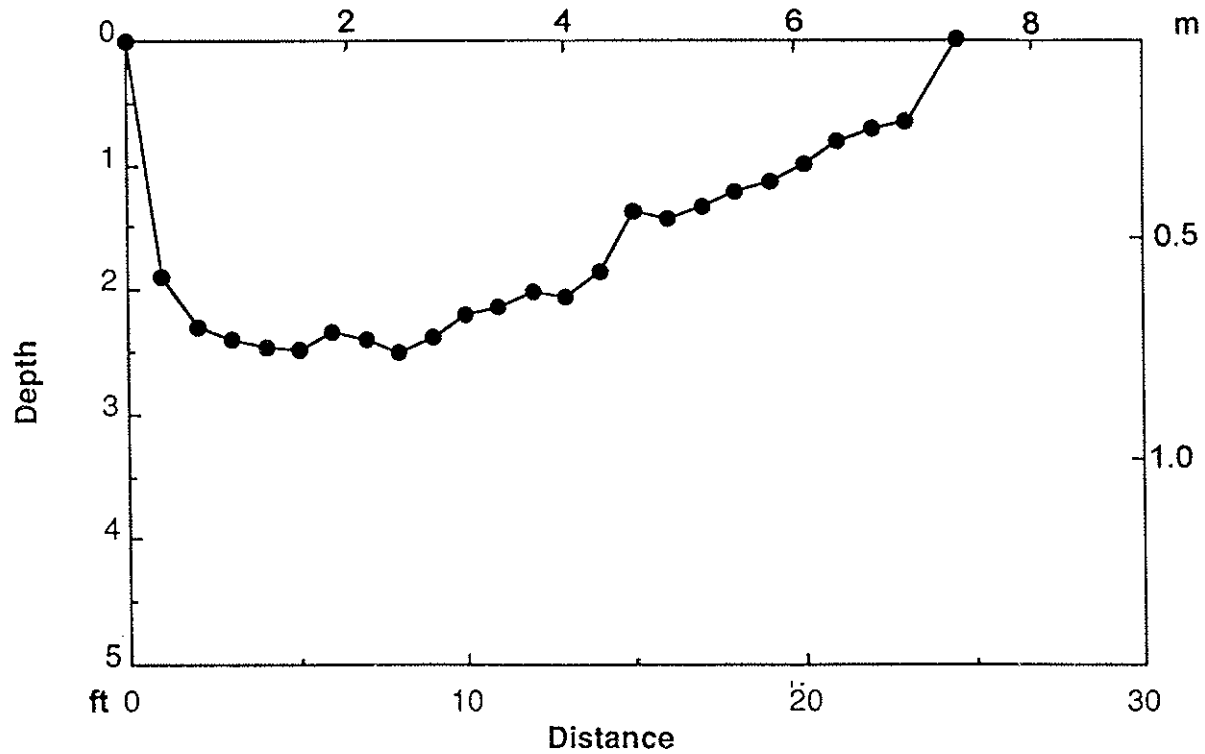


Figure 12. Fisherman's Cay Cross-Section looking into Pond E.

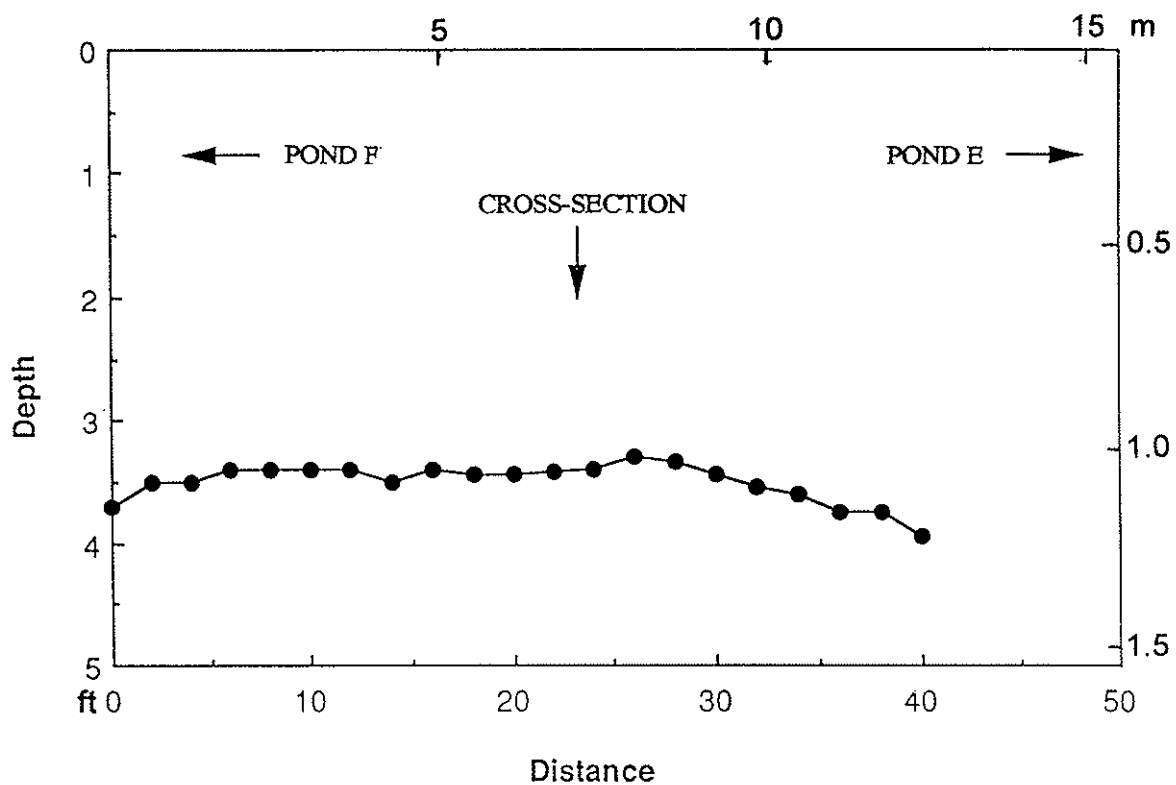


Figure 13. Fisherman's Cay Channel Axial Profile from Pond F to Pond E.

