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SEAGRASSES

Synonyms

Definition

Seagrasses. Monocotyledon flowering plants adapted to marine environments.
Seagrass bed or meadows. Marine communities comprised of seagrass species that provide habitat for many other organisms.

Introduction

Seagrasses are the only botanical species whose ancestors recolonized the sea. This unusual group of vascular plants is generally defined as a diverse assemblage of angiosperm, monocotyledon plants found in brackish or more usually in marine waters of relatively shallow tropical and temperate regions of the world. These submerged, flowering organisms complete their entire life cycle underwater producing oxygen as they photosynthesize radiant energy. Seagrasses are normally rooted in thick, often vast, productive beds or meadows. As salt water plants, they influence the physical, chemical and geological processes affecting coastal environments in which they live by filtering waters and dissipating wave energy. Seagrasses also anchor sediments and thus provide protection from erosion. In addition, they provide habitats and food resources for many invertebrates, fish and avian species, as well as a few reptiles and mammals including some endangered marine species. Unfortunately, today many seagrass beds have been severely degraded due to a variety of human activities. Protection of these communities is essential for the preservation of many marine species.

Seagrass biology

Seagrass species have apparently evolved from dissimilar groups of freshwater plants; indeed, some seagrass species are closer in their evolutionary relationship to certain freshwater plants than they are to other seagrasses (Waycott *et al.* 2006). Although some water plant species can be found in marine habitats with low to moderate salinity, the assemblage of plant species defined as seagrasses only occur in oceanic water bodies with high salinity. These species do not require contact with the atmosphere, and their sexual reproductive cycle, including flowering and pollination, is completed under water. Particular adaptations of seagrasses to a life submerged in saltwater include an efficient ability to incorporate inorganic carbon from ocean water. They are able to obtain nutrients required for growth in some case by direct uptake through their roots (similar to the process used by terrestrial plants), or, in many situations, through their leaves from the water column itself. However, because sea floor sediment is typically deficient or devoid of oxygen, the underground parts of seagrass plants commonly obtain oxygen via their leaves by way of a system of air-filled channels that develop within their living tissue. Another important adaptation common to most seagrasses is their supple strap-like leaves (den Hartog

1970) which allows these plants to flourish in aquatic environments that are heavily affected by the flows of tides and waves. Among seagrasses, pollen dispersal to female flowers, typically aided by wind or insects in land plants, occurs via water currents (Borum *et al.* 2004).

Seagrass research

Early research involving seagrasses focused on taxonomic comparisons of their superficial morphology with that of other plant groups and only relatively little attention was directed toward other botanical or human use aspects of these plants. The study of additional scientific and resource management aspects of seagrasses accelerated in the second half of the 20th century; one publication in the late 1970s (Bridges *et al.* 1978) cited more than 1400 references from sources worldwide, and many, more recent studies of seagrasses have been undertaken during the past few decades (e.g., see Green and Short 2003; Borum *et al.* 2004, Larkan *et al.* 2006; Heck *et al.* 2008).

Seagrass taxonomy

Seagrasses are not true species of grass which all belong to the family Poaceae. In fact, seagrasses as a whole are best referred to as an ecological group rather than a taxonomic group. There is still no officially recognized classification system that completely describes the recorded genera of “true seagrasses.” This situation can be explained by the polyphyletic nature of seagrasses, as well as the lengthy debate over placement of the individual genera into respective families and the lack of an accepted scientific definition of “seagrass.” Although the quantity and biological classification of seagrass species is still disputed, it has generally been assumed that there are approximately 50-60 species of these marine flowering plants (Duarte 2008, Hogarth 2007; Hughes *et al.* 2009), belonging to 12 genera in four families. These include species in the following genera and families: *Posidonia* in the family Posidoniaceae; *Zostera, Heterozostera* and *Phyllospadix* in the family Zosteraeae; *Enhalus, Halophila* and *Thalassia* in the family Hydrocharitaceae; and *Amphibolis, Cymodocea, Halodule, Syringodium and Thalassodendron* in the family Cymodoceaceae (according to Duarte 2008, over 50% of the seagrass species belong to *Halophila, Zostera* and *Posidonia*; see Kuo and den Hartog 2001 for short descriptions of all seagrass species recorded as of 2006). Other, recent phylogenetic research suggests that seagrass species can be further divided into six families: Cymodoceaceae, Hydrocharitaceae, Posidoniaceae, Ruppiaceae, Zannichelliaceae, and Zosteraeae (Waycott *et al.* 2006). However, even this taxonomic perspective is debatable since species belonging to the genera of *Ruppia* and *Zanichella* are able to complete their life cycles beyond marine waters (Larkum *et al.* 2006). Furthermore, some recent authors continue to refer to Potamogetonaceae as one of the seagrass families (e.g., Allen 2003; Hogarth 2007; Duarte 2008).

