

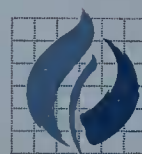
The global distribution and status of seagrass ecosystems

**Discussion paper prepared for the
UNEP-WCMC Global Seagrass Workshop**

St Pete's Beach, Florida, 9 November, 2001

Prepared by:


Mark D. Spalding, Michelle L. Taylor, Sergio Martins, Edmund P. Green, and Mary Edwards



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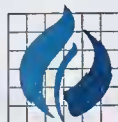
Mark Taylor and Corinna Ravilious

Table of Contents

Introduction to the workshop	2
The global distribution and status of seagrass ecosystems.....	3
Introduction.....	3
Definitions.....	3
The diversity of seagrasses.....	3
Species distribution.....	4
Associated Species.....	6
Productivity and biomass.....	7
The distribution and area of seagrass habitat.....	8
The value of seagrasses.....	13
Threats to seagrasses.....	13
Management Interventions.....	14
Bibliography:.....	16
Annex 1 : Seagrass Species Lists by Country.....	29
Annex 2 – Species distribution maps.....	34
Annex 3 – Seagrass distribution maps.....	68
Annex 4 – Full list of MPAs by country.....	74



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Introduction to the workshop

The Global Seagrass Workshop of 9 November 2001 has been set up with the expressed aim to develop a global synthesis on the distribution and status of seagrasses world-wide. Approximately 20 seagrass experts from 14 countries, representing all of the major seagrass regions of the world have been invited to share their knowledge and expertise. A list of the expected participants is provided below:

Name	Country	Name	Country
Bujang Sidik Japar	Malaysia	Kun-Seop Lee	Korea
Caroline Ochieng	Tanzania	Mark Spalding***	UK
Chatcharee Supanwanid	Thailand	Michelle Taylor***	UK
Diana Walker	Australia	Miguel D. Fortes	Philippines
Dr Jagtap Tanaji Gajanan	India	Nataliya Milchakova	Ukraine
Evamaria W. Koch	USA	Robert Coles	Australia
Frederick T. Short	USA	Ronald C. Phillips	USA
Gabriele Procacini*	Italy	Salomao Bandeira	Mozambique
Gilberto Cintron**	USA	Sandy Wyllie-Echeverria	USA
Hugh Kirkman	Thailand	Graeme Inglis	New Zealand
Joel Creed	Brazil	Sven Beer*	Israel
Keiko Aioi*	Japan		

* Providing input, but not attending

** Ramsar Convention representative

*** UNEP-WCMC representatives

Prior to the meeting each of the participants has prepared short summary documents describing the seagrasses resources in their region of expertise. In parallel with this work, staff at UNEP-WCMC have prepared a global assessment of seagrasses. All of these papers were circulated prior to the workshop. The structure of all of these documents has been broadly standardised, with the aim of focussing attention under the following headings:

1 – Species distribution and extent

Species lists by country, or specific sites,

Seagrass associates, notably commercially important species and threatened species,

Major seagrass areas and ecosystem types, in specific regions

Maps of distribution of seagrass ecosystems, or references of seagrass mapping works

Area estimates, for individual sites or countries

2 – Uses and threats

Indirect uses – coastal protection, fisheries, aquaculture etc. Pointers to specific studies.

Direct uses – any uses of seagrasses for food, fodder, handicrafts, medicinal products etc.

Threats – full list of threats, with locations and estimates of extent of impacts.

Estimates of area loss or degradation

3 – Seagrass management and restoration

Protected areas – lists of protected areas containing seagrass ecosystems

Other legal and policy measures

Restoration – case studies, including both successes and failures

4 – Bibliography and contacts

List of all seagrass references from each region

List of all agencies and individuals with an interest and working knowledge of seagrass ecosystems, including official government agencies, academic organisations, fisheries and NGOs.

This workshop has been kindly supported by the UK Department For International Development, the Ramsar Convention Secretariat, the Estuarine Research Federation and the Scientific Committee on Oceanic Research

The global distribution and status of seagrass ecosystems

Introduction

Seagrasses are a mixed group of flowering plants which grow submerged in shallow marine and estuarine environments world-wide. In many areas they form extensive ecosystems, often referred to as seagrass beds or seagrass meadows. They are considered to be one of the most important shallow-marine ecosystems to humans, being highly productive, and playing an important role in fisheries production as well as binding sediments and providing some protection from coastal erosion.

In this discussion paper we attempt to summarise distribution, importance and status of seagrasses world-wide. Firstly we consider in more detail the definition of seagrasses, both as species and as habitats, and look at the geographic patterns of biodiversity and habitat distribution. Next we consider their importance to humans. Finally we look at the human impacts on these ecosystems, including both threats, and the and management measures for the protection or restoration of seagrass beds.

Definitions

Seagrasses are flowering plants which grow fully submerged and rooted in estuarine and marine environments. They are not true grasses. Although they are all monocotyledons, they do not have a single evolutionary origin, but are a polyphyletic group, defined by the particular ecological niche they inhabit. Five particular adaptations to enable survival in this niche have been identified (Phillips and Meñez, 1988):

- 1 An adaptation to survive in high, and in some cases varying, salinity
- 2 An ability to grow whilst completely submerged, which presents problems, notably of lowered gas concentrations and rates of diffusion
- 3 The use of an anchoring system to withstand water movements
- 4 The development of submarine pollination strategies
- 5 An ability to compete with other species in the marine environment

These adaptations have led to a number of morphological characteristics which are widespread or ubiquitous amongst seagrasses, notably: flattened leaves (with the exception of *Syringodium*); strap-like leaves (with the exception of *Halophila*); and extensive system of roots and rhizomes (Phillips and Meñez, 1988).

Although arguments still remain over the details of nomenclature and taxonomic relations of particular species (Kuo and McComb, 1989) there is little or no controversy over which species are, or are not seagrasses, and Table 1 provides a list of the currently accepted species.

Point for discussion: is there indeed consensus on this list?

Taxonomy and nomenclature?

Diplantera, Potamogeton, Ruppia, Zostera?

Seagrass ecosystems are areas of estuarine or sea floor where seagrasses make up an important part of the biomass or play a key role in the ecosystem function. Typically these are areas dominated by soft substrates such as sand or mud, but some species can be found growing on more rocky substrates. In some cases seagrasses can be observed with a scattered distribution over otherwise bare substrate, or in small patches as part of a mosaic of rocky or coral habitats, and in these cases the delimitation of seagrass ecosystems becomes more subjective. They are only found in shallow waters because of the rapid attenuation of light with depth, but have been recorded to 70m in clear waters (Lipkin, 1979). Although typically permanent over periods of decades, seagrass systems can be highly opportunistic, and can form relatively transient communities in others.

The diversity of seagrasses

Using the definition provided there are 60 species from four families which are widely accepted as true seagrasses. A small group of species from the family Potamogetonaceae (notably species from the genera *Ruppia* and *Potamogeton*) are also included as seagrasses by some experts, but are not considered further in this report.

Table 1: A list of generally accepted seagrass species.

FAMILY	GENUS	SPECIES	FAMILY	GENUS	SPECIES	
Cymodoceaceae	<i>Amphibolis</i>	<i>antarctica</i>	Posidoniaceae	<i>Halophila</i>	<i>stipulacea</i>	
	<i>Amphibolis</i>	<i>griffithii</i>		<i>Halophila</i>	<i>tricostata</i>	
	<i>Cymodocea</i>	<i>angustata</i>		<i>Thalassia</i>	<i>hemprichii</i>	
	<i>Cymodocea</i>	<i>ciliata</i>		<i>Thalassia</i>	<i>testudinum</i>	
	<i>Cymodocea</i>	<i>nodosa</i>		<i>Posidonia</i>	<i>angustifolia</i>	
	<i>Cymodocea</i>	<i>rotundata</i>		<i>Posidonia</i>	<i>australis</i>	
	<i>Cymodocea</i>	<i>serrulata</i>		<i>Posidonia</i>	<i>coriacea</i>	
	<i>Halodule</i>	<i>beaudettei</i>		<i>Posidonia</i>	<i>denhartogii</i>	
	<i>Halodule</i>	<i>bermudensis</i>		<i>Posidonia</i>	<i>kirkmanii</i>	
	<i>Halodule</i>	<i>emarginata</i>		<i>Posidonia</i>	<i>oceanica</i>	
	<i>Halodule</i>	<i>pinifolia</i>		<i>Posidonia</i>	<i>ostenfeldii</i>	
	<i>Halodule</i>	<i>uninervis</i>		<i>Posidonia</i>	<i>robertsonae</i>	
	<i>Halodule</i>	<i>wrightii</i>		<i>Posidonia</i>	<i>sinuosa</i>	
	<i>Syringodium</i>	<i>filiforme</i>		Zosteraceae	<i>Heterozostera</i>	<i>tasmanica</i>
	<i>Syringodium</i>	<i>isoetifolium</i>			<i>Phyllospadix</i>	<i>iwatensis</i>
<i>Thalassodendron</i>	<i>ciliatum</i>	<i>Phyllospadix</i>	<i>japonicus</i>			
<i>Thalassodendron</i>	<i>pachyrhizum</i>	<i>Phyllospadix</i>	<i>scouleri</i>			
		<i>Phyllospadix</i>	<i>serrulatus</i>			
Hydrocharitaceae	<i>Enhalus</i>	<i>acoroides</i>	<i>Phyllospadix</i>	<i>torreyi</i>		
	<i>Halophila</i>	<i>australis</i>	<i>Zostera</i>	<i>asiatica</i>		
	<i>Halophila</i>	<i>baillonis</i>	<i>Zostera</i>	<i>caespitosa</i>		
	<i>Halophila</i>	<i>beccarii</i>	<i>Zostera</i>	<i>capensis</i>		
	<i>Halophila</i>	<i>capricorni</i>	<i>Zostera</i>	<i>capricorni</i>		
	<i>Halophila</i>	<i>decepiens</i>	<i>Zostera</i>	<i>caulescens</i>		
	<i>Halophila</i>	<i>engelmannii</i>	<i>Zostera</i>	<i>japonica</i>		
	<i>Halophila</i>	<i>hawaiiiana</i>	<i>Zostera</i>	<i>marina</i>		
	<i>Halophila</i>	<i>johnsonii</i>	<i>Zostera</i>	<i>mucronata</i>		
	<i>Halophila</i>	<i>minor</i>	<i>Zostera</i>	<i>muelleri</i>		
	<i>Halophila</i>	<i>ovalis</i>	<i>Zostera</i>	<i>noltii</i>		
	<i>Halophila</i>	<i>ovata</i>	<i>Zostera</i>	<i>novaezelandica</i>		
	<i>Halophila</i>	<i>spinulosa</i>	<i>Zostera</i>			

Species distribution

As a part of the present work, seagrass distribution information has been compiled from some 500 sources (see bibliography). The majority of these include direct observations of species, and these have been used to generate species lists for every country as species richness statistics. These sources provided at least partial information for the seagrass flora in 115 countries and territories world-wide, and this is provided in Annex 1. These show that the most diverse countries include Australia (31 species), the Philippines (18 species) and Japan (17 species).

These same geographic data were added to a geographical information system (GIS) at UNEP-WCMC, developing both spatial and point data as available. Plotting the available information by species, generalised distribution maps were produced for every species, updating earlier work by den Hartog (1970) and by Phillips and Meñez (1988). These maps are presented in Annex 2.

Feedback please: it would be possible, using the individual species maps for each country presented in Annex 2 to generate "predicted" or "expected" species lists for any country or region. This would allow generation of lists for smaller or unstudied areas. Would this be a valuable exercise?