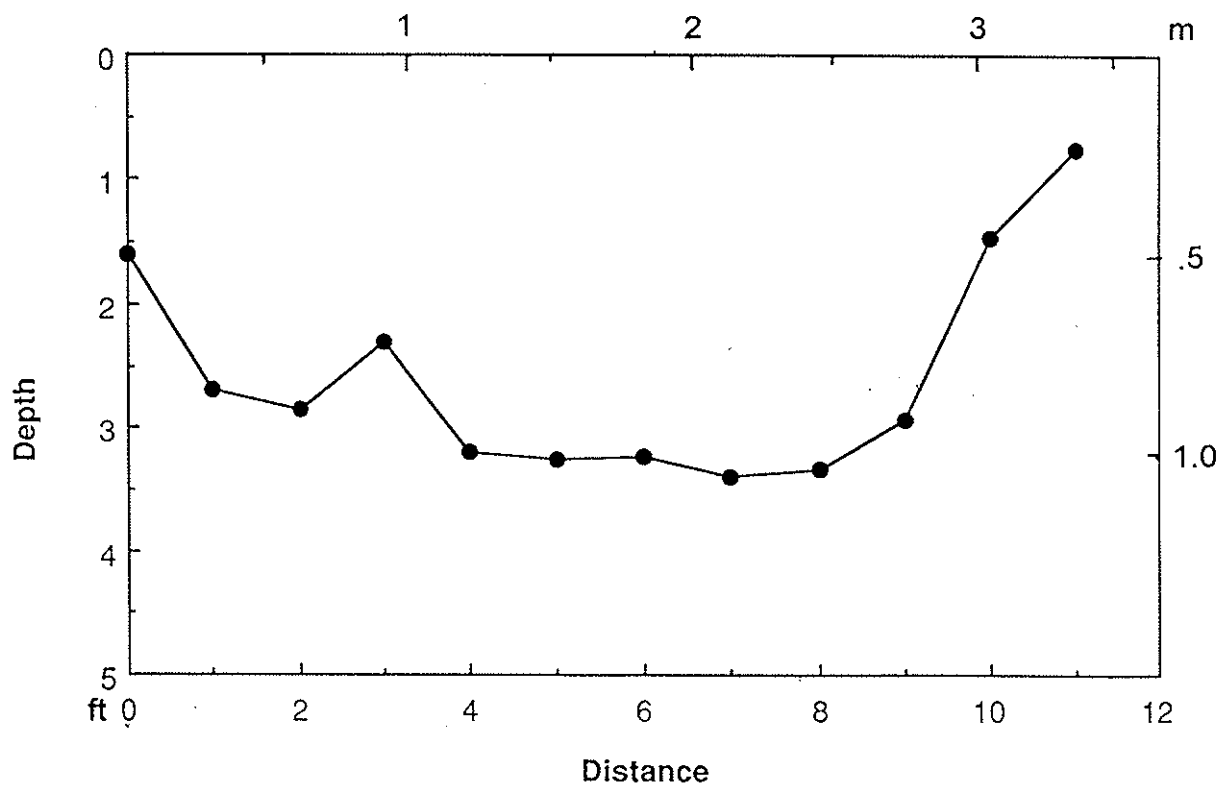


Figure 14. Fisherman's Cay Cross-Section looking from Pond E into Pond F.

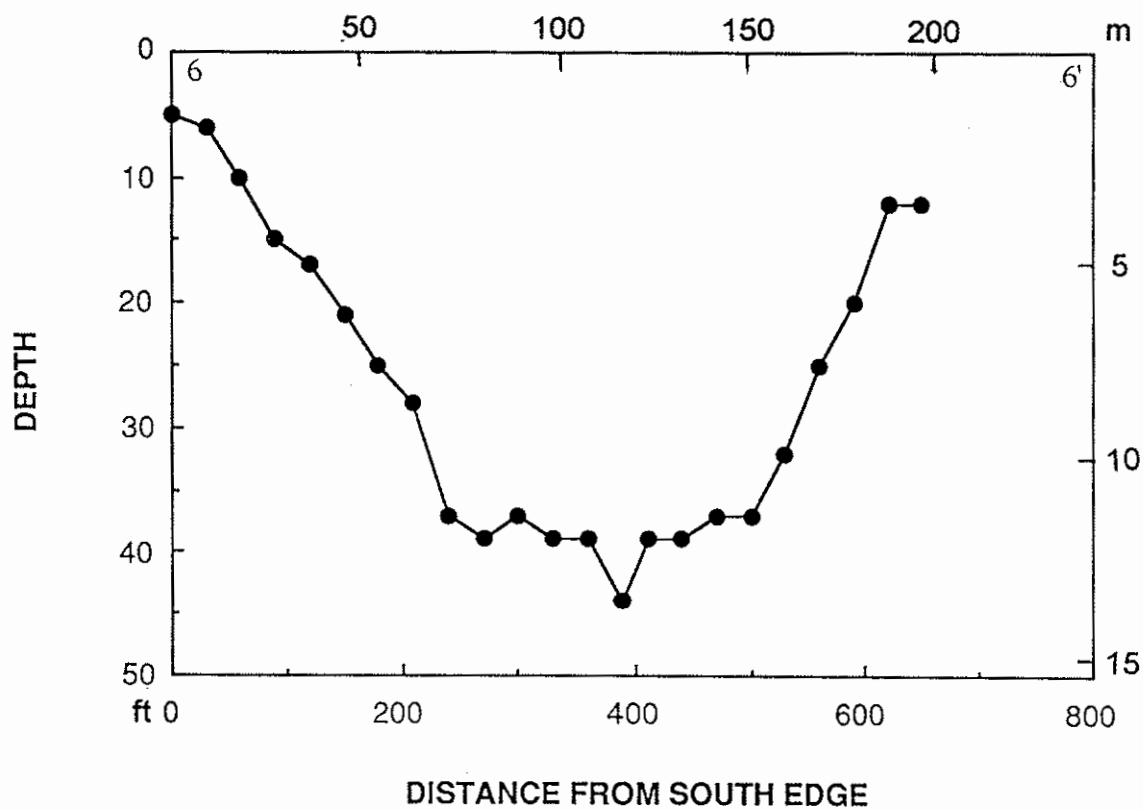


Figure 15. Pond G - Fisherman's Cay Bottom Profile 6-6'.

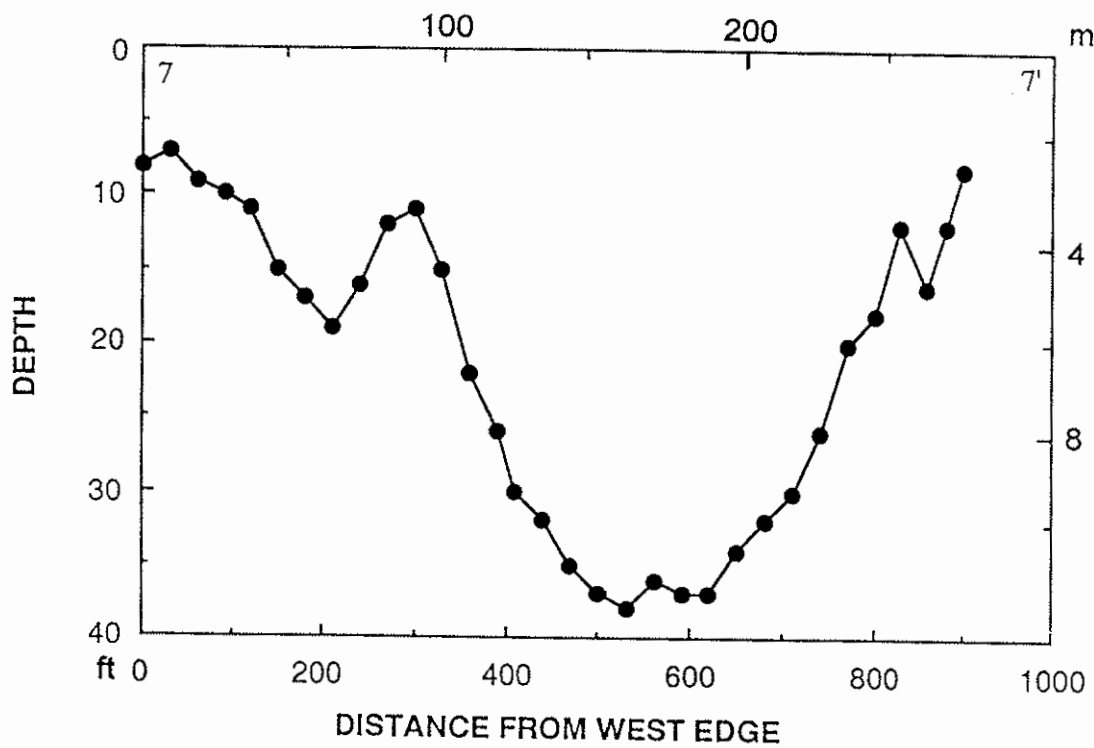


Figure 16. Fisherman's Cay Bottom Profile 7-7'.