Seagrass biogeography

Seagrass species vary in the size of their leaves from more than 4 m long, as occurs in the strap-like blades of *Zostera caulescens* (“eelgrass”) in the Sea of Japan, to only 2-3 cm in the rounded blades of *Halophila decipiens* (“sea vine”) in relatively deep tropical marine areas adjacent to Brazil. Seagrasses of one or sometimes multiple species often form extensive beds or meadows over shallow, unconsolidated sediments on all continental shelves except those of Antarctica, as well as on inshore environments of many oceanic islands of the world. For example, huge underwater seagrass beds occur along sections of the coasts of Australia, Alaska, southern Europe, India, east Africa, the islands of the Caribbean and other places around the globe. The maximum water depth in which these salt water plants are known to occur is ~90 m (Duarte 1991). They can be found in both temperate and tropical marine environments, frequently growing near to and associated environmentally with coral reefs, mangroves, salt marshes, bivalve reefs and other saline aquatic habitats. Seagrass beds can be either monospecific, comprised of only a single species, such as *Zostera marina* in parts of the North Atlantic, or they can be multispecific, where various species co-exist, such as in tropical marine environments like the Philippines where up to 13 species are known to occur. The highest diversity of seagrasses in the world exists in Australia, which harbors over half of the world's species and contains the most widespread seagrass beds found anywhere (Butler and Jernakoff 1999). New records of seagrasses are still being established, and in at least one case these records have expanded the known biogeographical distribution of some species. For example, until recently, the only seagrass species recorded in the Hawaiian Islands was the endemic *Halophila hawaiiana* (Doty and Stone 1966); however we now know that a close relative, the very widespread seagrass species, *Halophila decipiens* also occurs in the Hawaiian Islands, where it was first recorded from Midway Atoll, and is now known from at least three locations spanning the archipelago (McDermid *et al.* 2002).

The geomorphological role of seagrasses

Seagrasses play a role in helping create their own habitat, and thus they have been referred to as "ecosystem engineers" (Wright and Jones 2006; Coleman and Williams 2002). For example, their leaves reduce the speed of ocean currents which enhances sedimentary processes, and the roots and rhizome of seagrasses aid in the stabilization of the seabed; they literally hold or bond reefs together. In addition, seagrass beds improve water quality by stabilizing loose sediment and filtering some pollutants out of the water column. If seagrass beds were not in place, widespread marine areas in the world would have environments with unstable, shifting sand and mud. A recent modeling study by the United Nations Environmental Program, based on data collected from the effects of the huge 2004 Indian Ocean Tsunami, suggests that seagrasses provide the significant beneficial effect of absorbing wave energy and can thus reduce physical and biological damage from such a potentially devastating natural hazard (Chatenoux and Peduzzi 2005).