We clearly have more work to do to get these tables complete? It would be valuable to get updates for each country, but also to try and gather information for entire countries that we are currently missing.

The species distribution information points clearly to the centres of diversity both at national and regional levels. The highest levels of diversity are clearly located in Australia (31 spp.) and the Philippines (18 spp.). The maps also point clearly to species with restricted ranges, and to species endemic to single countries (Table 2). Two species of seagrasses have been listed as globally threatened: *Halophila johnsonii* (Vulnerable) and *Phyllospadix* (Rare) (IUCN, 1997).

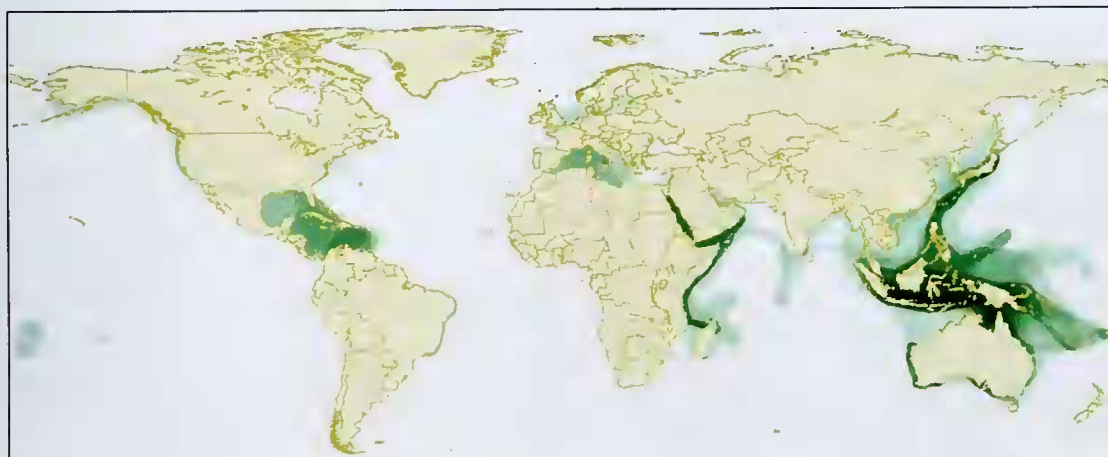
Japan
Scrub water

Table 2: list of single country endemic species of seagrasses.

Countries	Species
Australia	<i>Amphibolis antarctica</i> , <i>Amphibolis griffithii</i> , <i>Cymodocea angustata</i> , <i>Halophila australis</i> , <i>Halophila capricorni</i> , <i>Halophila tricostata</i> , <i>Posidonia angustifolia</i> , <i>Posidonia australis</i> , <i>Posidonia coriacea</i> , <i>Posidonia denhartogii</i> , <i>Posidonia kirkmanii</i> , <i>Posidonia ostenfeldii</i> , <i>Posidonia robertsonae</i> , <i>Posidonia sinuosa</i> , <i>Thalassodendron pachyrhizum</i> , <i>Zostera mucronata</i>
Bermuda	<i>Halodule bermundensis</i>
Brazil	<i>Halodule emarginata</i>
Japan	<i>Phyllospadix japonicus</i> , <i>Zostera caespitosa</i>
Madagascar	<i>Halophila stipulacea</i>
New Zealand	<i>Zostera novazelandica</i>
USA	<i>Halophila hawaiiiana</i> , <i>Halophila johnsonii</i>

*How accurate is this, are there others? Does this in any way reflect the bias of the workers?
If we were to change this to restricted range species are there any in particular? Or what should constitute a restricted range?
What are thoughts about threatened species?*

The species distribution maps have also been amalgamated to develop a global map of seagrass biodiversity. This map is the first of its kind for seagrasses, however it has been modelled on similar maps compiled for corals (Veron 2000) and for mangroves (UNEP-WCMC, 2000).



Map 1: Contour map showing the diversity of seagrass species world-wide.

This map shows the clear focus of biodiversity in Southeast Asia reaching up to southern Japan, and a second focus of diversity in the Red Sea and East Africa. In some ways these mirror the patterns of diversity observed in corals and mangroves. The Southeast Asian centre of diversity is a particular feature of all marine biodiversity maps produced to date, however it is interesting to note that, for seagrasses, this extends further north and into the temperate waters of Japan. Furthermore, seagrasses clearly show a much wider global distribution into cold temperate waters, and show relatively high diversity in other regions, notably in the Mediterranean and southern Australia.

Theories for the development of Southeast Asian centre of diversity have been advanced for a number of species groups, and it has been variously suggested that this region may have been a centre for species accumulation (“the vortex model of coral reef biogeography”, Jokiel and Marinelli, 1992), a location where high diversity was maintained thanks to benign climatic conditions during recent ice-ages (McCoy and Heck, 1976), or a centre for species evolution with the combination of benign conditions and changing sea levels (“eustatic diversity pump model”, Rosen, 1984).

The apparent radiation of species in locations outside of this region, most notably in southern and western Australia and in Japan, is also of considerable evolutionary interest (Phillips and Meñez, 1988).

Associated Species

A vast array of species can be found within seagrass ecosystems. Many are obligate members of the seagrass ecosystem, and are found no-where else. Others may be restricted to seagrass areas for shorter periods of their life-history, using them as breeding or nursery areas, or settling there for the adult phases of their life-history. Many more are found across a broad range of marine habitats, but regularly inhabit seagrass areas.

Table 3 lists some of the major groups of species regularly recorded from seagrass ecosystems, with links to particular references which address the association with seagrasses. Species of high conservation importance have also been included

Table 3: The major taxonomic groups found in seagrass ecosystems, with brief notes. Key references for this table include various chapters in Phillips and McRoy (1980).

Taxonomic group	Notes
Bacteria	
Blue-green algae (Cyanophyta)	
Red algae (Rhodophyta)	Including calcareous species
Brown algae (Phaeophyta)	<i>Pea-na</i>
Green algae (Chlorophyta)	Notably <i>Halimeda</i> <i>calcareo</i>
Protozoa	Includes the slime-moulds <i>Labyrinthula</i> spp., Diatoms and Foraminifera
Sponges	
Cnidarians	Includes epiphytic hydrozoans, sea anemones, and Scleractinia such as <i>Pavona</i> , <i>Psammacora</i> , <i>Porites</i> , <i>Pocillopora</i> , <i>Siderastrea</i>
Polychaetes	Many boring species
Ribbon worms	
Sipunculid worms	
Flatworms	
Crustaceans	Includes amphipods, and many decapod crustaceans including crabs, stomatopods and commercially important shrimp and lobster - <i>eribedie</i>
Bivalve molluscs	Some oysters, also many boring species
Gastropod molluscs	A broad range including nereids, <i>Conus</i> , <i>Cypraea</i> , and commercially important species of <i>Strombus</i>
Cephalopod molluscs	Squid and cuttlefish often found over seagrass areas
Bryozoans	Epiphytic on seagrass and rocks
Echinoderms	An important range of commercially important holothurian species, ophiroids are widespread, but also asteroids, and echinoids
Tunicates	Ascideans
Fish	All groups, but including the commercially important Haemulidae (grunts), Siganidae (rabbitfish), Lethrinidae (emperors), Lutjanidae (snappers), Syngnathidae (pipefishes and seahorses). Many of the latter, which are used in the aquarium trade and Chinese medicine trade, are considered threatened.
Reptiles	Notably the Green turtle..
Mammals	Notably the sirenian species (dugong and manatee)

Levels of diversity can be very high indeed. Harlin (1980) cites a study by Humm (1964) which listed 113 species of algal epiphytes from *Thalassia testudinum* beds in Florida. These lists were combined with 26 others from various publications world-wide to produce a total of some 450 algal species epiphytic on seagrasses, still probably an underestimate. Looking at a broader faunal list, Hutchings (1994) listed some 248 arthropods, 197 molluscs, 171 polychaetes, and 15 echinoderm species from Jervis Bay in New South Wales, Australia. In Florida, Roblee *et al.* (1991) noted 100 species of fish, and 30 crustaceans. Such figures are lower than many coral reef biodiversity

statistics (for example 1500 fish on the Great Barrier Reef; 534 species from 27 phyla on a 5sq m Caribbean reef microcosm, or 220 animal species from an individual coral head, Spalding *et al.* 2001), however these figures are still very high, and point to an important biodiversity which is often overlooked.

Whilst many of these species are broad ranging, others appear to be restricted to seagrass ecosystems, or dependant on them for a significant part of their life cycle. These seagrass dependent species include epiphytic algae (Harlin, 1980), and many of the 215 species of pipefishes and seahorses, including globally threatened species.

The importance attached to endemic and unique species by conservation agencies and funders is considerable – would it be worth trying to compile a list of obligate members of seagrass ecosystems, at least for particular groups?

We are clearly still a long way from developing a concept of total species numbers within seagrass ecosystems, and even further from establishing which of these are wholly dependent on these systems. It would appear from the above statistics, however, that the totals may be very large indeed – most of the comprehensive assessments have been undertaken in temperate waters, or the relatively low diversity waters of the Caribbean. The close association of seagrass ecosystems with coral reefs and mangrove forests will greatly boost the numbers of facultative inhabitants of these ecosystems in these areas, and it seems like that the total figures will number tens, perhaps hundreds of thousands of species.

Productivity and biomass

Seagrasses are often cited for their high productivity, despite often having relatively low biomass. Numerous studies have been undertaken on seagrass ecosystems world-wide, illustrating the considerable variance, but often very high overall figures. Comparisons of such figures are very difficult between studies. There are numerous types of measure, with biomass statistics ranging from stalk density to the dry weight of complete plant-root systems and with productivity statistics including rates of shoot extension to the dry weight of carbon produced per year. With considerable seasonal variation in growth rates and other less predictable fluctuations in growth the period and length of sampling greatly affects such measures. In addition, the selection of sampling areas may greatly bias overall measures. Table 4 provides a sample of some measures.

Seagrasses are described by many as being among the world's highly productive ecosystems. Most of these quote figures of 500-4000 gC/m²/year, clearly much higher than the examples provided here

Is this a claim we can still make?

Can we also develop estimates by region (Tropical SEAsia, Caribbean, Mediterranean, Temperate waters)?

Table 4: Selected examples of measures of seagrass biomass and productivity statistics.