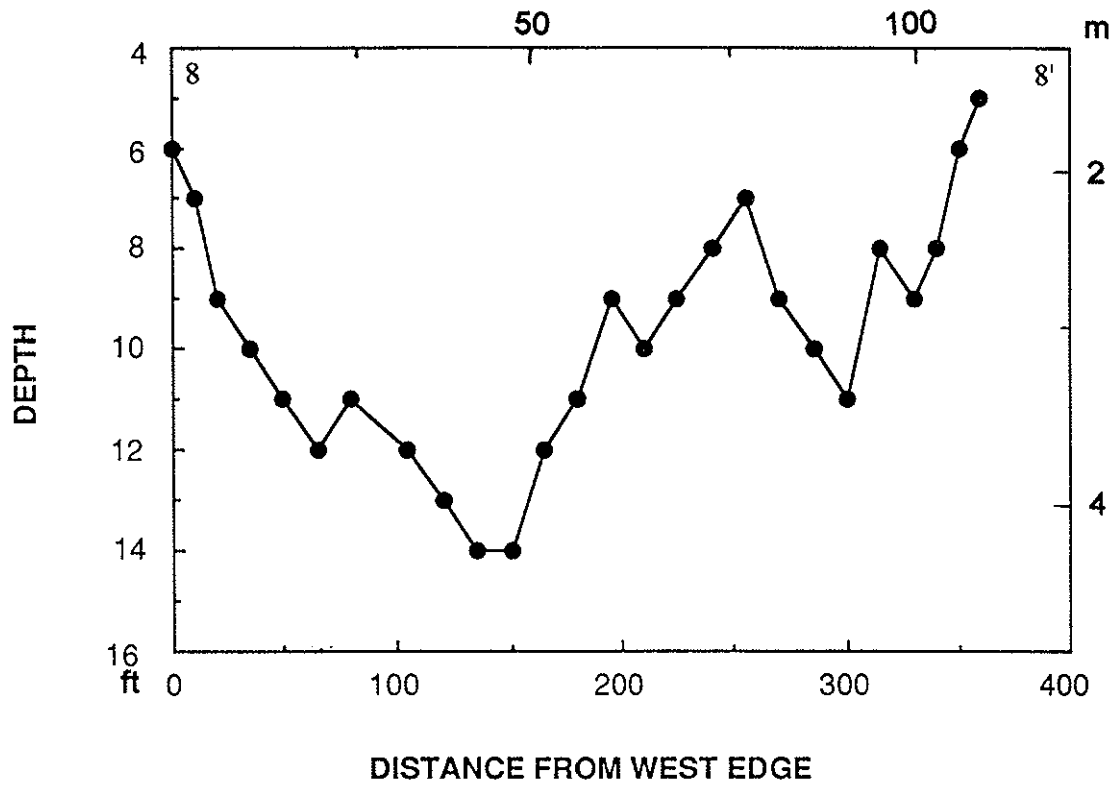


Figure 17. Pond E - Fisherman's Cay Bottom Profile 8-8'

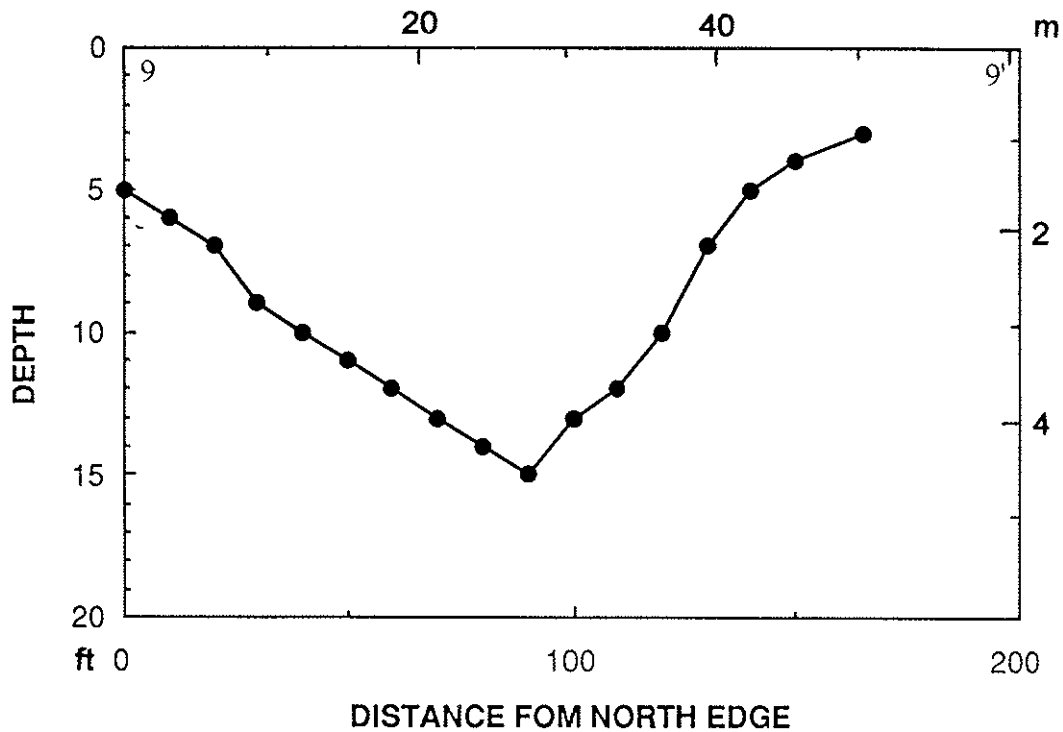


Figure 18. Pond E - Fisherman's Cay Bottom Profile 9-9'.

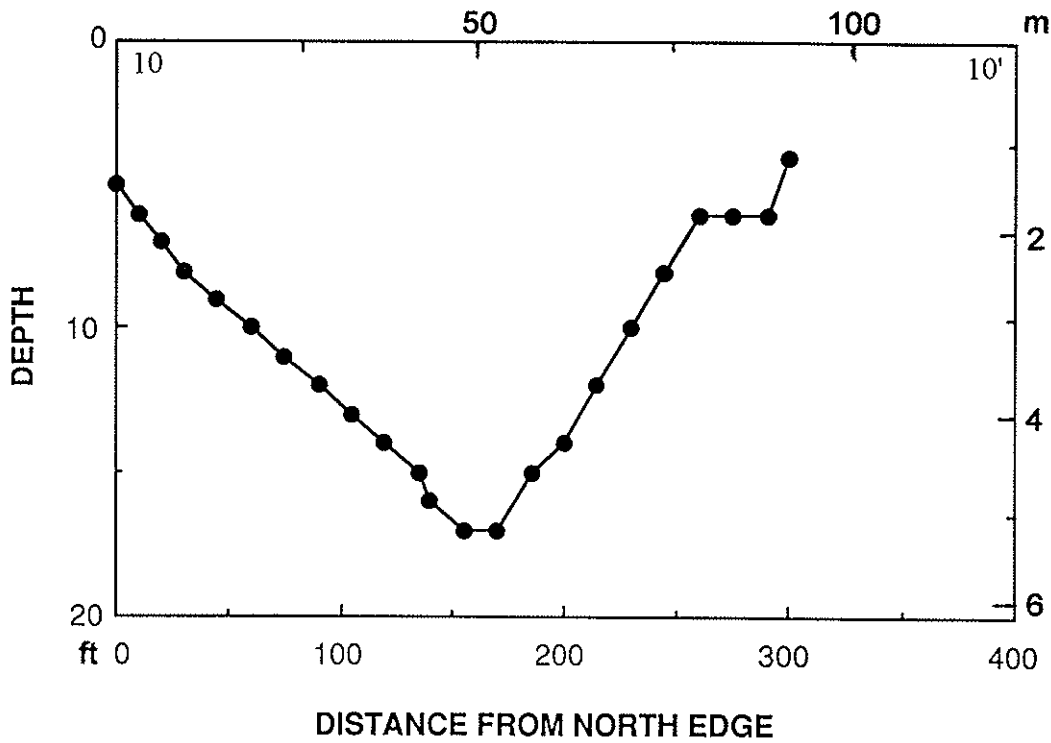


Figure 19. Pond F - Fisherman's Cay Bottom Profile 10-10'.

