taken in the random selection of individual fish growth trajectories. The full range of observed sizes at age must be included and no bias should occur due to a poor random number generator (Press et al., 1989). Any biases present in the random selection of the individual growth parameters will be directly reflected in simulations using the growth transfer matrix created from these trajectories.

The approach presented here is not without limitations. For example, it cannot incorporate genetic inheritance of growth rate in the simulations because the simulated population is followed as a group, not as individual fish. Although individual fish growth trajectories are used to create the growth transfer matrix, the growth rates for any age-size bin are independent of how the fish arrived in that bin. The method implicitly assumes that growth rates are density-independent.

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Address: *University of Miami, Rosenstiel School of Marine and Atmospheric Science, Division of Marine Biology and Fisheries, 4600 Rickenbacker Causeway, Miami, Florida 33149. E-mail: clegault@rsmas.miami.edu.*

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DISTRIBUTION OF SEAGRASSES IN THE YUCATAN PENINSULA, MEXICO

Julio Espinoza-Avalos

The distribution of seagrasses around the Yucatán peninsula is poorly known even though it lies between the southern Gulf of Mexico and the northern Caribbean Sea (Fig. 1). *Thalassia testudinum* Banks ex König was mentioned in a review by Phillips (1992), and this species occurs in many shallow sandy areas of the Mexican Caribbean (Lot et al., 1986; Jordán-Dahlgren, 1993). The occurrence of *Halodule wrightii* Ascherson has only been mentioned by Reyes and