Type of measure	Details	Species or dominant spp	Location	Measure	Source
Biomass	Standing crop to 25cm depth of sediment	<i>Thalassodendron ciliatum</i>	Sinai	a few dozens to well over 100kg DW m ²	Lipkin, 1979
Biomass	Standing crop to 25cm depth of sediment	Mixed	Sinai	Several hundred grams to a few kg DW m ²	Lipkin, 1979
Biomass	Standing crop to 25cm depth of sediment	<i>Halophila ovalis</i> and <i>Haldude uninervis</i>	Sinai	a few grams to a few dozen grams DW m ²	Lipkin, 1979
Biomass	Standing crop of leaves and stems	<i>Heterozostera tasmanica</i>	Victoria Australia	56-286 g DW m ²	Bulthuis and Woelkerling, 1983
Biomass	leaves	<i>Cymodocea nodosa</i>	Spain	64-171 g DW m ²	Terrados and Ros, 1992
Biomass	rhizomes	<i>Cymodocea nodosa</i>	Spain	157-269 g DW m ²	Terrados and Ros, 1992

Biomass	above and below ground	Mixed	Texas	172.5-235.3 g DW m ²	Onuf, 1996
Primary production		Various	Australia	120-690 gC m ² per year	Hillman et al, 1989 in Phillips and Durako (2000)
Primary production		<i>Halodule wrightii</i>	Tropics	280 gC m ² yr ⁻¹	Phillips and Durako (2000)
Primary production		turtlegrass	Tropics	825 gC m ² yr ⁻¹	Phillips and Durako (2000)
Primary production		eelgrass	Temperate regions	190 gC m ² yr ⁻¹	Thorne-Millar and Harlin, 1984 in Phillips and Durako (2000)
Primary production		eelgrass	Temperate regions	400-800 gC m ² yr ⁻¹	Sand-Jensen and Borum, 1983 in Phillips and Durako (2000)
Productivity	Annual leaf production	<i>Heterozostera tasmanica</i>	Victoria Australia	414-645 g DW m ² yr ⁻¹	Bulthuis and Woelkerling, 1983
Productivity	leaves	<i>Cymodocea nodosa</i>	Spain	160-427 g DW m ² yr ⁻¹	Terrados and Ros, 1992
Productivity	rhizomes	<i>Cymodocea nodosa</i>	Spain	46-78 g DW m ² yr ⁻¹	Terrados and Ros, 1992

The distribution and area of seagrass habitat

There has never been an accurate estimation of the global area of seagrass habitat. The total area of continental shelf (coastal waters to a depth of 200m) world-wide has been estimated at almost 25 million sq km (WR1, 2000).

Assuming a constant slope this would imply an area of 5-10 million sq km of water within the depth-range of most seagrasses. In reality seagrasses only occupy a small fraction of the world's nearshore waters and the total area of seagrasses is likely to be less than 10% of the shallow water area of the world's continental shelves, or 500,000 to 1,000,000 sq km.

~ Duale + Colorian 600,000 sq km

While global estimates have not been produced, a considerable number of studies have estimated the area of seagrasses in particular regions or in single study-sites. A number of these are presented in Table 5.

Table 5: Estimates of seagrass at local levels from around the world.

Country	Region	Area(km ²)	Reference
Australia	159E 35S	78.7	http://www.seagrass.unh.edu
Australia	Cape York - Moreton Bay, Queensland	4,300.0	Lee Long et al 1993
Australia	Cliff head lagoon	50.0	Kirkman, H. (1997)
Australia	Gulf of Carpentaria	906.0	Kirkman, H. (1997)
Australia	Gulf St Vincent	1,530.0	Kirkman, H. (1997)
Australia	New South Wales	155.0	Kirkman, H. (1997)
Australia	Queensland	4,000.0	http://www.seagrass.unh.edu
Australia	Queensland, Cape York to Hervey Bay	4,000.0	Lee Long et al 1993
Australia	Shark Bay	3,676.0	Kirkman, H. (1997)
Australia	Spencer Gulf	3,700.0	Kirkman, H. (1997)
Australia	Success Bank	10.4	Kendrick et al 2000
Australia	Success Bank	7.0	Kendrick et al 2000
Australia	SW Australia	2,200.0	Kirkman, H. (1997)
Australia	Swan-Cannign estuary	5.0	Kirkman, H. (1997)
Australia	Torres Strait	17,500.0	Kirkman, H. (1997)
Australia	western Australia	20,000.0	Kirkmand and Walker 1989
France	3E 43N	19.0	http://www.seagrass.unh.edu
France	Arcachon Bay	70.0	Auby 1991
France	Corsica	620.0	Pasqualini et al, 1998
Guadeloupe		84.0	Chauvaud et al 2001
Guatemala	88W 15N	20.0	http://www.seagrass.unh.edu
India	Kavaratti	0.4	Jagtap and Inamdar, 1991

Country	Region	Area(km ²)	Reference
Italy	Ligurian coasts:	71.0	http://estaxp.santateresa.enea.it/www/fanc/faneatlas.html
Italy	Sicily 12E 39N	300.0	http://www.seagrass.unh.edu
Italy	Sicily 13E 38N	10.0	http://www.seagrass.unh.edu
Italy	Venice	15.0	Rismondo et al (1997)
Jamaica	Kingston Harbour	10.0	Greenway, 1995
Japan	whole country	2,012.1	http://www.biodic.go.jp/english/kiso/fnd_f.html
Mauritania	Banc D'Arguin National Park	700.0	Kelleher et al, 1995
Mexico	Campeche	496.4	http://www.seagrass.unh.edu
Mexico	Caribbean coast	40.0	http://www.seagrass.unh.edu
Mexico	Tamaulipas	357.4	http://www.seagrass.unh.edu
Mexico	Veracruz	106.2	http://www.seagrass.unh.edu
New Caledonia	166E 20S	2,066.0	http://www.seagrass.unh.edu
New Caledonia	166E 22S	145.0	http://www.seagrass.unh.edu
Saudi Arabia		370.0	MEPA/IUCN, 1987
Spain	Med. 2W 39N	15,130.0	http://www.seagrass.unh.edu
Spain	Med. 2W 37N	7,529.0	http://www.seagrass.unh.edu
Spain	Med. 4W 37N	796.0	http://www.seagrass.unh.edu
Turks and Caicos	Caicos Bank	913.6	Green et al 2000
USA	Alaska	170.0	http://www.seagrass.unh.edu
USA	California	13.0	http://www.seagrass.unh.edu
USA	Florida Bay	1,800	Durako 2000
USA	Maryland	55.9	http://www.seagrass.unh.edu
USA	Maryland & Virginia	160.0	http://www.seagrass.unh.edu
USA	Texas	951.4	http://www.tpwd.state.tx.us/conservc/coastal/seegrass/chpt1.htm
USA	Texas	833.0	http://www.tpwd.state.tx.us/conservc/coastal/seegrass/chpt2.htm

The global distribution of seagrass habitat:

The broad picture of seagrass distribution has been long known (den Hartog, 1970), however there are still likely to be wide areas where even the existence of seagrasses remains unknown. Generalised distribution maps (see Map 1, above) do not provide any indication of the actual location of seagrass beds on a site-specific basis. The authors are only aware of one attempt at such a map, namely *Coral World* (National Geographic Society, 2000) annotated by den Hartog.

As a part of the present work, a comprehensive global GIS dataset was developed, bringing together seagrass distribution maps from multiple sources, including published literature and unpublished sources. Broadly, the source material fell into the following categories:

1 – **Direct habitat maps.** Often high resolution and very accurate. Many such maps are now produced from remotely sensed data, but smaller areas have been mapped entirely from field observations. With remote sensing accuracy is limited by the resolution of the sensor, the clarity of the water and the degree of sampling utilised. Some remotely sensed images will only pick up shallow (<10m) seagrass beds with a high shoot density, while large pixel size will lead to the loss of small or highly patchy seagrass areas.

2 – **Point based samples.** Although not strictly maps, numerous publications provide exact point-locations of seagrass beds which have been the location of particular studies. Such points can be placed within a GIS and can be “buffered” out to form small polygons. Although not representative of area on the ground, they are very useful in a broader mapping context where no further information is available.

3 – **Broad-scale, generalised interpolations** have been put together for a number of areas or countries. These differ from generalised range maps in that they have typically compiled by local experts, and are based on interpolation of ground-based knowledge and observation. Their accuracy is obviously highly variable.

Clearly, even with existing maps, there are differences in definition of what has been mapped, and significant differences in resolution. These will clearly influence the area of seagrass portrayed. Many mapping techniques, from remotely sensed image-processing to grab-sampling or side-scan sonar, may only pick up seagrasses at certain levels of shoot density, and the sensitivity to shoot density may be further altered by other attributes of the benthos or water column, the sampling routines or the time of day. Error also plays a part, and some mapping systems may incorporate non-seagrass species, such as *Halimeda*.

Scale is also important: Lower resolution maps will tend to ignore minor breaks in seagrass beds, while finer resolution maps will pick up even small breaks, which, it could be argued, are still a part of the seagrass ecosystem

In the following study we have utilised all three types of source material described above, and these have been harmonised into a single data layer. Each data point is clearly labelled with a series of attributes defining source, known species composition, and the date and scale of the original map. The primary aim of this work was to prepare a global map showing, as accurately as possible, the distribution of seagrasses, however it is clear that the same data layer may be used for more detailed analysis. The linked information in the GIS is thus of considerable importance in interpreting the layers on the map. Map 2 presents a global map of known seagrass distribution. A more detailed series of regional maps are presented in Annex 3.

We would like to make a global estimate of seagrass area. There are two possible routes:

1 – Map based – using our maps and estimating for missing information

2 – Direct estimates – using total estimates of shallow water and estimating proportion with seagrass based on selected studies (e.g. Estimates from Liguria suggest 14-22% of shallow water (above 35m) dominated by seagrass; and 17% of Caicos Bank)

Can we do this?



Map 2: The global distribution of seagrass habitats. Data are from highly varied source material as described. In order to make all data visible on a map at this scale, all data points and polygons have been exaggerated. This map should be seen as indicative of known occurrence only. Areas where seagrasses are not shown could indicate EITHER “no seagrass” OR “no data”.

We will be working up better maps from both global and regional maps during the workshop. Please note that we would like, wherever possible, to have references to underpin new data, so if you have written materials describing seagrass in other areas please bring these to the workshop.

The value of seagrasses

Seagrasses are a critical ecosystem for humans, providing food and other products, binding sediments and protecting coastlines from erosion, and providing linkage to other high value coastal ecosystems, including coral reefs, mangrove forests, and open ocean ecosystems. The role they play in fisheries is now widely recognised, and indeed many of the most important tropical shelf fisheries are heavily dependant on seagrass ecosystems.

Table 6: a summary of the goods and services provided by seagrass ecosystems.

Commerical and artisanal fisheries - Finfish (snappers, emperors, rabbitfish, surgeonfish) - Molluscs (conch, oysters) - Crustacea (shrimp, lobster)	
Food: - Seeds of <i>Zostera marina</i> used to make flour by Seri Indians - Rhizomes of <i>Enhalus</i> used as food in Lamu, Kenya	Felger and Moser, 1973 Crafter et al, 1992
Animal fodder	Sudara et al, 1994; UNEP 1986
Fabric - Used in mat weaving, Lamu, Kenya - Basket making, thatch, stuffing mattresses, upholstery	Crafter et al, 1992 Sudara et al, 1994
Fertiliser and mulch	Capps, 1977; Stewart & Mills, 1975; Walker, 1977
Building dykes	Van Katwijk, 2000
Packing material	Sudara et al, 1994; Hurley 1990
Offshore fisheries (using seagrass as nursery)	
Coastal protection (from erosion)	
Water purification (from pollutants and sediments)	
Nutrient export to adjacent ecosystems	
Stabilising sediments	

There have been very few studies of the direct economic value of seagrasses. In 1986 the North Queensland fisheries were estimated at an estimated US\$540,000 per year (Fortes, 1990). In Monroe County, Florida, the value of commercial fisheries for five species which depend on seagrasses was estimated at US\$48.7 million per year, whilst recreational fisheries as well as the diving and snorkelling industry contribute equally large sums to the economy, and are also heavily dependant on seagrasses (Heck, 2001).

Costanza *et al.* (1997) calculated a global value of annual ecosystem services for "seagrass/algae beds" of US\$19,004 per hectare per year. With an estimated total area for these combined ecosystems of 2,000,000 sq km they calculated a global annual value of US\$3,801,000,000,000 (i.e. US\$3.8 trillion), based almost entirely on their role in "nutrient cycling", in many ways a somewhat intangible role. Strangely, this same source gives no value to seagrass/algae beds for food production.

