

**PROCEEDINGS
OF THE
SEVENTH SYMPOSIUM
ON THE
NATURAL HISTORY OF THE BAHAMAS**

**Edited by
Tom K. Wilson**

**Conference Organizer
Kenneth C. Buchan**

**Bahamian Field Station, Ltd.
San Salvador, Bahamas
1998**

Cover Illustration: ArcView GIS generated elevation map of San Salvador. Produced by Matt Robinson of the University of New Haven for the Bahamian Field Station

© Copyright 1998 by Bahamian Field Station, Ltd.

All Rights Reserved

No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopy, recording, or any information storage and retrieval system, without permission in written form.

Printed in USA by RSMAS, University of Miami, Miami, Florida

ISBN 0-935909-66-4

TEMPORAL VARIATIONS IN THE PHOSPHORUS CONTENT OF BAHAMIAN SEAGRASSES

Shelby D. Harper and Garriet W. Smith
Biology Department
University of South Carolina at Aiken
Aiken, SC 29801

ABSTRACT

Seagrasses growing in the oligotrophic waters and carbonate sediments of San Salvador, Bahamas are nutrient stressed. As a result, the size of the plants are greatly reduced compared with those growing in terrigenous sediments or more eutrophic waters. Previous fertilization studies indicated that the primary limiting nutrient in San Salvador seagrasses is phosphorus. Seagrasses extracted from core samples taken biannually from 1988 until the present, in Graham's Harbor and French Bay, were analyzed for phosphorus content in stem-leaf and root-rhizome tissue. Considerable variation, in all tissues from all species, was observed throughout the sampling period. In Graham's Harbor, significant spikes in [P] of *Halodule wrightii* stem-leaves and root-rhizomes were observed from July 1992 samples. *Thalassia testudinum* stem-leaves, root-rhizomes and *Syringodium filiformis* root-rhizomes all had significant increases in [P] from December 1995 samples. In French Bay, a cyclic increase in [P] was found in *Syringodium* and *Thalassia* root-rhizomes. The [P] of *Thalassia* stem-leaves increased steadily from July 1992 until December 1994, then dropped. We are continuing to observe these fluctuations and attempting to correlate them with other parameters.

INTRODUCTION

Seagrasses provide significant amounts of primary and secondary production in shallow, coastal, marine environments (Zieman, 1982; Thayer *et al.*, 1984). Most fixed carbon is provided to other trophic levels directly via microbial degradation of the plant tissue (Smith, 1987; Kenworthy *et al.* 1989), although direct herbivory can also be important (Ogden, 1976; Lewis, 1986). Seagrass meadows also stabilize sediments and act as a barrier against wave action (Fonseca, 1989; Fonseca and Fisher, (1986). The presence of extensive root-rhizome systems provide an environment for nutrient interactions among the plants, associated microbiota and sediments (Morgan and Smith, 1992; Smith and Hayasaka, 1982; Smith *et al.*, 1984; Wehner and Smith, 1994; Wong and Smith, 1994). These

interactions often change the chemical nature of the sediments (Kaplan *et al.*, 1990).

The growth and biomass of seagrass species are generally reduced in oligotrophic waters and nutrient-poor carbonate sediments (Zieman *et al.*, 1997), typical of the Bahamas, including San Salvador Island (Gerace *et al.*, 1997). The relatively low productivity rates exhibited by seagrasses in San Salvador were shown to be due to phosphorus limitation (Short *et al.*, 1985; 1990).

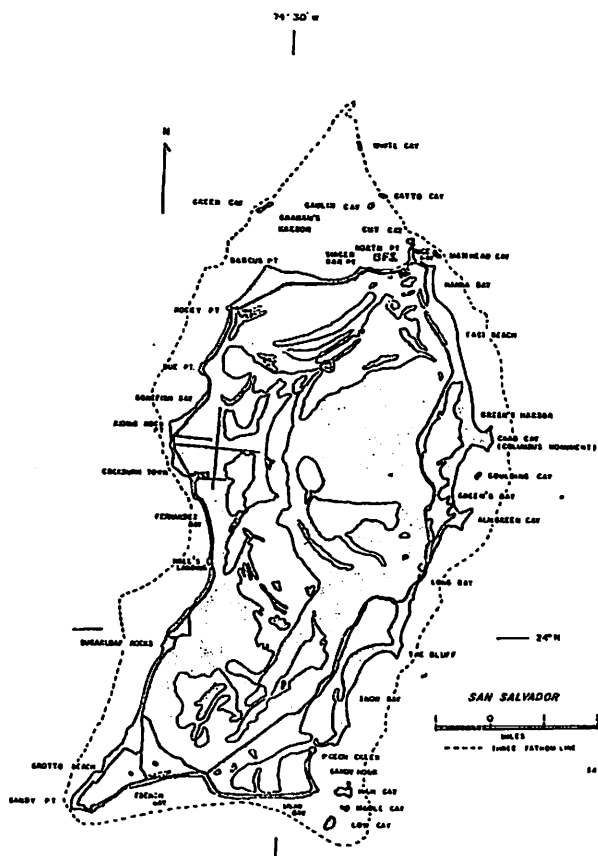
The purpose of the present study was to determine temporal variations in tissue phosphorus content of the seagrasses; *Thalassia testudinum*, *Halodule wrightii* and *Syringodium filiforme* at a high-energy site (French Bay) and a stable, relatively low-energy site (Graham's Harbor) in San Salvador Island, Bahamas. This island has been undergoing increases in development and population since 1992. Seagrasses have been monitored at the two sample sites since 1988. Correlations among growth measurements, development and tissue phosphorus content may then be assessed.