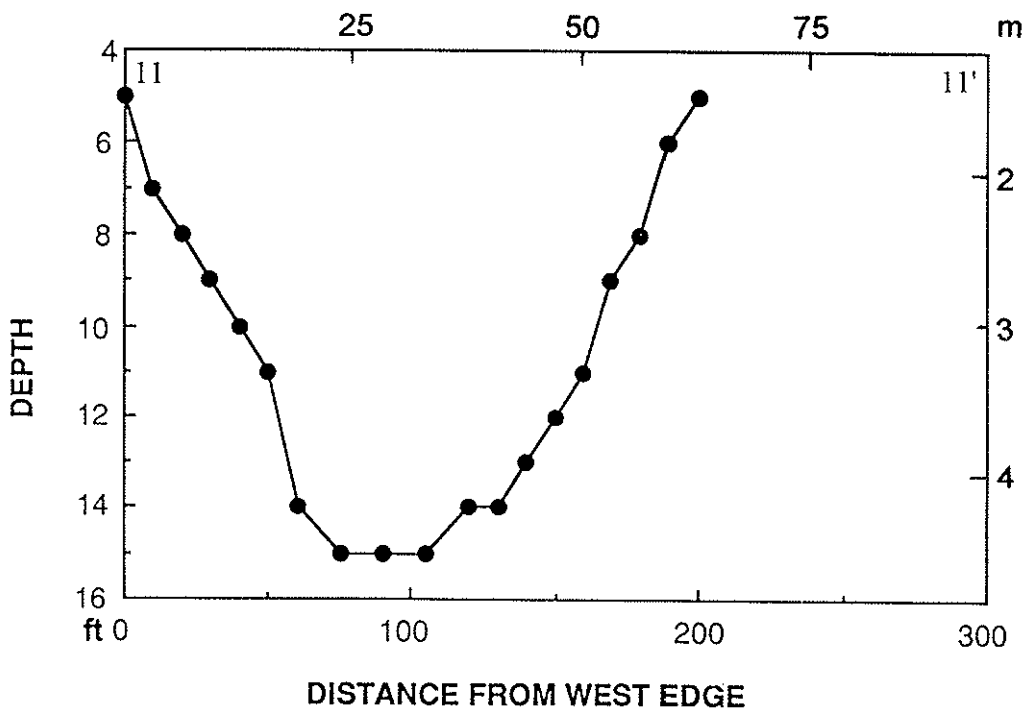


Figure 20. Pond F - Fisherman's Cay Bottom Profile 11-11'.

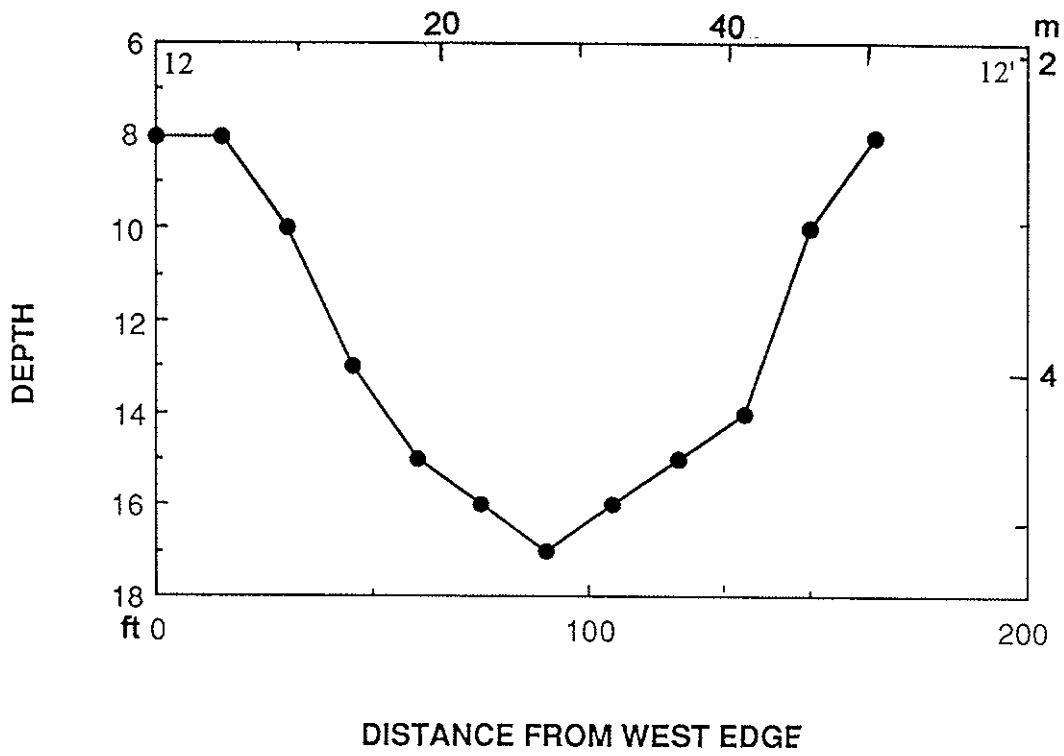


Figure 21. Pond F - Fisherman's Cay Bottom Profile 12-12'.

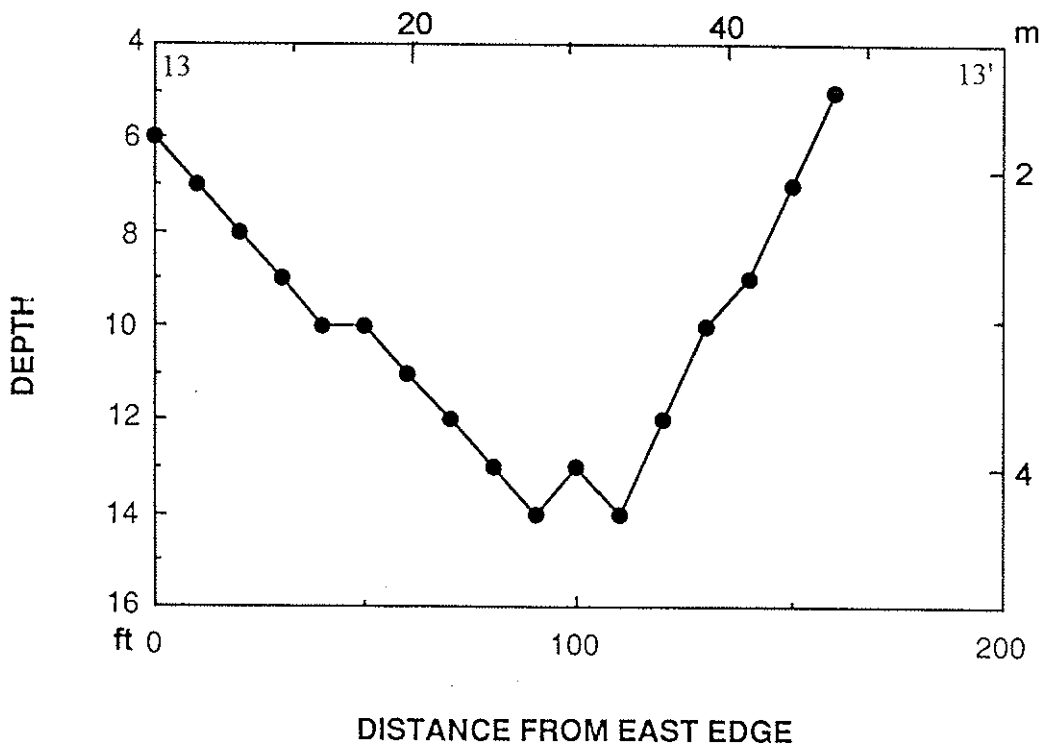


Figure 22. Pond F - Fisherman's Cay Bottom Profile 13-13'.