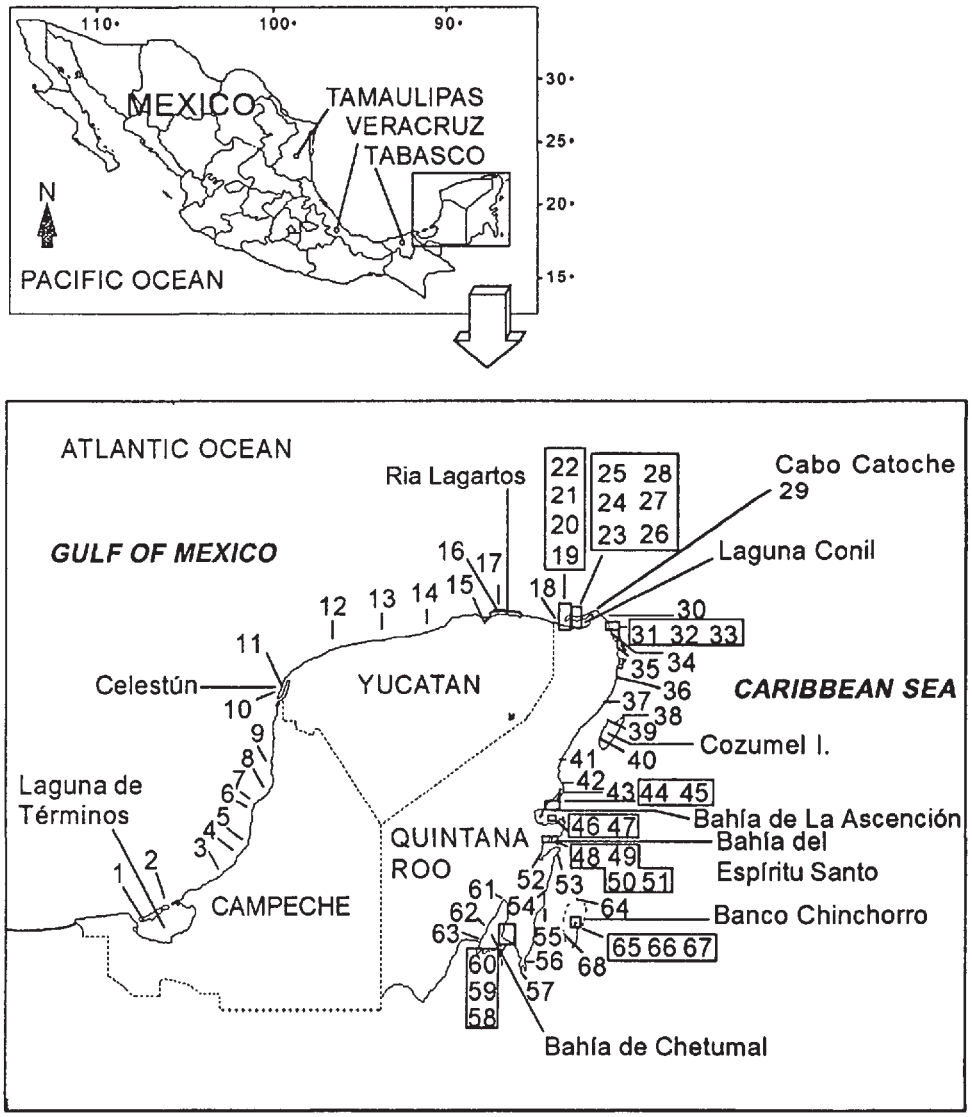

Figure 1. Yucatán peninsula, in Southeast Mexico, showing 68 sites where seagrasses were found in this study. 1. Cayo, 2. Puerto Real, 3. Chenkan, 4. Pozas de mareas (Champotón-Chenkan), 5. Champotón, 6. Punta Morro, 7. Playa Bonita, 8. Ria San Francisco, muelle, 9. Tenabo, 10. Celestún, oceanic, 11. Celestún, estuarine, 12. Progreso, 13. Telchac Puerto, 14. Dzilám de Bravo, 15. San Felipe, 16. Las Coloradas, oceanic, 17. Las Coloradas, hypersaline; 18. Yalahaú, 19. Bajo de Gamboa, 20. Punta Sirinjote, 21. Isla Pajaros, 22. Chiquilá, 23. Punta Mosquito, 24. Punta Siquil, 25. Punta Chen, 26. Punta Chuchú, 27. Caleta de Sinaí, and 28. Bajo Media Luna, inside and outside Laguna Conil, 29. Cabo Catoche, 30. Boca Iglesias, 31. Cayo Angostura, 32. Bahía Chacmochuc, boca, 33. Isla Blanca, 34. Bahía Chacmochuc, fondo, 35. Punta Sam, 36. Punta Caracol, 37. Punta Maroma; 38. Punta Molas, 39. Playa San Juan, and 40. Playa de San Francisco, Cozumel Island, 41. Tulúm, 42. Xamach, 43. Xoquem; 44. Vigia Chico, 45. Cayo Culebras, 46. Tres Marias, 47. Cayo Cedro, 48. Mimiss, 49. Punta Nilut, 50. La Victoria, 51. Candelaria de Chal, and 52. Manantial, Bahía del Espíritu Santo; 53. La Sardina, 54. Uvero, 55. Rio Indio, 56. Xcalac; 57. Bacalar Chico, 58. Ensenada Mainada, 59. Punta Calentura, 60. Isla Dos Hermanos, 61. Rio Creek, 62. Calderitas, and 63. Chetumal-descargas, Bahía de Chetumal; 64. Cayo Norte, 65. Cayo Centro, noreste, 66. Cayo Centro, suroeste, 67. Agua Verde, and 68. Cordillera, Banco Chinchorro.

Merino (1991) for Quintana Roo, the Mexican Caribbean State, despite the fact that it is widely distributed around the peninsula.

Because of the limited studies, marine phanerogams of the Yucatán peninsula are only known from few places (Ibarra-Obando and Ríos, 1993), such as *Halophila engelmannii* Ascherson, collected from one coastal lagoon of the peninsula, while *H. decipiens* Ostenfeld had not been reported.

This study presents the distribution of seagrasses in the Yucatán peninsula. Additionally, the presence of seagrasses reported by other authors for the rest of the Mexican East coast is given.