Threats to seagrasses

The global threats to seagrasses have received considerable attention from a number of authors and their efforts have not been duplicated here. Table 7 provides a short summary of natural and human induced threats to seagrass ecosystems. In many cases it seems likely that seagrass areas have declined as a result of a combination of threats. The decline of seagrasses in the North Atlantic in the 1930s with the "wasting disease" was probably one such example, where the final decline was probably hastened by the spread of the slime-net *Labyrinthula zosterae*.

Table 7:

Natural threats	
Geological	
Biological	Grazing by sea urchins sirenians, geese, or removal by foraging rays
Meteorological	Storms and wave action
Human threats	
Dredging	To develop or widen shipping lanes and open new ports and harbours
Trawling	Various benthic trawling devices used in the fishing industry

Deliberate clearance	For example to "clean" tourist beaches
Erosion from alteration of hydrological regime	Coastal development and the building of sea defences has significant effects on the flow of currents in nearshore waters
Anchor damage	
Land reclamation	
Conversion to aquaculture ponds	
Sedimentation	Higher turbidity reduces light levels. Very high sedimentation smothers entire seagrass beds
Pollution	Can have toxic or eutrophic effects. With high levels of increased nutrients, photosynthesis can be reduced by excess epiphytic overgrowth, planktonic blooms or competition from macroalgae
Climate change	Potential threats from rising sea levels, localised decreases in salinity, damage from UV radiation, and unpredictable impacts from changes in distribution and intensity of extreme events. Possible increases in productivity resulting from higher CO2 concentrations

Short and Wyllie-Echeverria (1996, 2000) provide a detailed analysis of seagrass losses from reports world-wide. They estimated that 2,900sq km of seagrass loss had been documented in the 1990s, and extrapolated up to over 12,000sq km world-wide during this period alone.

*Are we in a position to revise a global estimate?
Or to produce regional estimates?*

Management Interventions

Concern over what is now perceived as a rapid decline in seagrass areas world-wide, coupled with growing interests in both biodiversity conservation and sustainable fisheries management has led to a relatively rapid growth in the designation of marine protected areas world-wide (Burke et al 2001), particularly in nearshore areas. A large number of these include seagrass habitat. Other legal measures to protect seagrass habitats have been relatively limited to date, although some more general legal measure have probably been beneficial for seagrass communities.

UNEP-WCMC maintains a global database on MPAs on behalf of the World Commission of Protected Areas. Linked to the current work a list of these areas which are known to contain seagrass habitat has been prepared and is presented in Annex 4. A summary of this information is provided in Table 8.

Table 8: Summary of seagrass protected areas. Note that the area statistics are for the total area of the parks and reserves, including marine and terrestrial area.

Country	Total MPA area (sq km)	No. of sites	Country	Total MPA area (sq km)	No. of sites
Antigua and Barbuda		1	France	47.4	2
Australia	1,069.0	3	French Polynesia	113.0	1
Bahamas	18.1	1	Germany, Federal Republic of		2
Belize	1,188.4	4	Guadeloupe	37.4	1
Brazil	0.1	1	Guam	61.4	1
British Indian Ocean Territory		1	Honduras	893.6	2
Cambodia	150.0	1	India	10,500.0	1
Cayman Islands	53.9	4	Indonesia	2,145.2	5
China	80.0	1	Jamaica	15.3	3
Colombia	1,360.0	3	Kenya	183.3	2
Costa Rica	234.7	2	Martinique	4.2	1
Cuba	174.2	1	Mauritania	11,730.0	1
Cyprus	6.5	1	Mauritius	13.0	2
Dominica	5.3	1	Mexico	28,020.6	5
Dominican Republic	5,034.5	4	Mozambique	20,170.0	4

Country	Total MPA area (sq km)	No. of sites	Country	Total MPA area (sq km)	No. of sites
Netherlands Antilles	34.2	2	Thailand	230.9	1
Nicaragua	500.0	1	Tonga	28.8	2
Palau	12.0	1	Trinidad and Tobago	6.5	1
Panama	3,200.0	1	Tunisia	126.0	1
Papua New Guinea	2,316.8	3	Turks and Caicos Islands	4.0	1
Philippines	57.5	1	United Kingdom	34.1	4
Puerto Rico	77.9	6	United States	12,167.3	18
Réunion		2	United States Minor Outlying Island	128.4	1
Saint Lucia	0.3	3	Venezuela	4,394.3	4
Saudi Arabia	2,796.0	2	Vietnam	150.4	1
Seychelles	15.8	2	Virgin Islands (British)	3.2	1
Singapore	9.8	1	Virgin Islands (U.S.)	54.5	3
Slovenia	1.9	1			
Spain	507.2	1			
Tanzania, United Republic of	843.9	3			

From this table we can see that there are 130 marine protected areas with seagrass communities world-wide. These are located in 57 countries and territories. This network is far smaller than the equivalent network for coral reefs and mangrove forests. While the total area of these sites appears to be very high, it should further be noted that these measures are for the total area of the sites, which may include both land and sea. They are not of the area of seagrass within this, which is likely to be only a small fraction of the total area. Figure 1 provides a model of the growth of this protected areas network over time.

At the meeting we will have a full list of over 4000 MPAs world-wide and will ask participants to highlight any which we have not captured in the list provided in the Annex.

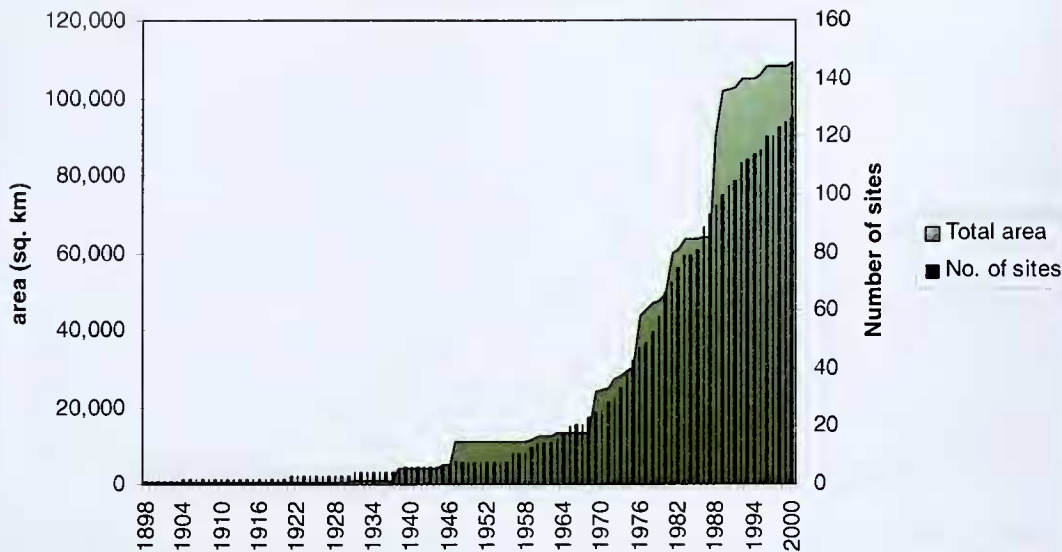


Figure 1: the growth of the protected areas network for marine protected areas including seagrass ecosystems
Source: UNEP-WCMC. World Database on Protected Areas

In addition to direct protection of specified areas, there are a number of other legal interventions which have been developed in particular countries which protect seagrasses, either directly, or via restrictions on particular activities. For example, in Queensland waters (Australia) all seagrasses and other marine plants are specifically protected under the Fisheries Act of 1994, for the protection of commercial and recreational fishing activities. In South Australia seagrass is protected under the native vegetation Act 1992. In the US, seagrass habitats are protected under Section 404 (c) of the Clean Water Act (33 USC 1341-1987) (Davis and Short, 1997).

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Annex 1: Seagrass Species Lists by Country

	Algeria	Angola	Anguilla	Antigua Barbuda	Australia	Bahamas	Bahrain	Bangladesh	Barbados	Belize	Bermuda	Brazil	British Indian O T	Brunei	Bulgaria	Cambodia	Canada	Cayman Islands	Chile	China	Colombia	Comoros	Costa Rica	Cuba
<i>Amphibolis antarctica</i>					1																			
<i>Amphibolis griffithii</i>					1																			
<i>Cymodocea angustata</i>					1																			
<i>Cymodocea ciliata</i>																								
<i>Cymodocea nodosa</i>		1													1									
<i>Cymodocea rotundata</i>					1																			
<i>Cymodocea serrulata</i>					1																	1		
<i>Enhalus acoroides</i>					1									1										
<i>Halodule beaudettei</i>								1	1															
<i>Halodule bermundensis</i>											1													
<i>Halodule emarginata</i>												1												
<i>Halodule pinifolia</i>					1																			
<i>Halodule uninervis</i>					1		1	1								1					1	1		
<i>Halodule wrightii</i>		1		1		1			1				1									1	1	1
<i>Halophila australis</i>					1																			
<i>Halophila baillonis</i>													1									1		
<i>Halophila beccarii</i>																					1			
<i>Halophila capricorni</i>																								
<i>Halophila decipiens</i>					1								1	1							1	1		
<i>Halophila engelmannii</i>																								1
<i>Halophila hawaiiiana</i>																								
<i>Halophila johnsonii</i>																								
<i>Halophila minor</i>					1																			
<i>Halophila ovalis</i>					1		1							1							1	1		
<i>Halophila ovata</i>					1																			
<i>Halophila spinulosa</i>					1									1										
<i>Halophila stipulacea</i>							1																1	
<i>Halophila tricostata</i>					1																			
<i>Heterozostera tasmanica</i>					1																			
<i>Phyllospadix iwataensis</i>																								
<i>Phyllospadix japonicus</i>																								
<i>Phyllospadix scouleri</i>																								
<i>Phyllospadix serrulatus</i>																								
<i>Phyllospadix torreyi</i>																								
<i>Posidonia angustifolia</i>						1																		
<i>Posidonia australis</i>						1																		
<i>Posidonia coriacea</i>						1																		
<i>Posidonia denhartogii</i>						1																		
<i>Posidonia kirkmanii</i>						1																		
<i>Posidonia oceanica</i>		1																						
<i>Posidonia ostenfeldii</i>						1																		
<i>Posidonia robertsonae</i>						1																		
<i>Posidonia sinuosa</i>						1																		
<i>Syringodium filiforme</i>				1	1		1			1	1	1										1	1	1
<i>Syringodium isoetifolium</i>						1																	1	
<i>Thalassia hemprichii</i>						1									1									
<i>Thalassia testudinum</i>				1	1		1		1	1	1										1		1	1
<i>Thalassodendron ciliatum</i>						1								1									1	
<i>Thalassodendron pachyrhizum</i>						1																		
<i>Zostera asiatica</i>																						1		
<i>Zostera caespitosa</i>																								
<i>Zostera capensis</i>																								
<i>Zostera capricorni</i>						1																		
<i>Zostera caulescens</i>																								
<i>Zostera japonica</i>																						1		
<i>Zostera marina</i>		1														1		1				1		
<i>Zostera mucronata</i>						1																		
<i>Zostera muelleri</i>						1																		
<i>Zostera noltii</i>		1															1							
<i>Zostera novaezelandica</i>																								
Grand Total	3	2	2	3	31	3	3	1	4	3	3	4	2	4	3	1	3	1	1	7	5	6	3	4