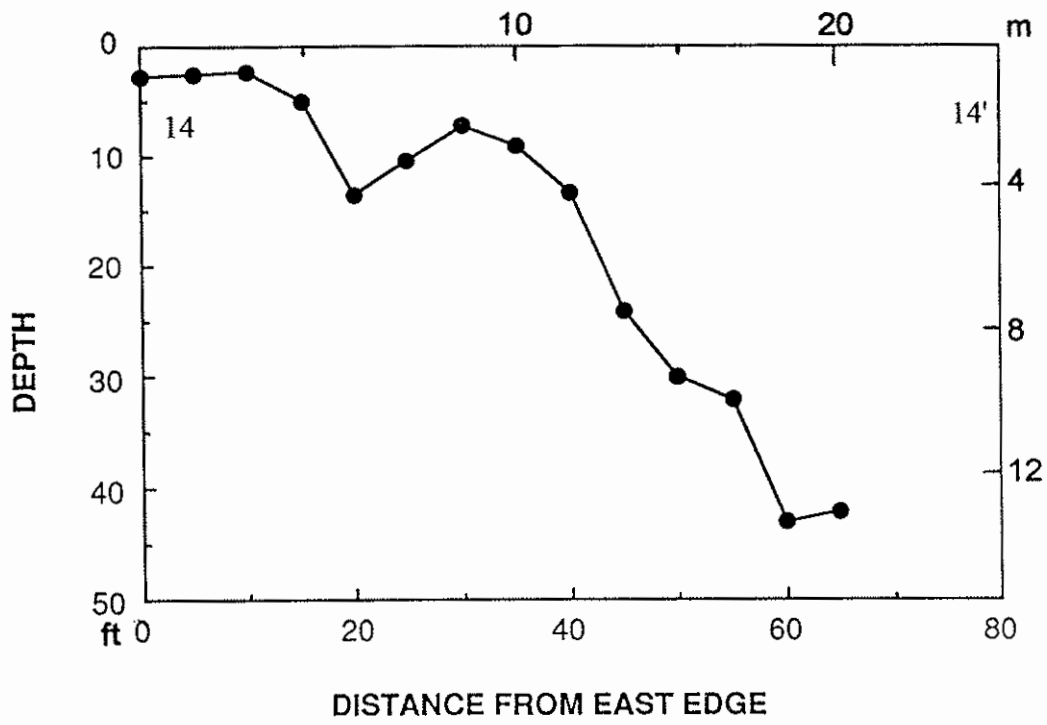


Figure 23. Fisherman's Cay Bottom Profile 14-14' outside of Pond E.

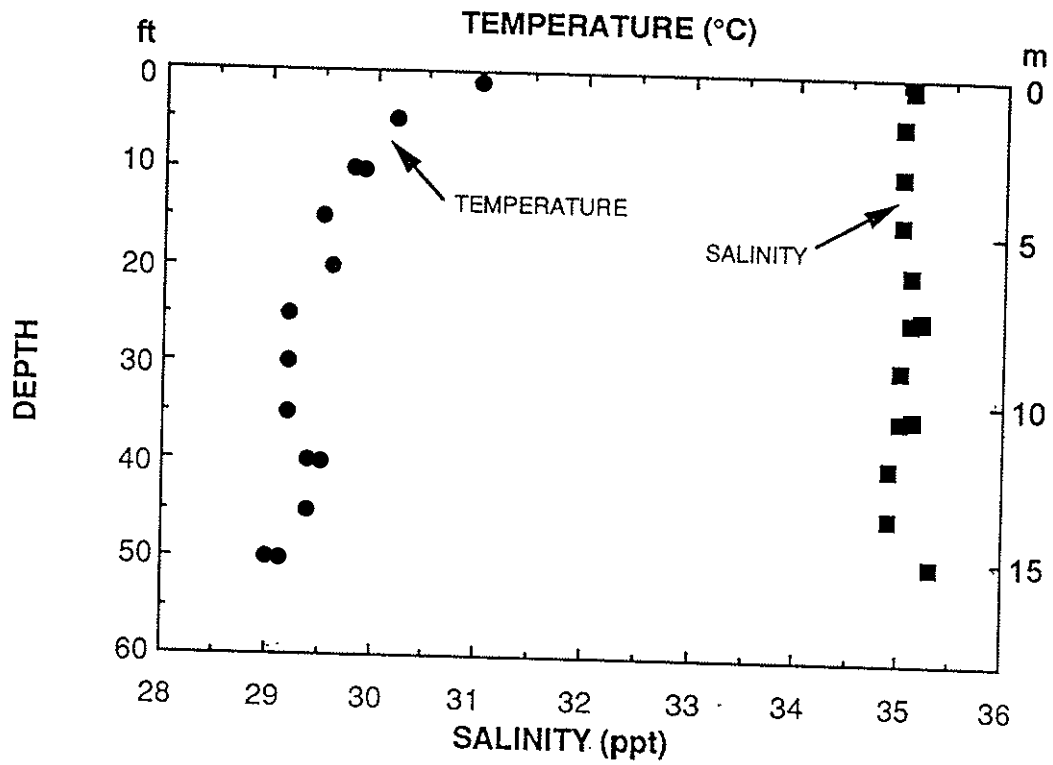


Figure 24. Pond A - Cat Cay Depth Profile A1.

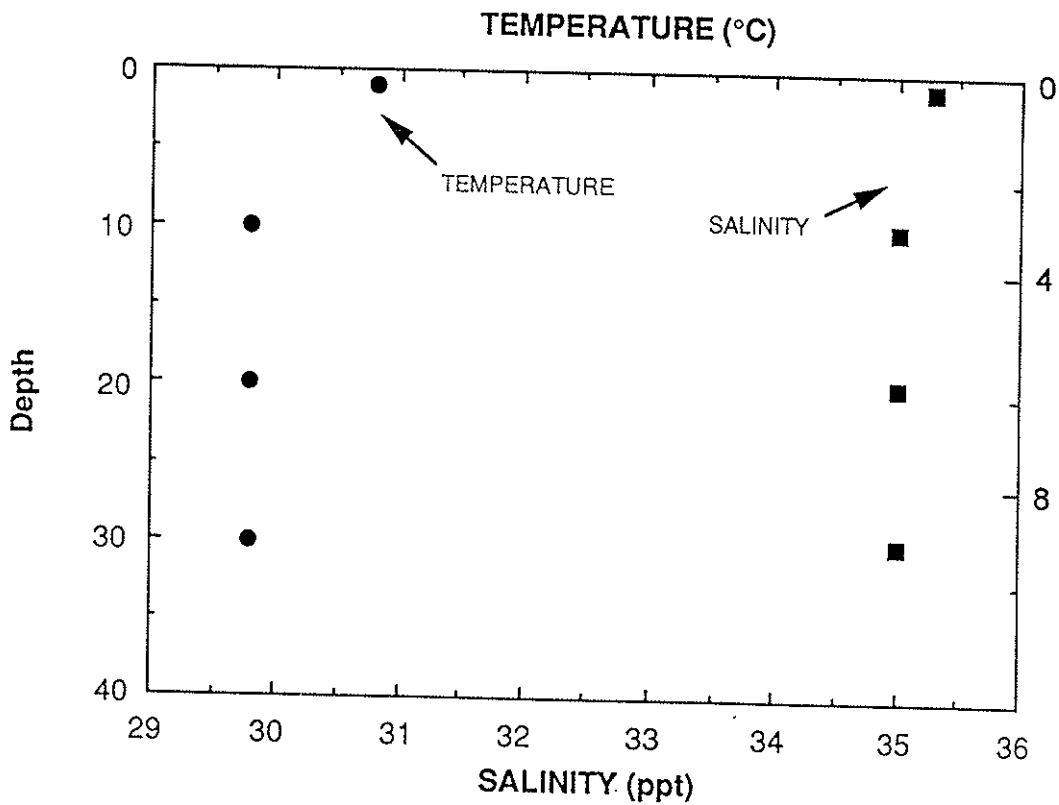


Figure 25. Pond A - Cat Cay Depth Profile A2.