Study Area and Methods

Three Mexican states cover the Yucatán peninsula in southeast Mexico: Campeche and Yucatán, on the Gulf of Mexico, and Quintana Roo, on the Caribbean Sea. The northern part of Quintana Roo faces the Gulf of Mexico and Cabo (cape) Catoche geographically divides the Gulf of Mexico and the Caribbean Sea (Fig. 1). There are approximately 1,800 km of coastline on the Yucatán peninsula including the islands (Alvarez, 1977).

Field sampling was acomplished in 68 sites, from September 1991 to August 1995. Marine phanerogams were collected twice in Laguna Conil area (numbers 18 to 28 in Fig. 1), but single collections were obtained for the other 57 sites. Seagrasses were sampled by diving, usually from less than 4 m in depth. Collections were preserved with 4% formalin in seawater. Salinity was occasionally measured with a hand-held refractometer ATAGO® S/Mill. Dry specimens were deposited in the herbarium of El Colegio de la Frontera Sur, subsede Quintana Roo (=CIQR).

The 68 study sites (see Fig. 1 for numerical arrangement) include 9 on the coast of Campeche, 8 on the coast of Yucatán and 51 on the coast of Quintana Roo.

Results and Discussion

Thalassia testudinum, Halodule wrightii, and *Syringodium filiforme* were the main seagrasses found in the Yucatán peninsula (Fig. 2), similar to that reported for the West coast of Florida (Zieman and Zieman, 1989) and the Caribbean Sea (Dawes et al., 1991). *T. testudinum* dominated in Quintana Roo (especially in coral reef lagoons) and Campeche, but not in Yucatán coastal waters (Fig. 2). The reason for the diminished dominance of *T. testudinum* in Yucatán is not clear, perhaps the influence of cold upwelled waters in northern Yucatán peninsula (Lanza-Espino, 1991) may be a factor.

Halodule wrightii was the only species of *Halodule* found in the Yucatán peninsula because *H. beaudettei* (den Hartog) den Hartog (Hartog, 1964) could not be identified due to the variability in tip leaf morphology (Phillips et al., 1974; Phillips and Meñez, 1988). *H. wrightii* was found mixed with other seagrasses but also occurred in monospecific stands, mainly in waters less than 1 m in depth. Large populations of *H. wrightii* were found in salinities of 57‰ in Las Coloradas, Ria Lagartos, Yucatán (16 in Fig. 1), demonstrating its tolerance to high salinities (Zieman and Zieman, 1989).

Syringodium filiforme Kützing was located throughout the Mexican Caribbean coast (Fig. 2) where strong currents (4 Knots $\approx$ 2 m s^{-1}) of oceanic water move along the Yucatán Strait (Merino-Ibarra, 1992). *S. filiforme* was rarely collected inside coastal lagoons (Fig. 2).

Halophila engelmannii was found in small patches for the first time on the coasts of Yucatán and Quintana Roo (Fig. 2). The species appears to be seasonal in the Yucatán peninsula since specimens in Laguna Conil were collected in July 1993 but not in April 1992. The species has also been reported at Tamaulipas, Veracruz and Campeche, Mexico (Thom, 1969, in Hornelas-Orozco, 1975; Lot et al., 1986; Lot Helgueras, 1991; Martínez and Novelo, 1993), Belize (Tsuda and Dawes, 1974), and the northern (Buesa, 1975) and southern (Jiménez-Domínguez,