MATERIALS AND METHODS

Seagrass cores were taken biyearly (July and December), beginning in 1988, from Graham's Harbor and French Bay (Fig. 1). Triplicate cores were taken at 2M intervals along a 60M transect line, each sampling period to a depth of 20cm. Contents of cores were put into plastic bags and washed free of adhering sediment on shore. Plant material was taken to the BFS laboratory and washed in 0.1 N HCl to remove epiphytes, sorted by species and plant part (stem-leaves or root-rhizomes), and dried at 100 C for 48 h. Material was then weighted and taken to USCA for chemical analysis.

Dried seagrass tissue was ground in a wiley mill, acid digested and ashed in a combustion oven. Dry ash was dissolved and phosphorus concentration determined spectrophotometrically and compared with standard a curve (Strickland and Parsons, 1972).

Figure 1, San Salvador Island, Bahamas. Graham's Harbor is at the northern, protected end. French Bay is at the southern, more exposed end of the island.



RESULTS AND DISCUSSION

The [P] of stems and leaves from all seagrass species in Graham's Harbor fluctuated from 0.1 to just over 0.3 % over the sampling period (Fig. 2), with two unusual peaks, both to approximately 0.5 % P. The first was *Halodule* in the summer of 1992, the other was *Thalassia* in the winter of 1995. *Halodule* would be expected to be a sensitive indicator of increased levels of P since this plant harbors nitrogen-fixing bacteria in its' roots (Smith, 1996) and both N and P occur at low concentrations in this environment. The building of Club Med in San Salvador was in full swing at this time. It is not known if this was the cause of the spike since prevailing currents from the building

site were not toward Graham's Harbor. Storms, however, can change the overall direction for short periods. The other spike in [P] in stems and leaves at Graham's Harbor occurred with *Thalassia* during the winter of 1995. Although *Thalassia* is not thought to be as efficient at recycling unavailable P (apatite and organic-P) as the pioneering species (particularly *Syringodium*, Wehner and Smith, 1994). Once mineralized, *Thalassia* can take up and transport P efficiently. The root-rhizome [P] of *Syringodium* was high during this time (Fig.3), as was the root-rhizome [P] for *Thalassia*. This indicates concentrations of organic-P may have been high at this time.

Root-rhizome [P] in Graham's Harbor was somewhat lower than for leaves and stems, except for winter peaks generally observed with *Syringodium*. Again, this indicates a major role played by *Syringodium* in providing available P to other species. This is analogous to the role played by *Halodule* providing fixed N to other seagrass species. Although seagrass biomass is dominated by *Thalassia* in Graham's Harbor (Smith *et al.*, 1995), shoot density is approximately equal. There appears to be a nutritional symbiosis within the seagrass community in Graham's Harbor.

In French Bay, the stem-leaf [P]s were high for both species in the winters of 1988 and 1989. The following summer concentrations fell to below 0.1% and remained near that for *Syringodium* (Fig.4). The stem-leaf [P] steadily increased for *Thalassia* from July 1992 to December 1994, then decreased (Fig. 5). Root-rhizome [P] showed peaks in July 1992, July 1994 and December 1995 for *Syringodium*. Delayed peaks (by a season) were seen in root-rhizome samples of *Thalassia* in French Bay. This increase in *Thalassia* root-rhizome [P] may be due to the recycling of *Syringodium* root-rhizome tissue.

Overall comparisons of *Thalassia* and *Syringodium* tissue [P]s are given in Figures 6-9. No general trend was found with either *Thalassia* tissue type (Figs. 6,7), or with *Syringodium* root-rhizome tissue (Fig. 8). *Syringodium* stems and leaves from Graham's Harbor, however, always had a higher [P] than those from French Bay (Fig. 9).