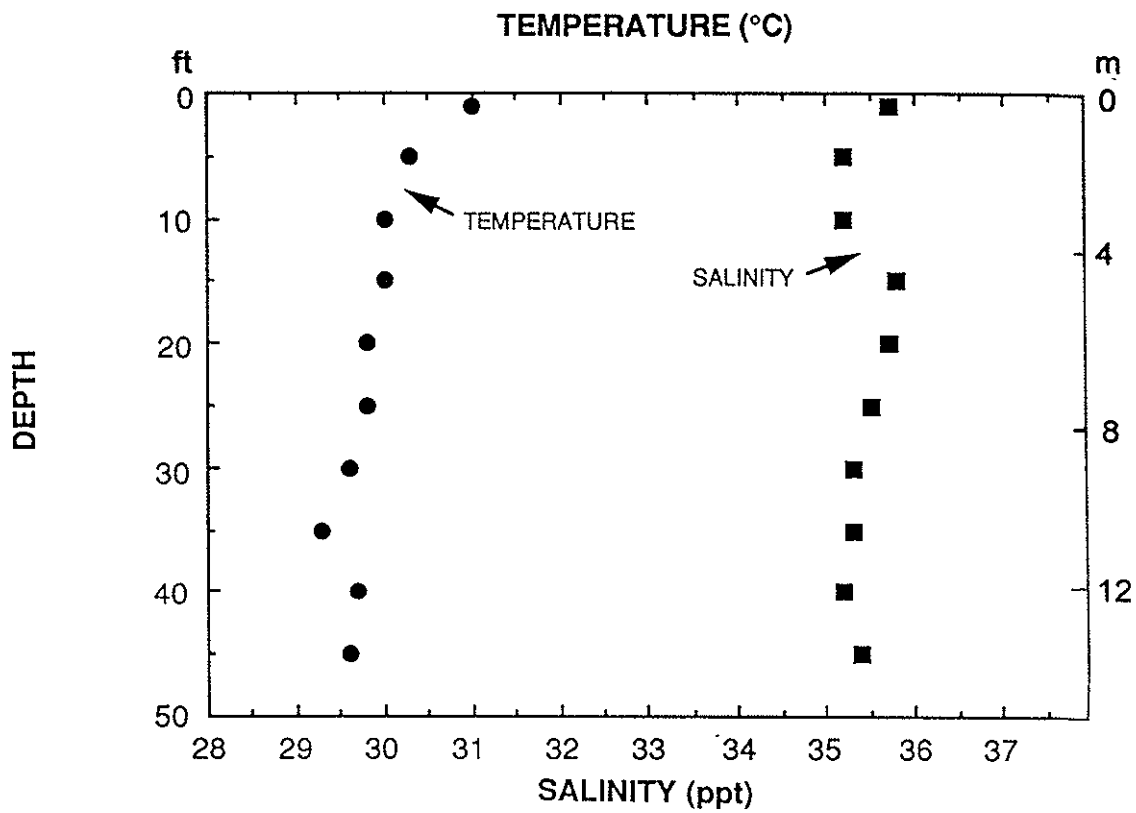


Figure 26. Pond C - Manatee Cay Depth Profile C1.

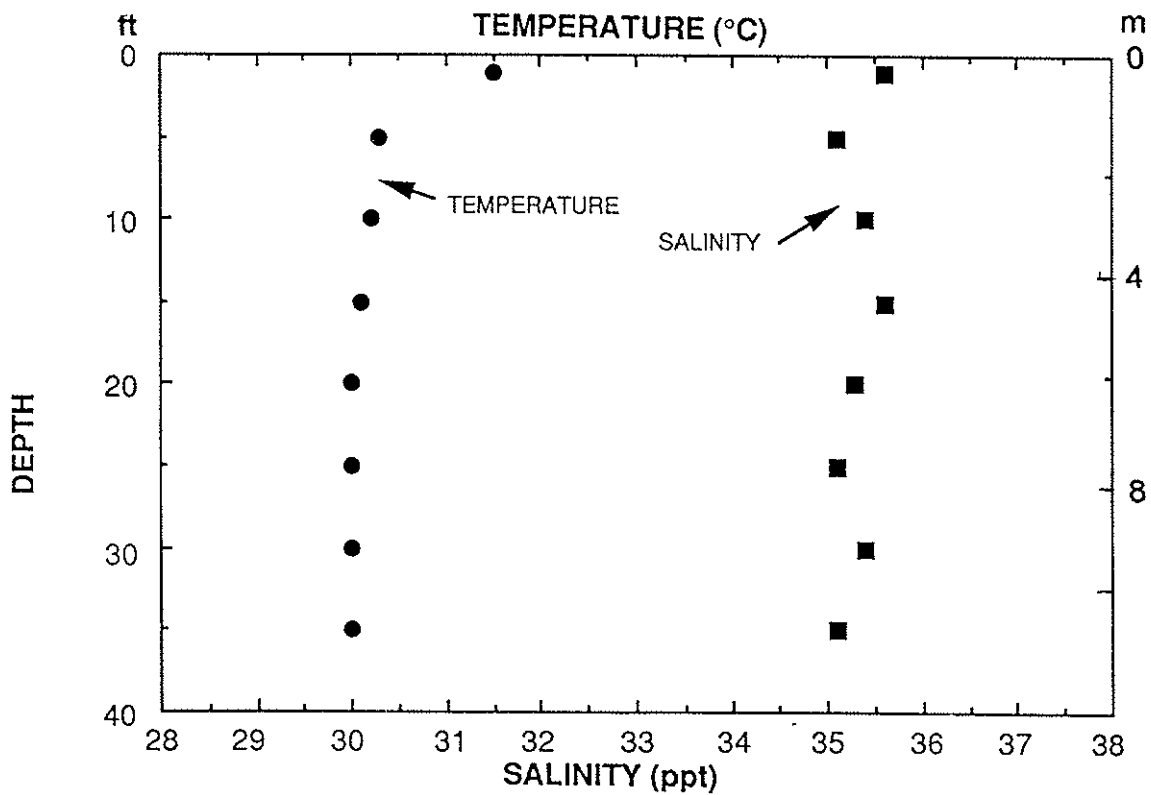


Figure 27. Pond C - Manatee Cay Depth Profile C2.

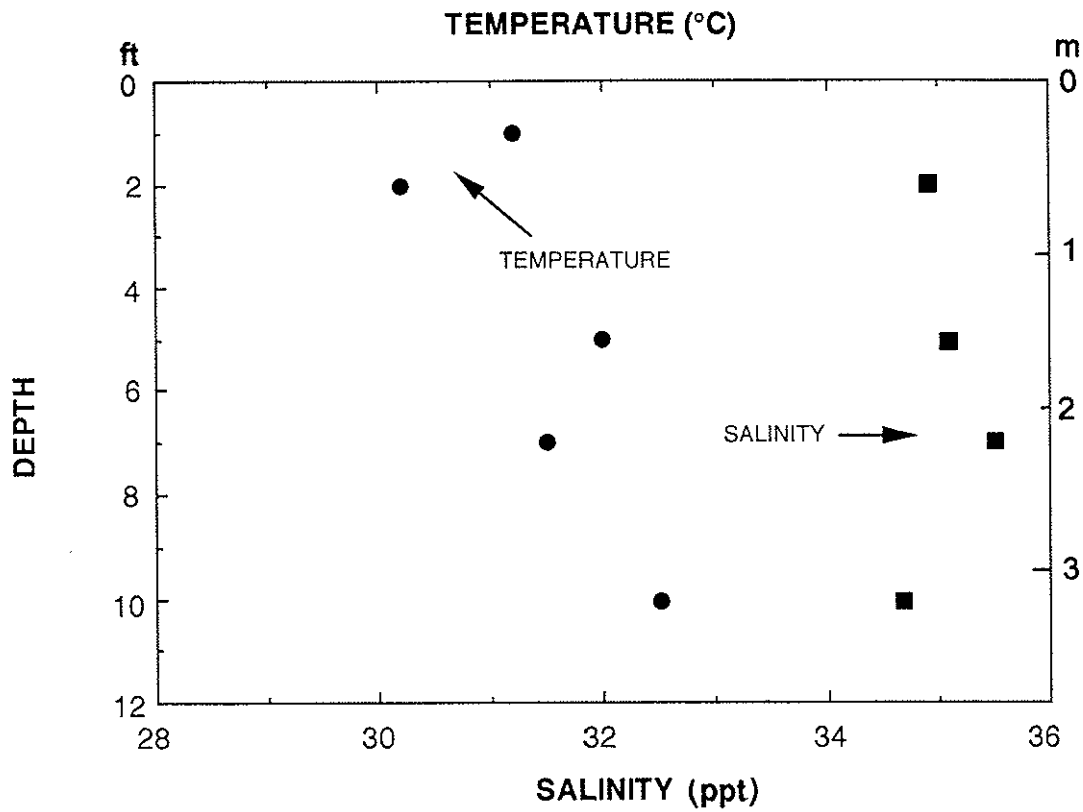


Figure 28. Pond E - Fisherman's Cay Depth Profile E1.