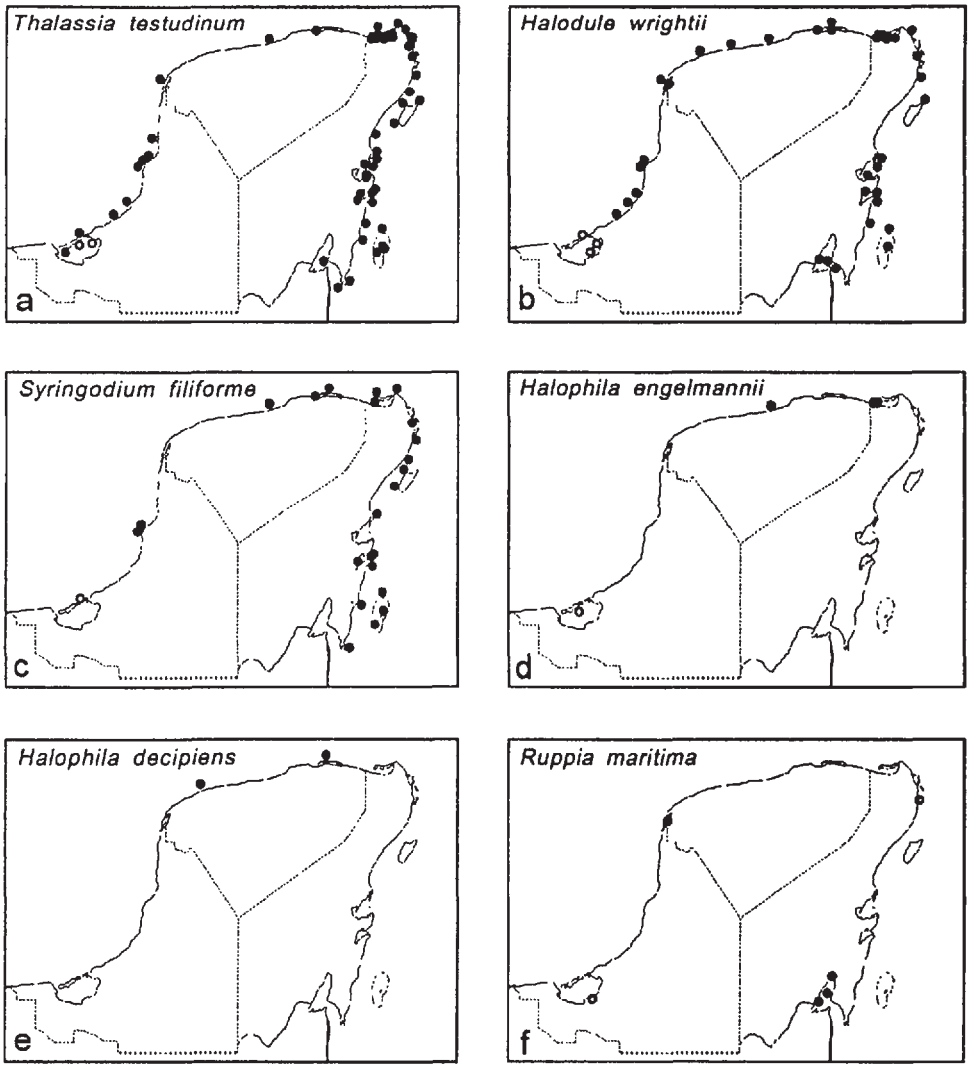

Figure 2. Distribution of the seagrasses *Thalassia testudinum* (Fig. 2a), *Halodule wrightii* (Fig. 2b), *Syringodium filiforme* (Fig. 2c), *Halophila engelmannii* (Fig. 2d), and *Halophila decipiens* (Fig. 2e), in the Yucatán peninsula, Mexico. The distribution of the euryhaline phanerogam *Ruppia maritima* is also provided (Fig. 2f). Open circles indicate places with seagrasses, obtained from published data (Thom, 1969, in Hornelas-Orozco, 1975; Jordán et al., 1978; Yañez-Arancibia et al., 1983; Moore and Wetzel, 1988).

1990) coasts of Cuba. It appears that is endemic to the northern part of the Tropical Western Atlantic region (0°N—28°N; Alvarez et al., 1988).

Collections of *Halophila decipiens,* the only pantropic seagrass species (Phillips and Meñez, 1988), came from open waters of Progreso and Las Coloradas, Yucatán (sites 12 and 17 in Fig. 1) where it was present in small patches, on sandy bottoms of 4–6 m in depth. This species has been previously reported for Mexican waters only from Veracruz (Lot et al., 1986; Lot-Helgueras, 1991).

Ruppia maritima Linneaus, an euryhaline phanerogam, was found growing with other seagrasses, mainly *Halodule wrightii,* in Laguna de Términos (Yañez-

Arancibia et al., 1983), Laguna de Nichupté (Jordán et al., 1978), and Celestún and Bahía de Chetumal (Fig. 2), four coastal lagoons with fresh water inputs.