In conclusion, phosphorus cycling within and among seagrass species in a common meadow appears complex. Only *Syringodium* showed any cyclic behavior. The [P] of *Thalassia* tissue seems to increase after *Syringodium*, indicating a recycling mechanism initiated by the latter species. Spikes in [P] may have occurred due to activities associated with construction or, more recently, storm events.

Figure 2. Percent phosphorus of above sediment seagrass tissue from Graham's Harbor (1988-1996).

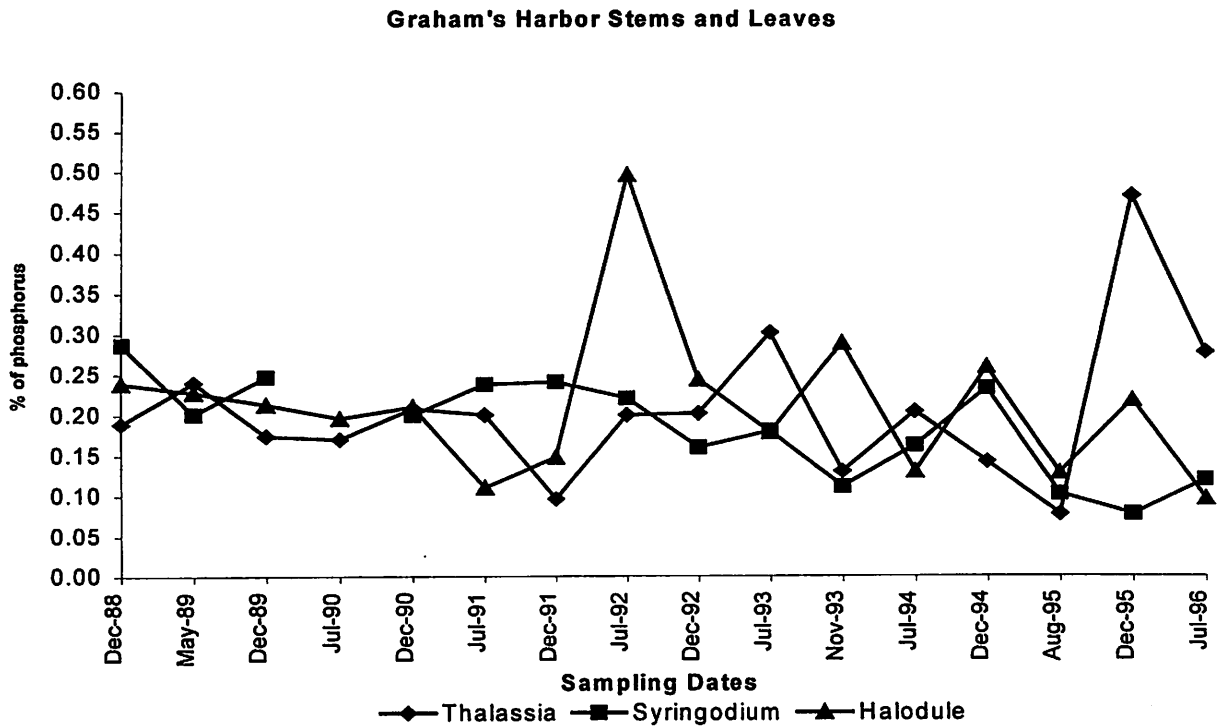


Figure 3. Percent phosphorus of below sediment seagrass tissue from Graham's Harbor (1988-1996).