The ecological roles of seagrasses

Seagrasses provide a large number of vital ecological services to the marine habitats in which they are "foundation species" (e.g., Costanza *et al.* 1997; Hemminga and Duarte 2000; Conservation International 2008). Their significance for associated species is based primarily on the protective cover they provide by means of their three-dimensional configuration in the water column, as well as their extremely high rate of primary production (e.g., Virnstein 1982; Phillips 1992; Heck *et al.* 2008). Consequently, seagrasses supply inshore habitat with many ecosystem goods and services, such as nurseries for finfish, shellfish and crustaceans, protection of biota from wave damage, production of oxygen and shelter against coastal erosion. Generally, seagrass beds can be characterized as among the most productive natural communities in the world serving as major suppliers to the marine food web. Thousands of plants, animals and other organisms live among the seagrasses in a multifaceted and delicate ecological environment. For example, sea turtles, sea cows (dugong and manatees) graze upon seagrass species, and numerous kinds of worms, snails, shrimps, crabs and small fish live their whole lives within seagrass beds. In addition, many marine fish important to fishermen depend upon seagrass communities during some periods of their lives, and bigger fish and seabirds also come to these beds to eat the smaller animals. Although the role of seagrass (as well as mangrove) habitats as nurseries for coral reef fish species has long been debated, a study of the use of seagrass habitats by juvenile coral reef fish using visual census surveys at four islands along the East African coast of Tanzania, and at the island of Grande Comoros in the Comoros archipelago, indicates that areas with seagrass beds had a positive influence on the adult concentration of several reef fish species on adjoining coral reefs (Dorenbosch *et al.* 2005:63).

Conservation issues affecting seagrasses

Seagrass beds can extend into deep waters, and those that still cover large areas today are typical of marine coastal environments that have not suffered from significant human impact. Because of the amount of light that seagrasses require, the depths in which they can survive are limited by water clarity, and because these marine plant species are generally perennial organisms, they develop over time into integrated, often highly diverse biological communities. Therefore, seagrasses are prime indicators of the degree of anthropogenic disturbance in marine habitats, and thus they are useful for periodic ecological observation and the implementation of effective management policies. Even though a number of scientists and some concerned citizens recognize that healthy seagrass beds are of great value both ecologically and economically, a large number of their habitats in many regions of the world have been totally ruined or are being degraded rapidly by a multitude of human activities in the form of nutrient loading, siltation and mechanical disturbance (e.g., Short 1987; Shepard *et al.* 1989; Short and Wyllie-Escheverria 1996; Cardoso *et al.* 2004; Orth *et al.* 2006). Runoff of nutrients and sediments resulting from human activities on land are most likely the main overall threat to the existence and health of seagrass beds worldwide. Because of the relatively high light requirements of seagrass species they are quite susceptible to the effects of nutrient and sediment loading on water clarity. Seagrass beds are also damaged directly by inappropriate boating activities, dredge-and-fill activities and harmful commercial fishing practices. For example, the seagrass beds of Florida's coastal areas were reduced in aerial extent by about 60%, from approximately 5 million acres to 2 million acres during the second half of the 20th century, mainly dredge-and-fill projects and reduced water quality (Florida Fish and Wildlife Conservation Commission 2007). Global climate change that can result in rising sea level and the production of more frequent severe storms could and may already be having impact on the range and vigor of seagrasses (Short and Neckles 1999). Furthermore, seagrasses are the main food or are associated in other ways with a number of threatened and endangered species (e.g., see Hughes *et al.* 2009; Preen and Marsh 1995); these include species such as the Green sea turtle (*Chelonia mydas*), fan mussel (*Pinna nobilis*), dwarf seahorse (*Hippocampus zosterae*) and dugong (*Dugong dugon*). Indeed, green sea turtles as well as dugongs and manatees (*Trichechus* spp.) are recognized as appealing species of significant public interest, and thus the reduction and degradation of their necessary seagrass environment is a tragedy for these and many other species. Unfortunately, seagrasses worldwide are generally receiving modest protection even though there are numerous pressures on their various coastal habitats (Green and Short 2003). Scientists agree that there is a strong need for competent monitoring and management strategies for many, if not most seagrass species and their homes on coral reefs and other environments (e.g., see Duarte 2002; Green and Short 2003; Borum *et al.* 2004; Hughes *et al.* 2009). Furthermore, a significant increase in public awareness through communication and education regarding the important ecological and economic roles of seagrass communities is strongly needed to enlighten and stimulate effective management of these crucial coastal seagrass beds and the species that inhabit them (Duarte *et al.* 2008).