	Denmark	Dominican Republic	Egypt	Estonia	Fiji	France	Fr - Guadeloupe	Fr - Martinique	French Polynesia	Germany	Great Britain	Greece	Greenland	Grenada	Guatemala	Haiti	Honduras	India	Indonesia	Israel	Italy	Jamaica	Japan	Kenya	
<i>Amphibolis antarctica</i>																									
<i>Anphibolis griffithii</i>																									
<i>Cymodocea angustata</i>																			1						
<i>Cymodocea ciliata</i>																					1	1			
<i>Cymodocea nodosa</i>						1						1													
<i>Cymodocea rotundata</i>			1																1	1			1	1	
<i>Cymodocea serrulata</i>			1																1	1			1	1	
<i>Enhalus acoroides</i>																			1	1			1	1	
<i>Halodule beaudettei</i>																									
<i>Halodule bermundensis</i>																									
<i>Halodule emarginata</i>																									
<i>Halodule pinifolia</i>					1															1			1		
<i>Halodule unimervis</i>			1		1														1	1			1	1	
<i>Halodule wrightii</i>	1																1	1				1	1		
<i>Halophila australis</i>																									
<i>Halophila baillonis</i>																									
<i>Halophila beccarii</i>																			1						
<i>Halophila capricorni</i>																									
<i>Halophila decipiens</i>		1	1						1						1				1	1			1		
<i>Halophila engelmannii</i>																									
<i>Halophila hawaiiiana</i>																									
<i>Halophila johnsonii</i>																									
<i>Halophila minor</i>						1													1	1			1	1	
<i>Halophila ovalis</i>			1	1					1										1	1	1		1	1	
<i>Halophila ovata</i>					1														1	1			1		
<i>Halophila spinulosa</i>			1																1						
<i>Halophila stipulacea</i>			1									1							1			1		1	
<i>Halophila tricostata</i>																									
<i>Heterozostera tasmanica</i>																									
<i>Phyllospadix iwatensis</i>																								1	
<i>Phyllospadix japonicus</i>																								1	
<i>Phyllospadix scouleri</i>																									
<i>Phyllospadix serrulatus</i>																									
<i>Phyllospadix torreyi</i>																									
<i>Posidonia angustifolia</i>																									
<i>Posidonia australis</i>																									
<i>Posidonia coriacea</i>																									
<i>Posidonia denhartogii</i>																									
<i>Posidonia kirkmanii</i>																									
<i>Posidonia oceanica</i>						1															1	1			
<i>Posidonia ostenfeldii</i>																									
<i>Posidonia robertsonae</i>																									
<i>Posidonia sinuosa</i>																									
<i>Syringodium filiforme</i>			1																				1		
<i>Syringodium isoetifolium</i>			1	1		1														1	1		1	1	
<i>Thalassia hemprichii</i>				1																1	1		1	1	
<i>Thalassia testudinum</i>			1						1	1					1		1			1	1		1	1	
<i>Thalassodendron ciliatum</i>				1															1	1				1	
<i>Thalassodendron pachyrhizum</i>																									
<i>Zostera asiatica</i>																								1	
<i>Zostera caespitosa</i>																							1		
<i>Zostera capensis</i>																								1	
<i>Zostera capricorni</i>																									
<i>Zostera caulescens</i>																								1	
<i>Zostera japonica</i>																								1	
<i>Zostera marina</i>		1			1	1				1	1	1	1									1	1		
<i>Zostera mucronata</i>																									
<i>Zostera muelleri</i>																									
<i>Zostera noltii</i>							1				1	1	1								1	1			
<i>Zostera novaezelandica</i>																									
Grand Total		1	5	10	1	6	4	1	1	2	2	3	4	1	1	1	1	2	14	13	4	5	3	17	13

	Kiribati	Kuwait	Libya	Madagascar	Malaysia	Maldives	Marshall Islands	Mauritania	Mauritius	Mexico	Micronesia	Morocco	Mozambique	Myanmar	Netherlands	Netherlands Antilles	New Caledonia (Fr)	New Zealand	Nicaragua	North Korea	Norway	Oman	Palau	Panama
<i>Amphibolis antarctica</i>																								
<i>Amphibolis griffithii</i>																								
<i>Cymodocea angustata</i>																								
<i>Cymodocea ciliata</i>													1											
<i>Cymodocea nodosa</i>			1					1																
<i>Cymodocea rotundata</i>				1	1		1				1	1					1						1	
<i>Cymodocea serrulata</i>				1	1						1	1					1					1	1	
<i>Enhalus acoroides</i>				1	1						1	1	1				1						1	
<i>Halodule beaudettei</i>				1																				
<i>Halodule bermundensis</i>																								
<i>Halodule emarginata</i>																								
<i>Halodule pinifolia</i>						1					1							1					1	
<i>Halodule uninervis</i>		1		1	1				1		1		1	1			1					1	1	
<i>Halodule wrightii</i>				1				1	1			1								1			1	
<i>Halophila australis</i>																								
<i>Halophila baillonis</i>																								1
<i>Halophila beccarii</i>						1								1										
<i>Halophila capricorni</i>																	1							
<i>Halophila decipiens</i>					1				1					1			1	1						1
<i>Halophila engelmannii</i>																								
<i>Halophila hawaiiiana</i>																								
<i>Halophila johnsonii</i>																								
<i>Halophila minor</i>						1					1						1						1	
<i>Halophila ovalis</i>				1	1				1		1		1	1			1					1	1	
<i>Halophila ovata</i>						1																		
<i>Halophila spinulosa</i>						1																		
<i>Halophila stipulacea</i>		1		1					1				1											
<i>Halophila tricostata</i>																								
<i>Heterozostera tasmanica</i>																								
<i>Phyllospadix iwatensis</i>																								
<i>Phyllospadix japonicus</i>										1														
<i>Phyllospadix scouleri</i>											1													
<i>Phyllospadix serrulatus</i>																								
<i>Phyllospadix torreyi</i>										1														
<i>Posidonia angustifolia</i>																								
<i>Posidonia australis</i>																								
<i>Posidonia coriacea</i>																								
<i>Posidonia denhartogii</i>																								
<i>Posidonia kirkmanii</i>																								
<i>Posidonia oceanica</i>				1								1												
<i>Posidonia ostenfeldii</i>																								
<i>Posidonia robertsonae</i>																								
<i>Posidonia sinuosa</i>																								
<i>Syringodium filiforme</i>											1						1		1					
<i>Syringodium isoetifolium</i>					1	1	1		1		1		1										1	1
<i>Thalassia hemprichii</i>		1		1	1	1	1		1		1		1				1						1	1
<i>Thalassia testudinum</i>										1							1			1				1
<i>Thalassodendron ciliatum</i>					1		1		1				1										1	1
<i>Thalassodendron pachyrhizum</i>																								
<i>Zostera asiatica</i>																								
<i>Zostera caespitosa</i>																								
<i>Zostera capensis</i>						1							1											
<i>Zostera capricorni</i>																			1					
<i>Zostera caulescens</i>																								
<i>Zostera japonica</i>																					1			
<i>Zostera marina</i>				1						1		1					1						1	
<i>Zostera mucronata</i>																								
<i>Zostera muelleri</i>																								
<i>Zostera noltii</i>									1			1										1		
<i>Zostera novaezelandica</i>																								
Grand Total	1	2	3	12	13	3	2	3	7	6	9	3	12	5	1	3	11	3	3	1	2	7	10	3

	Papua New Guinea	Philippines	Poland	Portugal	Puerto Rico	Russian Federation	Samoa	Saudi Arabia	Seychelles	Sierra Leone	Singapore	Solomon Islands	Somalia	South Africa	South Korea	Spain	Sri Lanka	St Lacia	St. Kitts and Nevis	Sudan	Sweden	Syrian Arab republic	Taiwan	Tanzania	
<i>Amphibolis antarctica</i>																									
<i>Amphibolis griffithii</i>																									
<i>Cymodocea angustata</i>									1																
<i>Cymodocea ciliata</i>				1						1						1									
<i>Cymodocea nodosa</i>	1	1						1	1		1												1	1	
<i>Cymodocea rotundata</i>	1	1						1	1		1							1						1	
<i>Cymodocea serrulata</i>	1	1						1	1		1													1	
<i>Enhalus acoroides</i>	1	1						1	1		1							1						1	
<i>Halodule beaudettei</i>																									
<i>Halodule bermundensis</i>																									
<i>Halodule emarginata</i>																									
<i>Halodule pinifolia</i>	1	1									1														
<i>Halodule uninervis</i>	1	1						1	1		1		1							1			1	1	
<i>Halodule wrightii</i>					1																			1	
<i>Halophila australis</i>																									
<i>Halophila baillonis</i>					1																				
<i>Halophila beccarii</i>		1									1						1								
<i>Halophila capricorni</i>																									
<i>Halophila decipiens</i>	1	1			1				1								1	1	1						
<i>Halophila engelmannii</i>					1																				
<i>Halophila hawaiiiana</i>																									
<i>Halophila johnsonii</i>																									
<i>Halophila minor</i>	1	1									1		1												
<i>Halophila ovalis</i>	1	1						1	1	1	1		1	1			1							1	
<i>Halophila ovata</i>	1						1																		
<i>Halophila spinulosa</i>			1								1														
<i>Halophila stipulacea</i>								1																1	
<i>Halophila tricostata</i>																									
<i>Heterozostera tasmanica</i>																									
<i>Phyllospadix iwataensis</i>			1																						
<i>Phyllospadix japonicus</i>																									
<i>Phyllospadix scouleri</i>																									
<i>Phyllospadix serrulatus</i>																									
<i>Phyllospadix torreyi</i>																									
<i>Posidonia angustifolia</i>																									
<i>Posidonia australis</i>																									
<i>Posidonia coriacea</i>																									
<i>Posidonia denhartogii</i>																									
<i>Posidonia kirkmanii</i>																							1		
<i>Posidonia oceanica</i>																	1								
<i>Posidonia ostenfeldii</i>																									
<i>Posidonia robertsonae</i>																									
<i>Posidonia sinuosa</i>																									
<i>Syringodium filiforme</i>					1																1				
<i>Syringodium isoetifolium</i>	1	1					1	1	1		1	1					1						1	1	
<i>Thalassia hemprichii</i>	1	1						1	1		1	1	1								1			1	
<i>Thalassia testudinum</i>					1																				
<i>Thalassodendron ciliatum</i>	1	1						1	1			1	1	1										1	
<i>Thalassodendron pachyrhizum</i>																									
<i>Zostera asiatica</i>			1																						
<i>Zostera caespitosa</i>																									
<i>Zostera capensis</i>																1								1	
<i>Zostera capricorni</i>	1																								
<i>Zostera caulescens</i>		1				1										1									
<i>Zostera japonica</i>	1	1				1										1								1	
<i>Zostera marina</i>		1	1			1										1	1					1		1	
<i>Zostera mucronata</i>																									
<i>Zostera muelleri</i>																									
<i>Zostera noltii</i>					1	1											1					1			
<i>Zostera novazelandica</i>																									
Grand Total	14	18	1	2	6	4	3	9	10	1	11	3	5	3	3	3	5	7	1	2	2	2	1	5	11