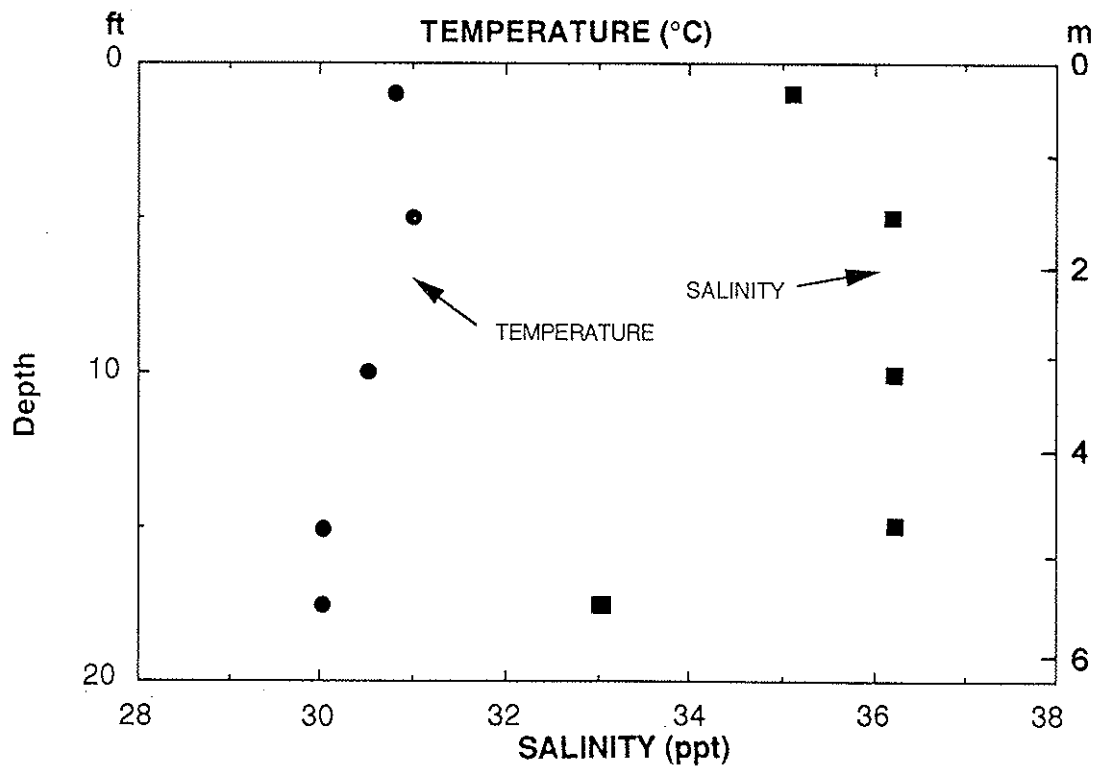


Figure 29. Pond F - Fisherman's Cay Depth Profile F1.

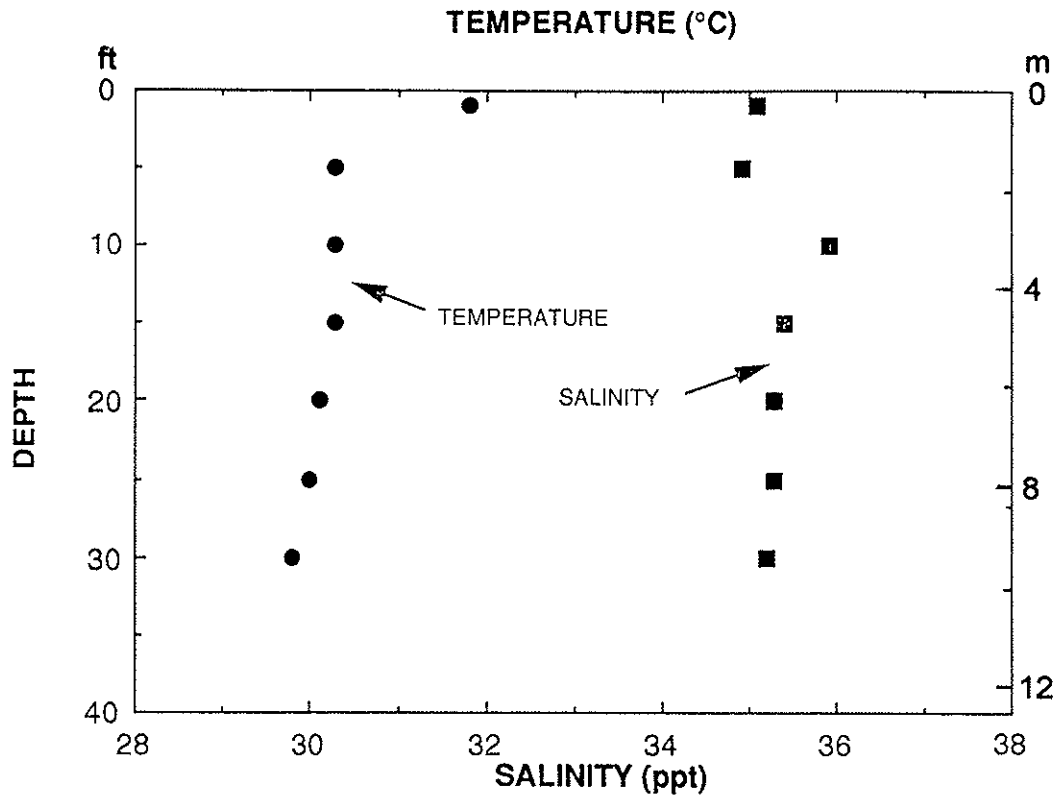


Figure 30. Pond G - Fisherman's Cay Depth Profile G1.

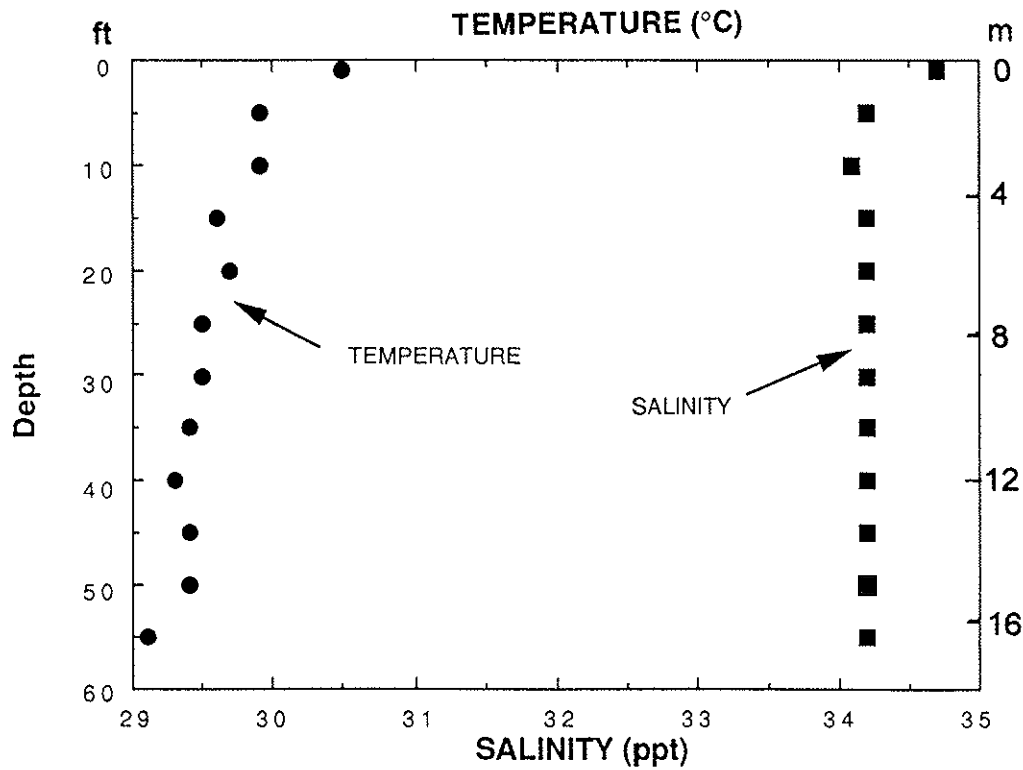


Figure 31. Fisherman's Cay Depth Profile E2.