Summary

Seagrasses are unusual, important and under appreciated species that inhabit coral reefs and many other marine habitats. Extensive, naturally occurring seagrass beds or meadows provide key ecological and economic resources for many coastal ecosystems worldwide. Even though there are still widespread seagrass beds on all of the world's continents except Antarctica, seagrass beds and the species they harbor have been reduced in size or completely destroyed in many areas. Human population continues to expand and become increasingly urbanized with more and more people residing disproportionately in the world's coastal regions. Consequently, an increase in scientific study, effective resource management and a major rise in public awareness of the environmental importance of seagrasses as coastal resources and vital habitats are more important than ever.

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Bibliography

Allen, G. 2001. Marine Life of the Pacific and Indian Oceans. Singapore: Periplus Editions

Bridges, K. W., Zieman, J. C., and McRoy, C. P. 1978. Seagrass literature survey. Final Report, Vicksburg, Miss., US Army Engineer Waterways Experiment Station. 174pp.

Butler, A and Jernakoff, P. 1999. Seagrass in Australia: Strategic Review and Development of an R & R Plan. Collingwood Victoria: CSIRO.

Borum, J., Duarte, C. M., Krause-Jensen, D. and Greve, T. M. 2004. European seagrasses: an introduction to monitoring and management. Hillerød: The M&MS project. ISBN: 87-89143-21-3.

Cardoso, P. G., Pardal, M. A., Lillebo, A. I., Ferreira, S. M., Raffaelli, D. and Marques, J. C. 2004. Dynamic changes in seagrass assemblages under eutrophication and implications for recovery. Journal of Experimental Marine Biology and Ecology 302: 233-248.

Chatenoux, B. and Peduzzi, P. 2005. Analysis on the Role of Bathymetry and other Environmental Parameters in the Impacts from the 2004 Indian Ocean Tsunami. Geneva: UNEP/GRID-Europe.

Coleman, F. C. and Williams, S. L. 2002. Overexploiting marine ecosystem engineers: potential consequences for biodiversity. Trends in Ecology and Evolution 17: 40–44.

Conservation International. 2008. Economic Values of Coral Reefs, Mangroves, and Seagrasses: A Global Compilation. Center for Applied Biodiversity Science, Conservation International, Arlington, VA, USA.
http://www.icriforum.org/library/Economic_values_global%20compilation.pdf

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Naeem, S., Limburg, K., Paruelo, J, O'Neill, J. V., Raskin, R., Sutton, P and van den Belt, M. 1997. The value of the world's ecosystem services and natural capital. Nature 387(1997): 253–260.

Dorenbosch, M. Grol, M. G. G., Christianen, M. J. A., Nagelkerken, I. and van der Velde, G. 2005. Indo-Pacific seagrass beds and mangroves contribute to fish density and diversity on adjacent coral reefs. Marine Ecology Progress Series 302: 63–76.

Doty, M. S. and Stone, B. C. 1966. Two new species of *Halophila* (Hydrocharitaceae). Brittonia 18: 303–306.

Duarte, C. M. 1991. Seagrass depth limits. Aquatic Botany 40: 363-373.

Duarte, C.M., 2002. The future of seagrass meadows. Environmental Conservation 29: 192-206.

Duarte, C. (Lead Author); Gattuso, J-P. (Topic Editor). 2008. Seagrass meadows. In Cutler J. and Cleveland (Eds.) Encyclopedia of Earth. C. Washington, D.C.: Environmental Information Coalition, National Council for Science and the Environment). [First published in the Encyclopedia of Earth December 11, 2006; Last revised September 21, 2008; Retrieved July 14, 2009]. http://www.eoearth.org/article/Seagrass_meadows

Duarte, C. M., Dennison, W. C., Orth, R. J. W., and Carruthers, T. J. B. 2008. The Charisma of Coastal Ecosystems: Addressing the Imbalance. Estuaries and Coasts 31(2): 233-238.