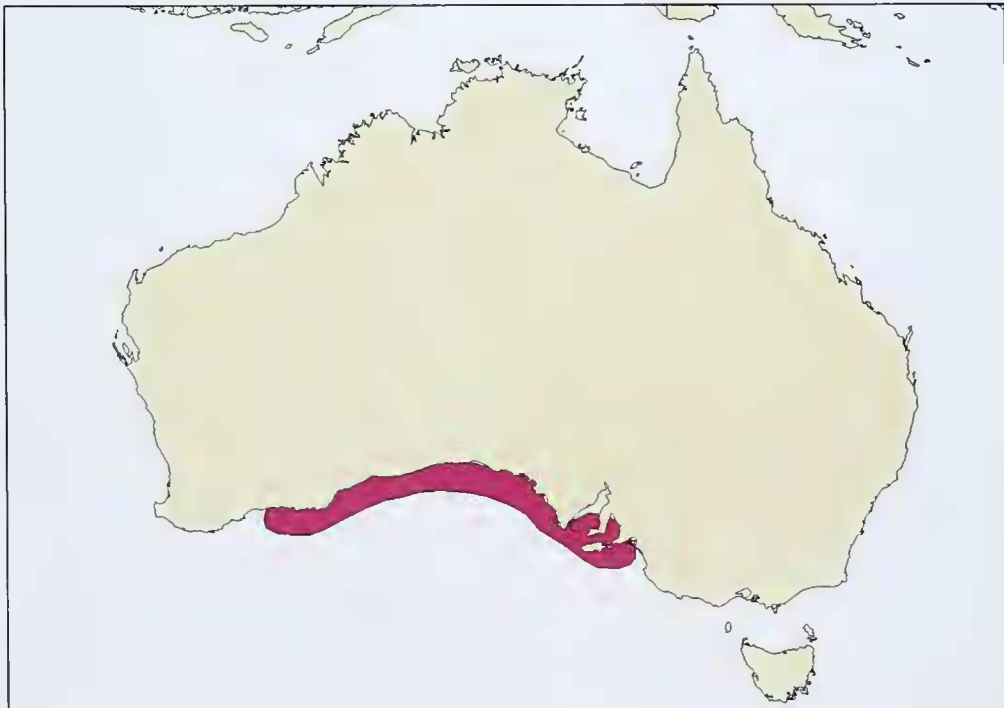
	Thailand	Tonga	Trinidad and Tobago	Tunisia	Turkey	Turks and Caicos	U.S. Virgin Islands	U.S.A.	U.S.A. - Atlantic	U.S.A. - Hawaii	U.S.A. - Pacific	U.S.A. - Puerto Rico	Ukraine	United Arab Emirates	Vanuatu	Venezuela	Vietnam	Western Samoa	Yemen	Grand Total
<i>Amphibolis antarctica</i>																				1
<i>Amphibolis griffithii</i>																				1
<i>Cymodocea angustata</i>																				1
<i>Cymodocea ciliata</i>																				3
<i>Cymodocea nodosa</i>				1	1															13
<i>Cymodocea rotundata</i>	1														1					1
<i>Cymodocea serrulata</i>	1														1		1			1
<i>Enhalus acoroides</i>	1														1		1			1
<i>Halodule beaudettei</i>								1												4
<i>Halodule bermundensis</i>																				1
<i>Halodule emarginata</i>																				1
<i>Halodule pinifolia</i>	1														1		1			15
<i>Halodule uninervis</i>	1	1												1	1		1		1	39
<i>Halodule wrightii</i>			1			1	1	1	1							1				27
<i>Halophila australis</i>																				1
<i>Halophila baillonis</i>												1				1				6
<i>Halophila beccarii</i>	1																1			9
<i>Halophila capricorni</i>																				1
<i>Halophila decipiens</i>	1						1	1	1			1			1	1				33
<i>Halophila engelmannii</i>								1	1											4
<i>Halophila hawaiiiana</i>										1										1
<i>Halophila johnsonii</i>								1	1	1										3
<i>Halophila minor</i>	1									1					1			1		19
<i>Halophila ovalis</i>	1	1								1					1	1		1	1	40
<i>Halophila ovata</i>	1																			9
<i>Halophila spinulosa</i>																				7
<i>Halophila stipulacea</i>														1					1	15
<i>Halophila tricostata</i>																				1
<i>Heterozostera tasmanica</i>																				2
<i>Phyllospadix iwataensis</i>																	1			3
<i>Phyllospadix japonicus</i>																				1
<i>Phyllospadix scouleri</i>												1								2
<i>Phyllospadix serrulata</i>								1				1								3
<i>Phyllospadix torreyi</i>											1									2
<i>Posidonia angustifolia</i>																				1
<i>Posidonia australis</i>																				1
<i>Posidonia coriacea</i>																				1
<i>Posidonia denhartogii</i>																				1
<i>Posidonia kirkmanii</i>																				1
<i>Posidonia oceanica</i>				1	1															10
<i>Posidonia ostenfeldii</i>																				1
<i>Posidonia robertsonae</i>																				1
<i>Posidonia sinuosa</i>																				1
<i>Syringodium filiforme</i>						1	1	1	1			1				1				22
<i>Syringodium isoetifolium</i>	1	1													1	1	1	1	1	36
<i>Thalassia hemprichii</i>	1						1								1		1		1	32
<i>Thalassia testudinum</i>			1				1	1	1			1				1				27
<i>Thalassodendron ciliatum</i>														1	1					1
<i>Thalassodendron pachyrhizum</i>																				1
<i>Zostera asiatica</i>								1												4
<i>Zostera caespitosa</i>																				1
<i>Zostera capensis</i>																				5
<i>Zostera capricorni</i>															1					4
<i>Zostera caulescens</i>																	1			5
<i>Zostera japonica</i>								1							1		1			12
<i>Zostera marina</i>				1	1			1	1		1	1								31
<i>Zostera mucronata</i>																				1
<i>Zostera muelleri</i>																				2
<i>Zostera noltii</i>				1	1								1							18
<i>Zostera novaezelandica</i>																				1
Grand Total	12	3	2	4	4	2	5	11	7	4	4	4	2	5	13	5	9	4	9	60