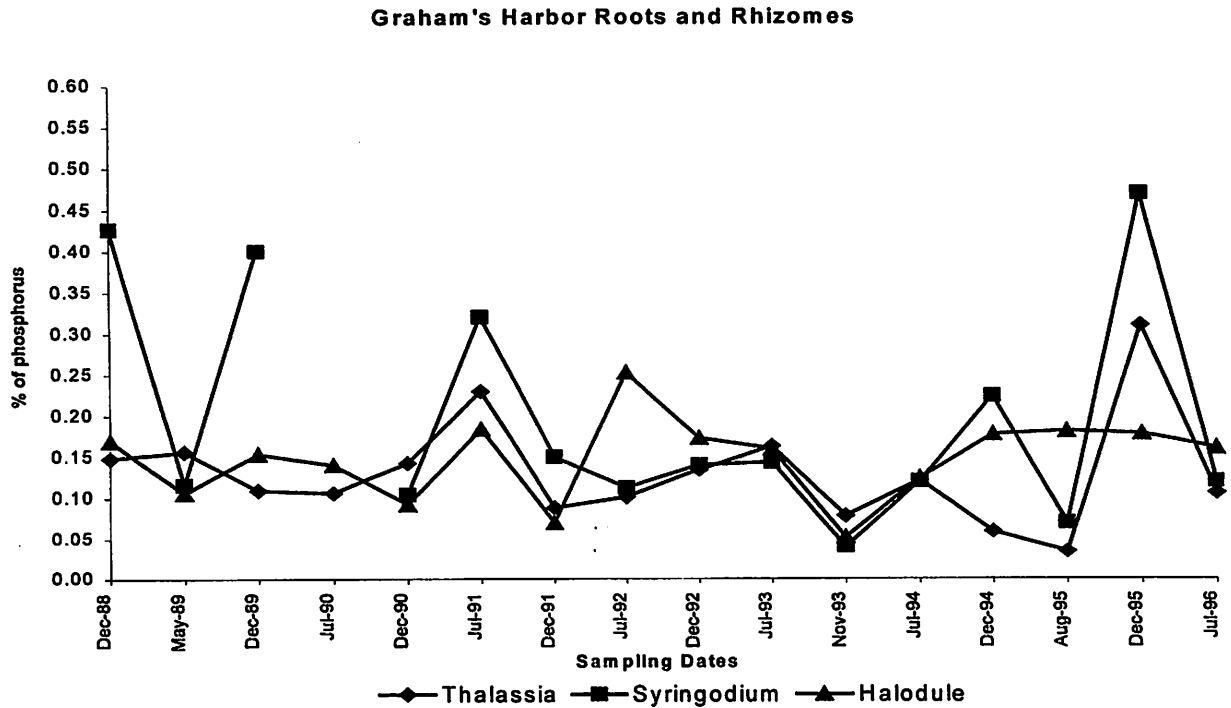


Figure 4. Percent phosphorus of *Thalassia* tissue in French Bay (1988-1996).

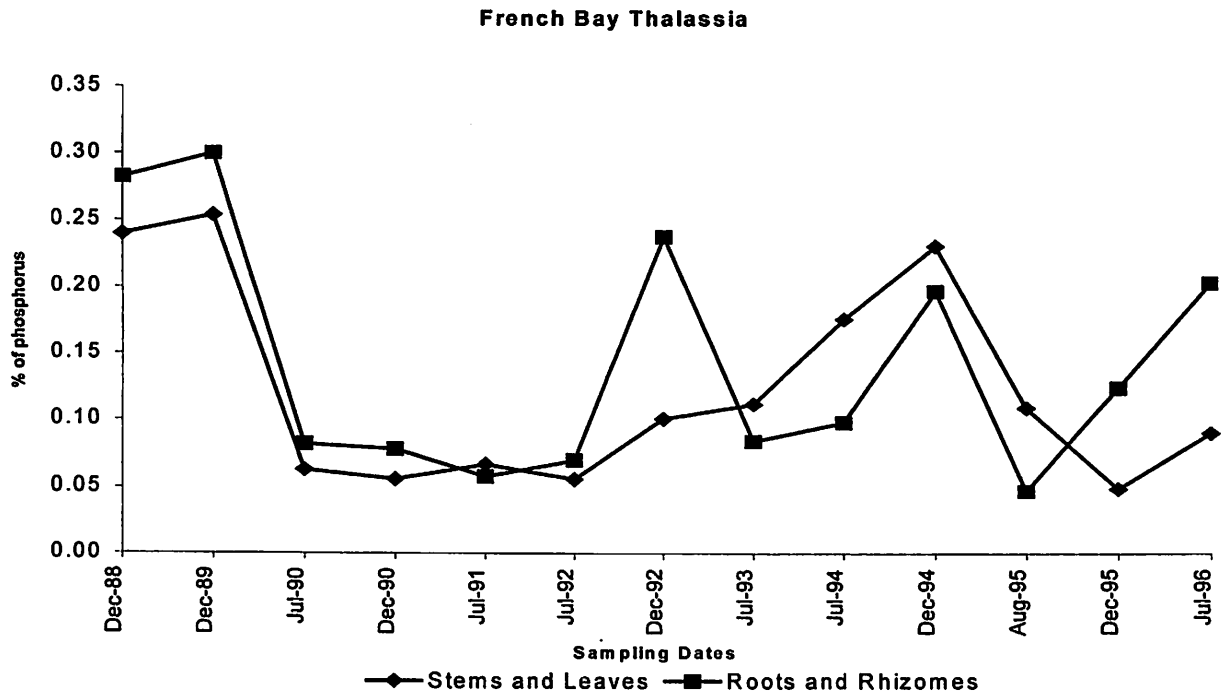


Figure 5. Percent phosphorus of *Syringodium* tissue in French Bay (1988-1996).