Florida Fish and Wildlife Conservation Commission. 2007. Florida's Seagrasses. Florida St. Petersburg, Fl.: Fish and Wildlife Research Institute.

Green, E. P. and Short, T. F. (Eds.) 2003. World Atlas of Seagrasses. Berkeley: University of California Press.

Heck Jr, K. L., Carruthers, T., Duarte, C., Hughes, A. R., Kendrick, G. Orth, R. and Williams, S. W. 2008. Trophic transfers from seagrass meadows subsidize diverse marine and terrestrial consumers. Ecosystems 11(7): 1198–1210.

Hemminga, M. A. and Duarte, C. M. 2000. Seagrass Ecology. Cambridge, U.K.: Cambridge University Press.

Hogarth, P. J. 2007 The biology of mangroves and seagrasses. Oxford: Oxford University Press. 2nd ed.

Hughes, A. R., Williams, S. L., Duarte, C. M. Heck Jr, K. L. and Waycott, M. 2009. Associations of concern: declining seagrasses and threatened dependent species. Frontiers in Ecology and the Environment 7(5): 242-246.

Kuo, J., and C. Den Hartog. 2001. Seagrass taxonomy and identification key. In: Short. F. T. and Coles, R. G. (Eds.) Global seagrass research methods. Amsterdam: Elsevier Science Publications, pp. 31-58.

Larkum, A.W.D., Orth, R. J. and Duarte, C. M. 2006. (eds). Seagrass Biology, Ecology and Conservation. Amsterdam: Springer.

McDermid, K. J. Gregoritza, M. C. and Freshwater, D. W. 2002. A new record of a second seagrass species from the Hawaiian archipelago: *Halophila decipiens* Ostenfeld. Aquatic Botany 74(3): 257-262.

Orth, R. J., Carruthers, T. J. B., Dennison, W. C., Duarte, C. M., Fourqurean, J. W., Kenworthy, W. J., Olyarnik, S. Short, F. T., Waycott, M. and Williams, S. L. 2006. A global crisis for seagrass ecosystems. BioScience 56(12): 987–96.

Phillips, R. C. 1992. The Seagrass Ecosystem and Resources in Latin America. In: Seeliger, U. (ed.) Coastal Plant Communities of Latin America. San Diego: Academic Press, pp. 107-21.

Preen, A. and Marsh, H. 1995. Response of Dugongs to Large-Scale Loss of Seagrass from Hervey Bay, Queensland, Australia. Wildlife Research 22: 507-519.

Shepherd, S.A., McComb, A.J., Bulthuis, D.A., Neverauskas, V., Steffensen, D.A., and West, R. 1989. Decline of seagrasses. In Larkum, A.W.D., McComb, A.J., and Shepherd, S.A. (eds.) Biology of seagrasses: a treatise on the biology of seagrasses with special reference to the Australian region. Amsterdam: Elsevier, pp. 346-93.

Short, F. T. 1987. Effects of sediment nutrients on seagrasses: literature review and mesocosm experiment. Aquatic Botany 27: 41-57.

Short, F. T. and Neckles, H. A. 1999. The effects of global change on seagrasses. Aquatic Botany 63: 169-196.

Short. F. T. and Wyllie-Escheverria, S. 1996. Natural and human-induced disturbance of seagrasses. Environmental Conservation 23: 17-27.

Virnstein, R. W. 1982. Leaf growth of the seagrass *Halodule wrightii* photographically measured in situ. Aquatic Botany 12: 209–218.

Waycott, M., Procaccini, G., Les, D.H., and Reusch, T.B.H. 2006. Seagrass Evolution, Ecology and Conservation: A Genetic Perspective. In (eds.) Larkum, A.W.D., Orth, R. J. and Duarte, C. M. (eds). Seagrass Biology, Ecology and Conservation, Chapter 2, pp. 25-50.

Wright, J. P. and Jones, C. G. 2006. The concept of organisms as ecosystem engineers ten years on: Progress, limitations, and challenges. BioScience 56: 203–209.