Annex 2 – Species distribution maps

Cymodoceaceae



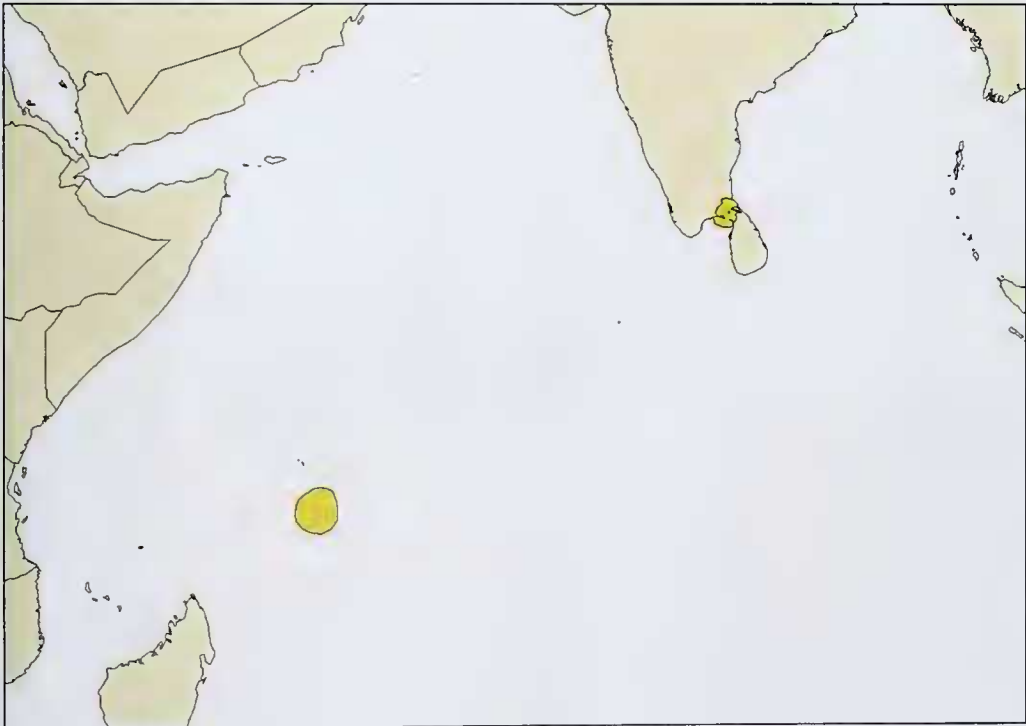
Amphibolis antarctica



Amphibolis griffithii



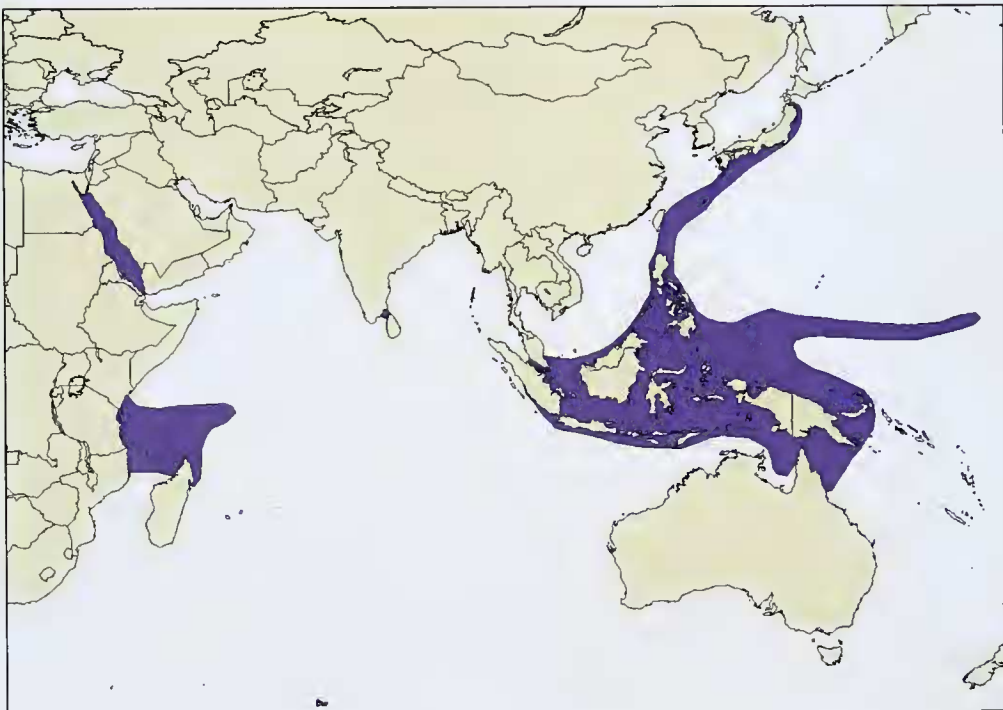
Cymodocea angustata



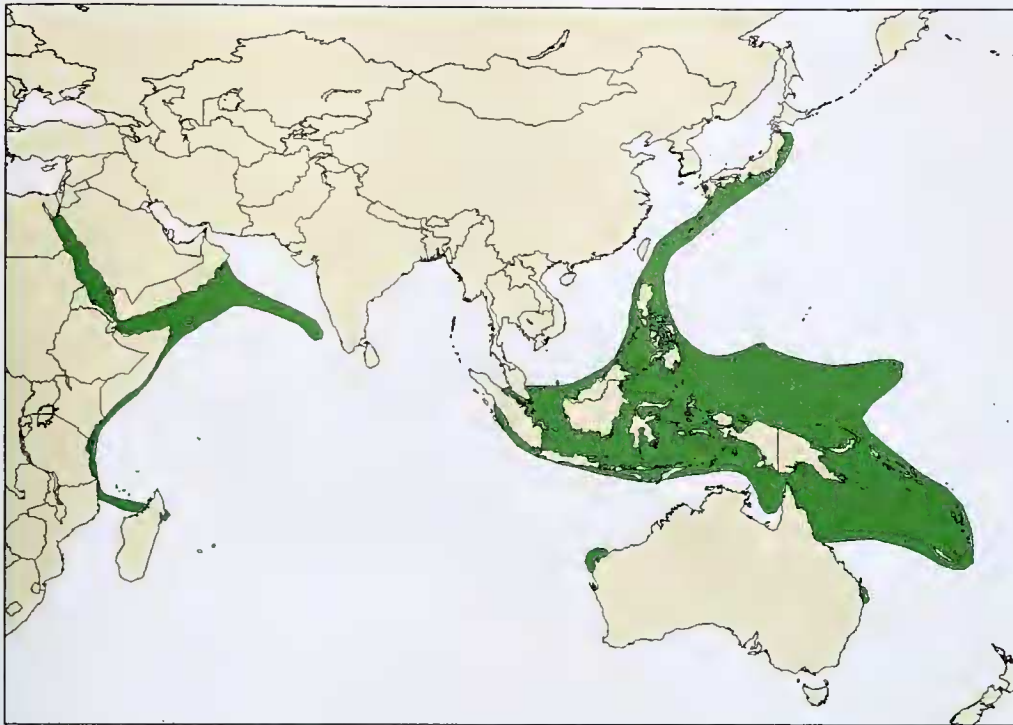
Cymodocea ciliata



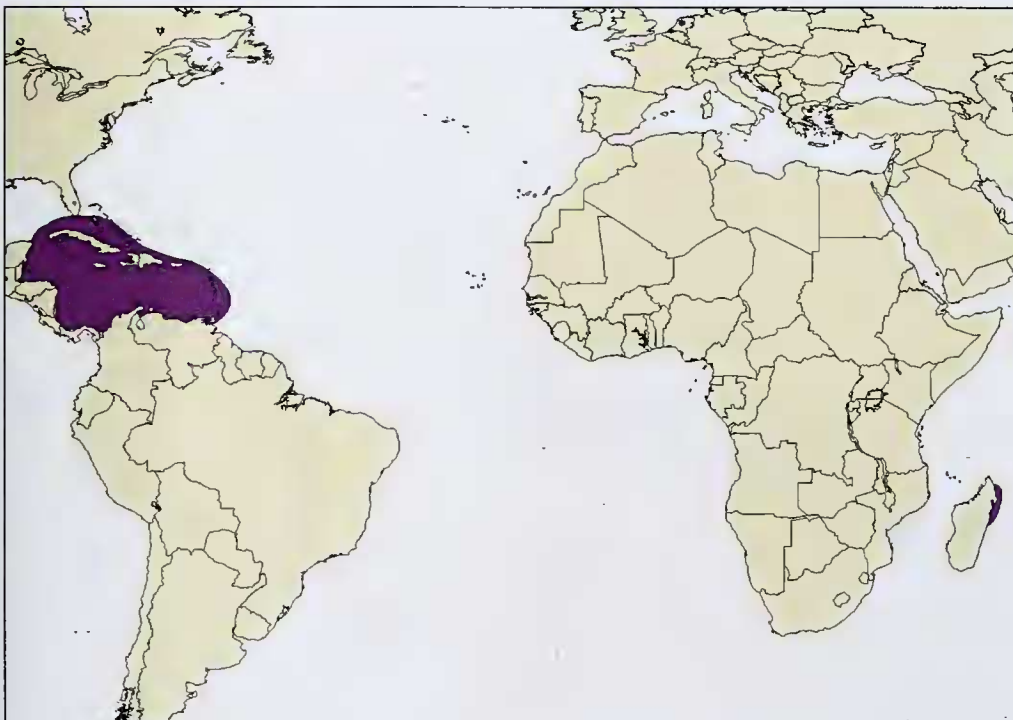
Cymodocea nodosa



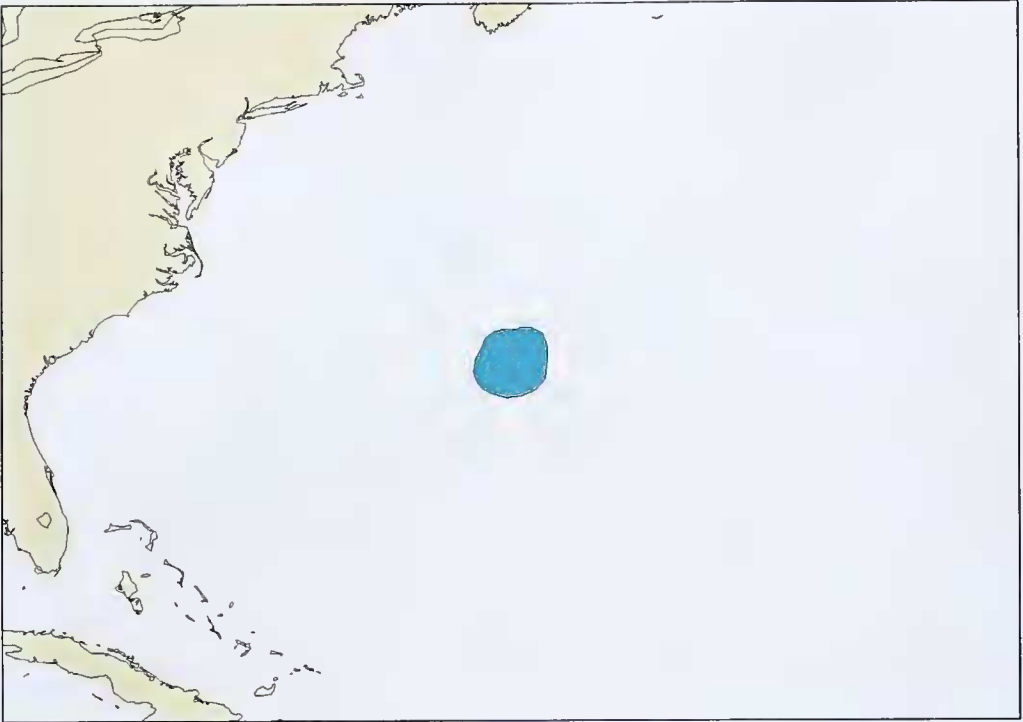
Cymodocea rotundata



Cymodocea serrulata



Halodule beaudettei



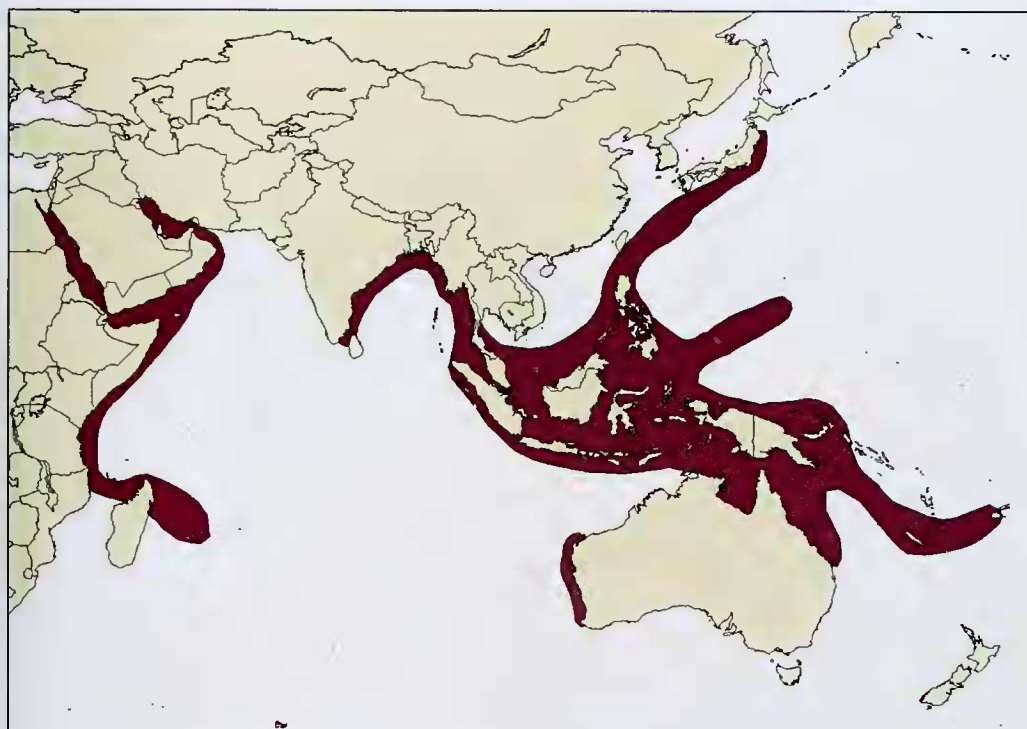
Halodule bermudensis



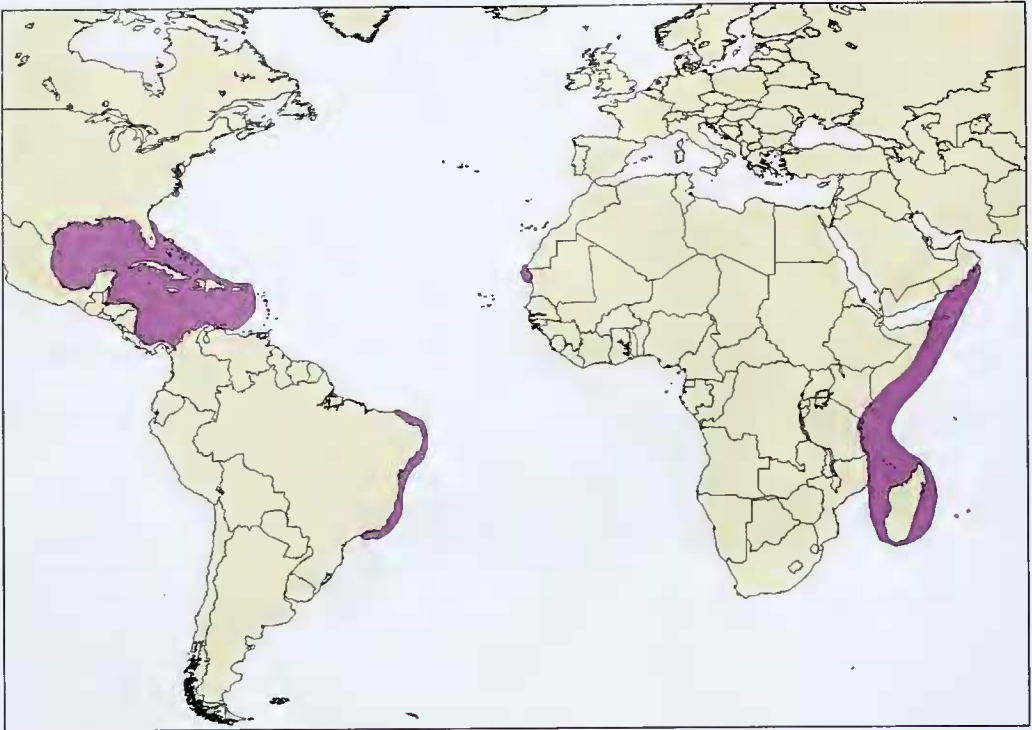