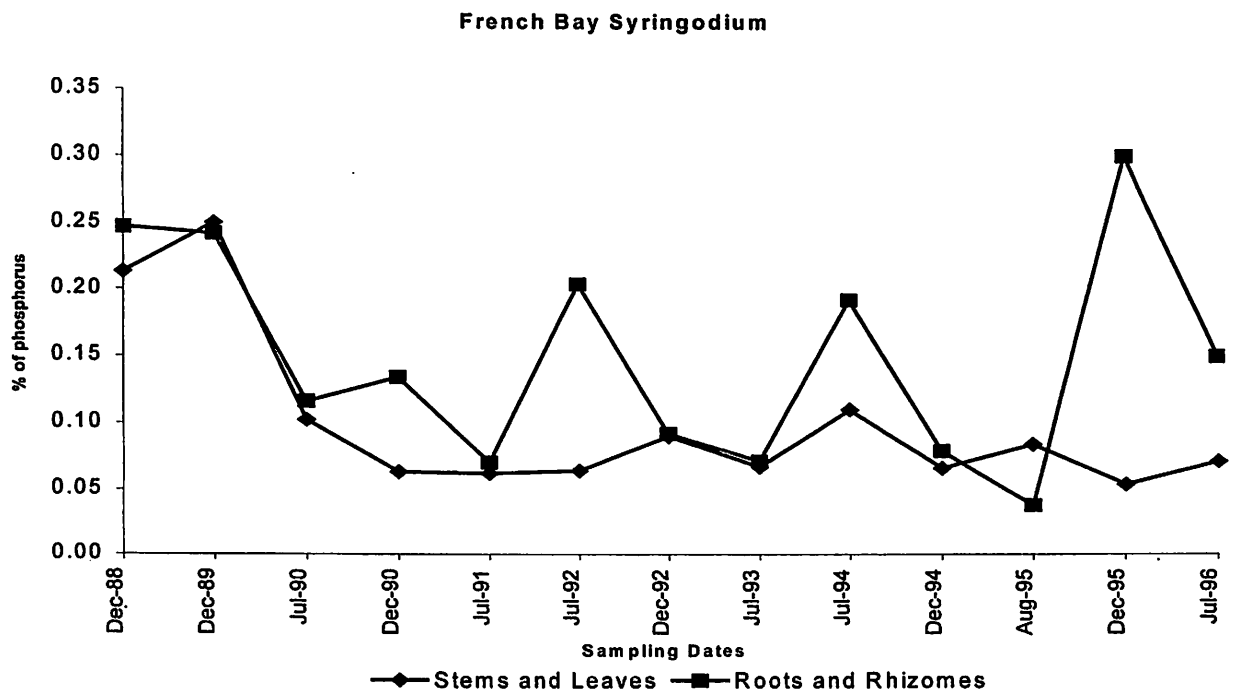


Figure 6. Comparison of the % P in *Thalassia* root-rhizomes from Graham's Harbor and French Bay.