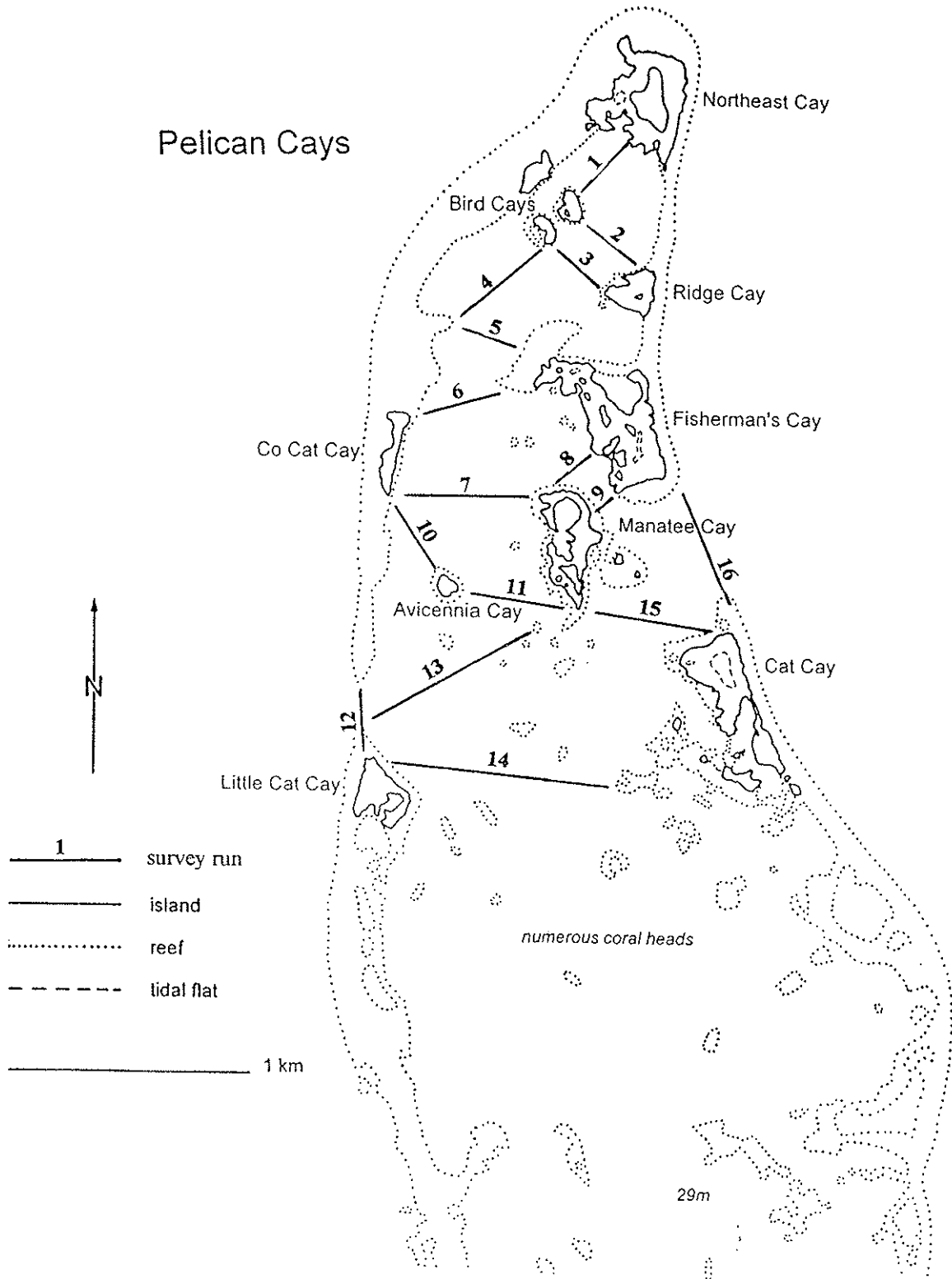


Figure 32. Map of Pelican Cays showing locations of inter-cay hydrographic survey runs.

DISCUSSION

Pond depths ranged from 4.6 m (15 feet) in relatively small Pond E at Fisherman's Cay to 15.2 m (50 feet) in the large Pond A at Cat Cay. In general, there appears to be a direct correlation between size and depth in the ponds. Such a correlation might be better determined by more detailed examination of the size of the circular bottom contour pattern and the depth of the configuration. The large ponds seem to be a composite of smaller circular depressions. Results for the ponds are summarized in Table 2.

Table 2. Inter-cay water depths of Pelican Cays group. Survey run locations are shown on Figure 32.

Survey Run	Distance (m)	Max. Depth (m)
1	330	18.3
2	330	21.3
3	300	22.6
4	549	19.8
5	300	21.3
6	400	22.6
7	650	22.0
8	300	20.1
9	100	15.2
10	400	22.6
11	550	20.1
12	350	26.8
13	1100	26.8
14	1150	28.0
15	650	28.7
16	600	28.0

The variation in salinity within ponds, or between ponds is noteworthy, but not remarkable. The near-surface water salinity was 35.1 ppt, except in Manatee Cay, which averaged 35.6 ppt, while the bottom water was in most cases about 0.2–0.5 ppt or less. In two ponds at Fisherman's Cay, the bottom salinity was slightly higher. Near-surface salinities are likely to be significantly less during the rainy season.

The variation in temperature within ponds and between ponds was not large but is consistent and significant. Near-surface water temperatures ranged from 31.0° C to 31.8° C, averaging 31.3° C, while bottom water temperatures ranged from 29.0° C for the deepest reading in Pond A at Cat Cay to 31.5° C for the shallowest reading in Pond E at Fisherman's Cay. This is not surprising since water temperature is a result of solar radiation and the volume of water available to absorb it. The measurements were all taken during the middle of generally sunny

days. Significant semidiurnal, as well as seasonal, variations in the near-surface temperature are to be expected.

Analysis of the hydrographic survey data for the lagoon regions between the cays (Table 2) shows that the sides of the cays exhibit very steep slopes similar to the ponds and relatively flat bottoms over the major length of the runs. Analysis of 23 lagoon slopes gives an average of 28° , considerably greater than the 17° of the ponds. Again, there appears to be a direct correlation between water depth and distance across open water, whether in the ponds of the cays or in the lagoon between cays.

CONCLUSIONS

Hydrographic and hydrologic surveys of ponds in three cays—Cat Cay, Manatee Cay, and Fisherman's Cay—of the Pelican Cays Group show that the pond bathymetry characteristically shows a circular pattern with steeply sloping sides. An articulated ridge frequently occurs between these circular patterns. The pond depths range from 4.6 m in a small pond, such as Pond E in Fisherman's Cay (100 m wide) to 15.2 m in a large pond such as Pond A in Cat Cay (250 m wide). The average maximum pond depth is 10.7 m. In general, depth tends to increase with the width of the pond.

Measurements of water depth between the cays showed maximum depth ranged from 15.2 m over a survey run distance of 100 m to a maximum depth of 28.7 m over a survey run distance of 1,150 m. The average maximum depth of the intercay survey runs is 22.7 m, which is more than twice that of the interior ponds. Here, depth tends to increase with increasing distance between cays. Side slopes in both ponds and the lagoon are steep, averaging 17° for the ponds and 28° for the lagoon.

Maximum salinities in the ponds averaged 35.3 ppt near the surface and 35.2 ppt near the bottom, with a range of 1.5 ppt. There was a slight tendency for salinity to be lower near the bottom. Temperature showed a somewhat larger variation, ranging from an average maximum of 31.3°C near the surface to 30.2°C near the bottom, with a relative strong tendency for surface temperatures to be about 1.0°C higher at the surface.

ACKNOWLEDGMENTS

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