In summary, a) All six species of seagrasses reported for the Caribbean Sea occur in the Yucatán peninsula; b) The primary side of seagrass distribution in the peninsula is the Caribbean side; c) The distribution of *Halophila* spp. is very limited. Further studies are needed to determine if flowering and seed set occurs.

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ADDRESS: *ECOSUR, Apartado postal 424, Chetumal, Quintana Roo 77000, México.*

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METHANOL-INDUCED PHYSIOLOGICAL CHANGES IN MANGROVES

K. Kathiresan, P. Moorthy and N. Rajendran

Mangroves are a diverse group of tropical trees and shrubs growing in the marine intertidal zone (Duke, 1992). The mangroves which serve as primary producers in the coastal marine environment, often exhibit poor growth and photosynthetic activities (Kathiresan and Thangam, 1990; Kathiresan and Moorthy, 1993). To overcome this, several chemical treatments have been attempted (Kathiresan and Thangam, 1990; Kathiresan et al., 1990; Kathiresan and Moorthy, 1994a, 1994b; Smith et al., 1995). Among the chemicals, triacontanol—a long chain aliphatic alcohol, has been found promising in enhancing growth and photosynthesis in *Rhizophora apiculata* Blume (Moorthy and Kathiresan, 1993; Kathiresan and Moorthy, 1994a). The use of a short chain alcohol, methanol, was never attempted to improve mangrove growth, although it has already been successfully demonstrated in many non-mangrove species (Nonomura and Benson, 1992). This study has been undertaken to evaluate the effect of methanol on the physiological responses of four mangrove species belonging to the family-Rhizophoraceae *viz., Rhizophora apiculata* Blume, *R. mucronata* Lam., *Bruguiera cylindrica* (L.) Blume and *Ceriops decandra* (Griff.) Ding Hou.

METHODS

Propagules were collected from Pichavaram mangroves (lat. 11°27′N; long. 79°47′E) on the southeast coast of India, Tamil Nadu, during September 1993. The propagules were placed for 24 h in Arnon-Hoagland nutrient medium supplemented with methanol at 0.001, 0.01, 0.1, 1 and 10% V/V. A control was kept without methanol. For each species, optimum salinity was maintained throughout the study period at 15‰ of salinity for *Rhizophora* sp. (Kathiresan and Thangam, 1990) and at 8‰ for *C. decandra* and *B. cylindrica.* Nutrient media were replenished once every 4 days. Plants were grown at 27 ± 2°C with a light intensity of 330 $\mu mol \cdot m^{-2} \cdot s^{-1}$, for 60 days for *Rhizophora* sp., 45 days for the other two species and were analysed for growth. Measurements included : number and length of roots, shoot height, number of leaves, leaf area (calculated by leaf area meter model Li-Cor 3100, USA) and dry matter production (measured by drying the tissue in an oven at 80°C for 48 h). Photorespiration was measured in the four species of mangroves by means of the determination of the compensation concentration of CO_2 as described by Treguna et al. (1961) and subsequently modified by Goldsworthy and Day (1970). The procedure involved floating leaf discs on water in Petri dishes which were enclosed in large transparent CO_2 impermeable mylar bags which had been previously flushed with nitrogen and exposed to saturating light for 1 h. After this, CO_2 accumulated inside the bag was expelled manually by pressing the air through the measuring cuvette of an infrared gas analyser, the maximum defelections obtained were recorded.

Rhizophora mucronata was analysed further in 60-day-old hydroponic-cultures, for chlorophylls (Arnon, 1949) and their fractions present in reaction centers of photosystems I and II and in light harvesting complex (Krivosheeva et al., 1991), carotenoids (Ridley, 1977) and photosynthetic characteristics of leaves (using Li-Cor portable photosynthesis system, USA). Three replicates of 10 propagules each were analysed from each treatment and the data are presented as mean ±SD. Different treatments were statistically analyzed and the least significant difference (LSD) values are expressed.