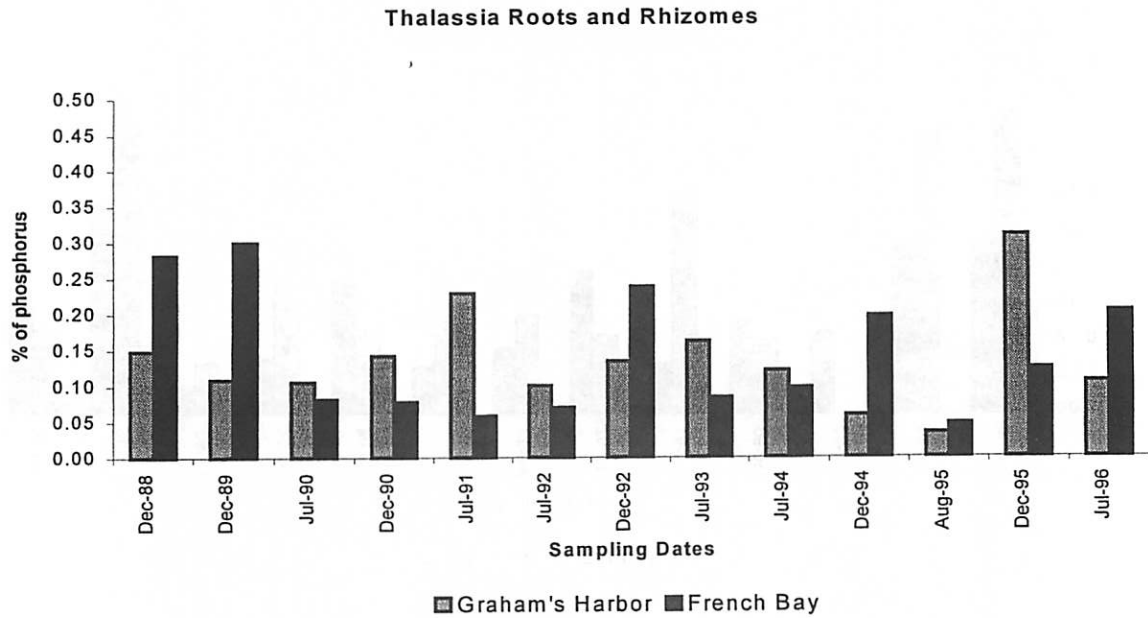


Figure 7. Comparison of the % P in *Thalassia* stems-leaves from Graham's Harbor and French Bay.

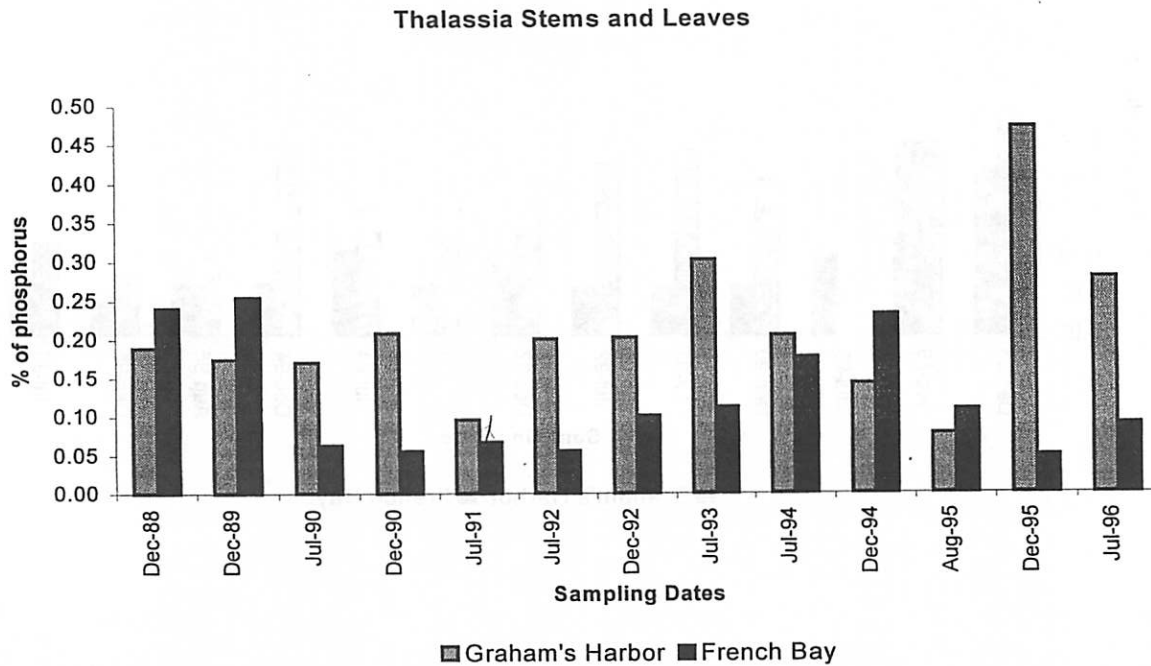


Figure 8. Comparison of % P in *Syringodium* root-rhizomes from Graham's Harbor and French Bay.

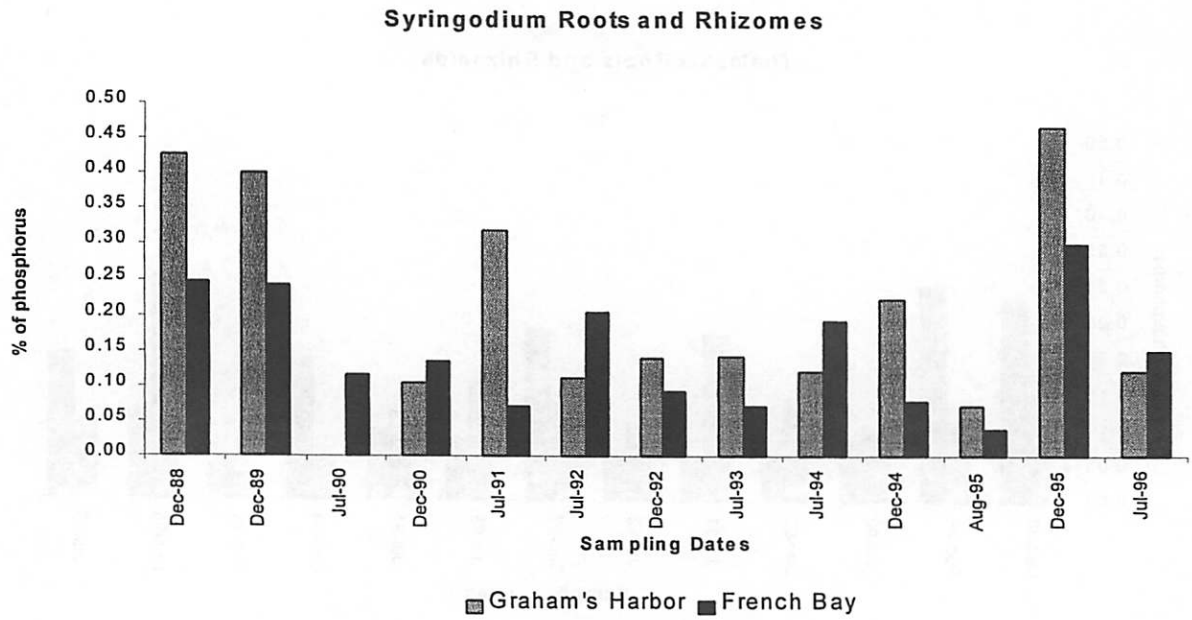
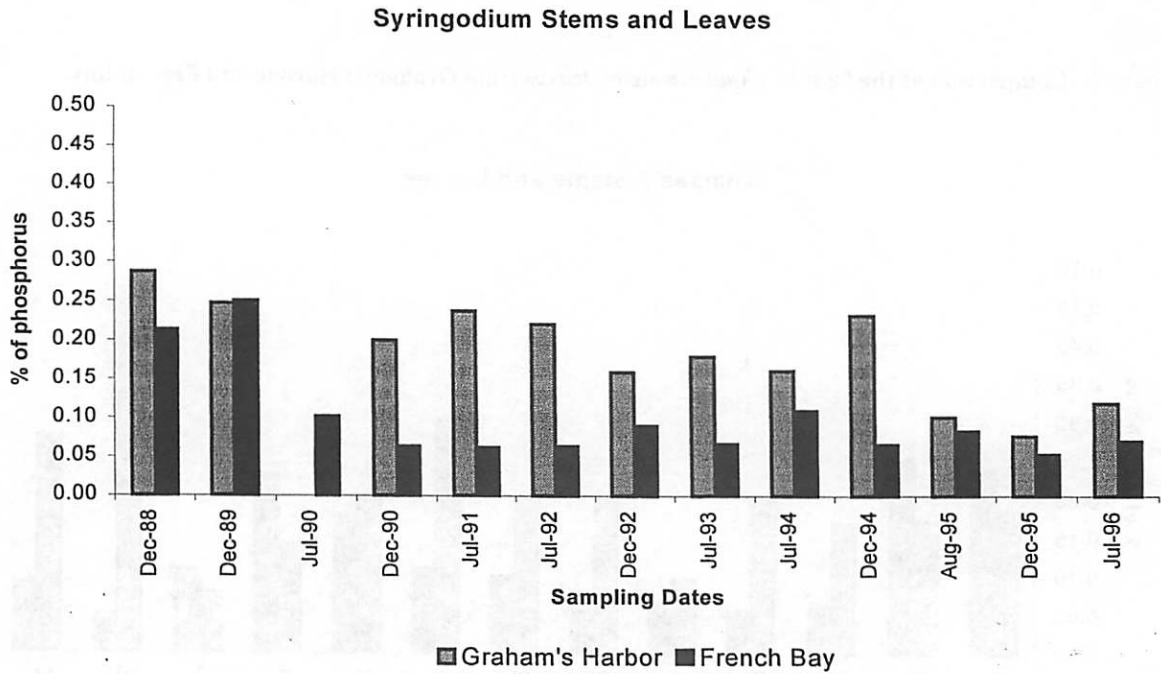


Figure 9. Comparison of % P in *Syringodium* stem-leaves from Graham's Harbor and French Bay.



ACKNOWLEDGEMENTS

This work was supported, in part, by the Bahamian Field Station and a grant from the Center for Field Research. We thank the administration and staff of the BFS and Drs. W. H. Ornes and B. Premo-Hopkins for support during this study.

LITERATURE CITED

- Fonseca, M.S., 1989. Sediment stabilization by *Halophila decipiens*. Estuarine, Coastal and Shelf Science 29: 501-507.
- Fonseca, M.S. and J.S. Fisher, 1986. A comparison of canopy friction and sediment movement between four species of seagrasses with reference to their ecology and restoration. Mar. Ecol. Prog. Ser. 29: 15-22.
- Gerace, D.T., G.K. Ostrander and G.W. Smith. 1997. San Salvador, Bahamas. In: *Caribbean Coastal Marine Productivity (CARICOMP): Coral Reef, Seagrass, and Mangrove Site Characteristics*. (ed. B. Kjerfve), 15pp., UNESCO, Paris, France. In press.
- Kaplan, D.I., F.T. Short and G.W. Smith. 1990. Chemical interactions between seagrasses and carbonate sediments. Proc. Sym. Bot. Bahamas 3: 41-45.
- Kenworthy, W.J., C.A. Currin, M.S. Fonseca and G.W. Smith. 1989. Production, decomposition and heterotrophic utilization of the seagrass *Halophila decipiens* in a submarine canyon. Mar. Ecol. Prog. Ser. 71: 297-299.
- Lewis, S.M., 1986. The role of herbivorous fishes in the organization of a Caribbean reef community. Ecol. Monogr. 56: 183-200.
- Morgan, T. and G.W. Smith. 1992. Deamination and glucose repression of seagrass rhizoplane isolates. Proc. Sym. Nat. Hist. Bahamas 4: 91-94.
- Ogden, J.C., 1996. Some aspects of herbivore-plant relationships on Caribbean reefs and seagrass beds. Aquatic Botany 2: 103-116.
- Short, F.T. *et al.* 1985. Evidence for phosphorus limitation in carbonate sediments of the seagrass *Syringodium filiforme*. Estuar. Coast. Shelf Sci. 20: 419-430.
- Short, F.T. *et al.* 1990. Phosphorus-limited growth of the tropical seagrass *Syringodium filiforme* in carbonate sediments. Mar. Ecol. Prog. Ser. 62: 169-174.
- Smith, G.W., 1987. Microbial contributions to the growth and degradation of tropical seagrasses. Proc. Symp. Bot. Bahamas 2: 45-53.
- Smith, G.W. 1996. The *Klebsiella-Halodule* symbiosis: Distribution and physiology of the endophyte. Proc. Symp. Nat. Hist. Bahamas 6: 4-8.
- Smith, G.W., S.S. Hayasaka and G.W. Thayer. 1984. Ammonification of amino acids in the rhizosphere of *Zostera marina* and *Halodule wrightii*. Bot. Mar. 27: 23-27.
- Smith, G.W., Hayasaka, S.S. 1982. Nitrogenase activity of bacteria associated with *Halodule wrightii* roots. Appl. Environ. Microbiol. 43: 1244-1248.
- Smith, G.W., T. B. Smith, B.M. Greenwood and D.T. Gerace. 1995. Seagrass standing stock, biomass and species distribution: A six year study. Assoc. Mar. Lab. Carib. Meet. 26: 285-269.
- Strickland, J.D.H. and T.R. Parsons. 1972. A practical handbook of seawater analysis. J. Fish. Res. Board Can. Bull. 167.
- Thayer, G.W., Kenworthy, W.J., Fonseca, M.S. 1984. The ecology of eelgrass meadows of the Atlantic coast: a community profile. U.S. Fish. Wildl. Serv., FWS/OBS-84/102.
- Wehner, K.A. and G.W. Smith. 1994. Mechanisms for phosphate cycling in seagrass beds. Proc. Symp. Nat. Hist. Bahamas 5: 94-101.
- Wong, W.P. and G.W. Smith. 1994. Sulphate-reducing bacteria associated with the rhizosphere of tropical seagrasses. Proc. Symp. Nat. Hist. Bahamas. 5: 103-106.
- Zieman, J.C. 1982. The ecology of the seagrasses of South Florida: a community profile. U.S. Fish. Wildl. Serv., FWS/OBS- 82/124.

Zieman, J., P. Penchaszadeh, J.R. Ramirez, D. Perez, D. Bone, J. Herrera-Silveira, R.D. Sanchez-Arguelles, D. Zuniza, B. Martinez, K. Bonair, P. Alcoládo, R. Laydoo, J. R. Garcia, J. Garzon-Ferreira, G. Diaz. P. Gayle, D.T. Gerace, G. Smith, H. Oxenford, C. Parker, L.P.J.J. Pors, J.A. Nagelkerken, B. Van Tussenbroek, S.R. Smith, R. Varela, K. Koltes and J. Tschirky. Variation in ecological parameters of *Thalassia testudinum* across the CARICOMP Network. Proc. 8th Int. Coral Reef Symp., 1:663-668. 1997.