Halodule emarginata



Halodule pinifolia



Halodule uninervis



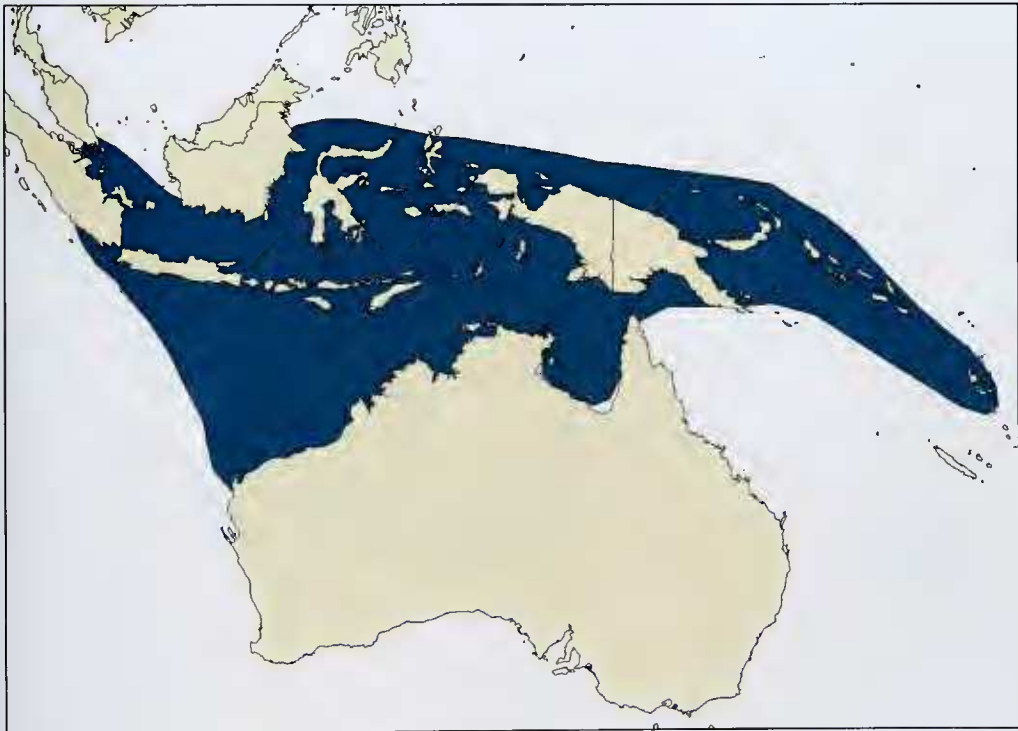
Halodule wrightii



Syringodium filiforme



Syringodium isoetifolium

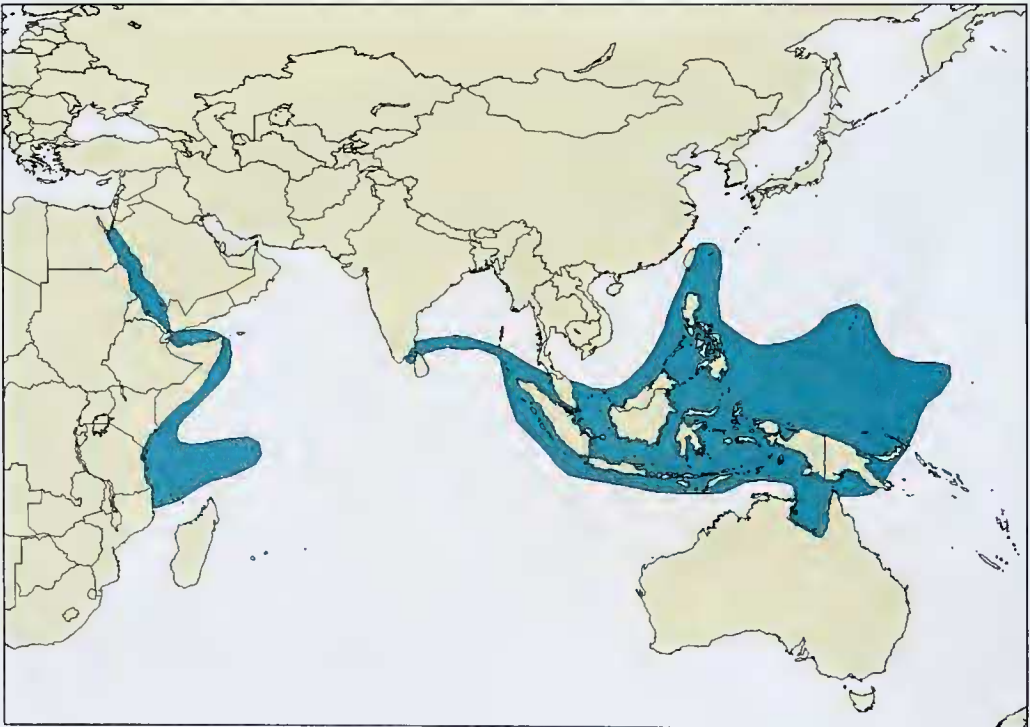


Thalassodendron ciliatum



Thalassodendron pachyrhizum

Hydrocharitaceae



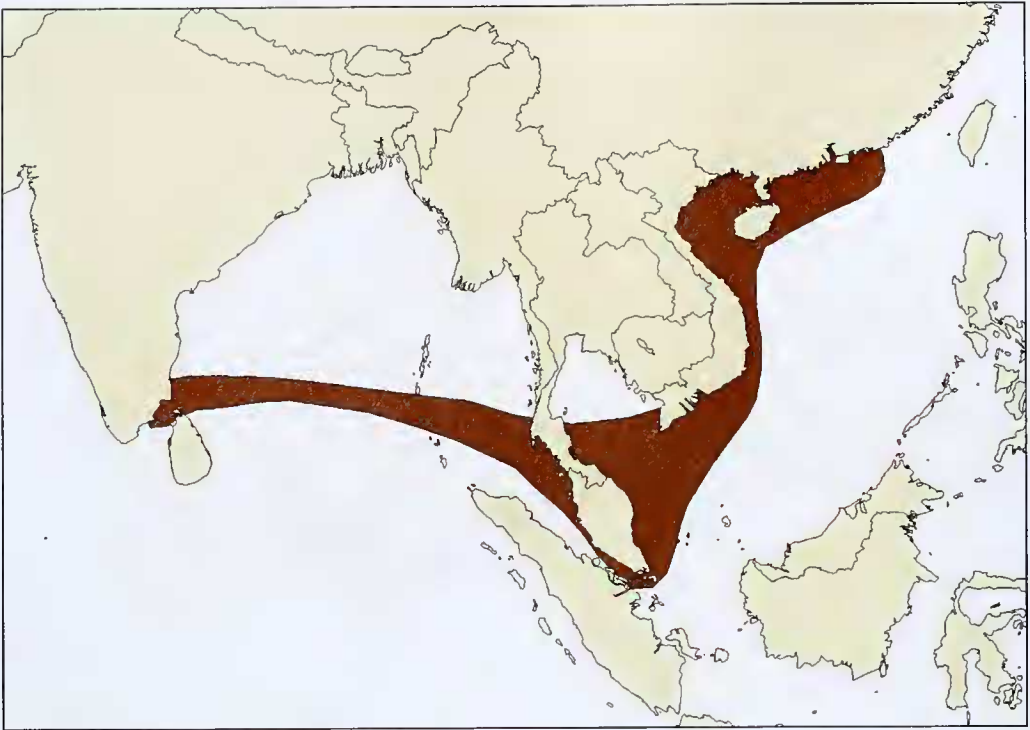
Enhalus acoroides



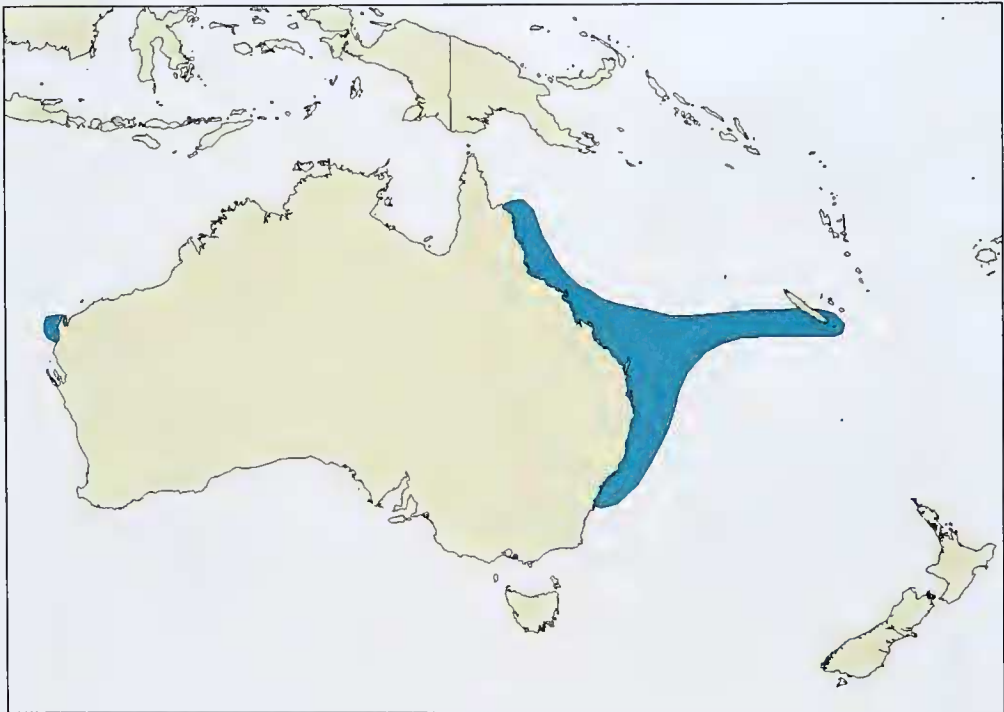
Halophila australis



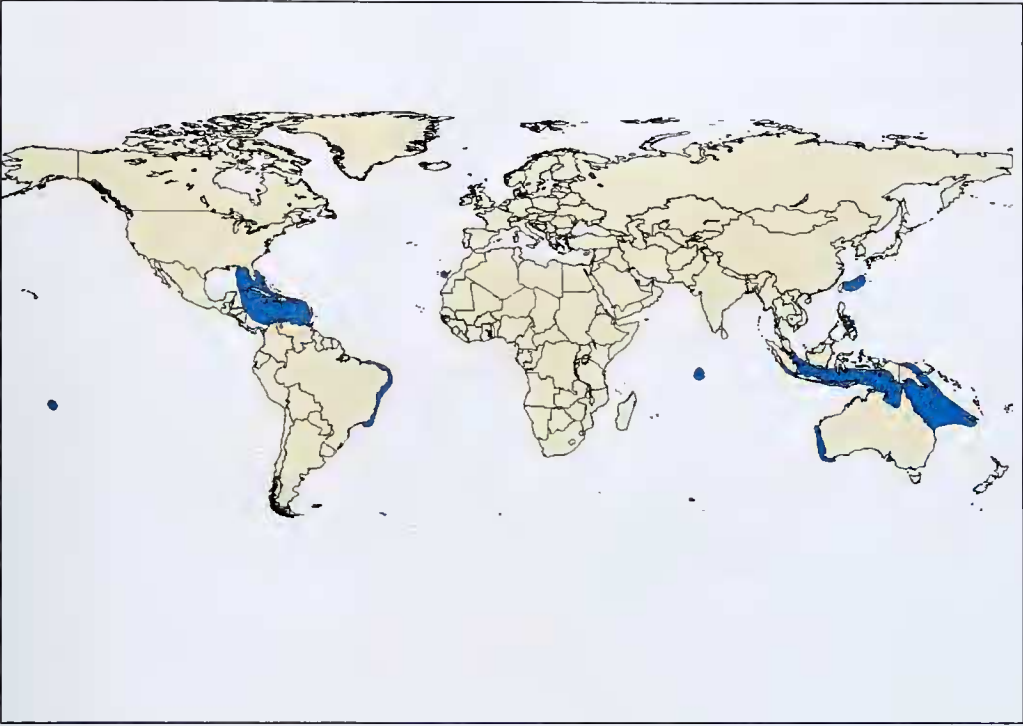
Halophila baillonis



Halophila beccarii



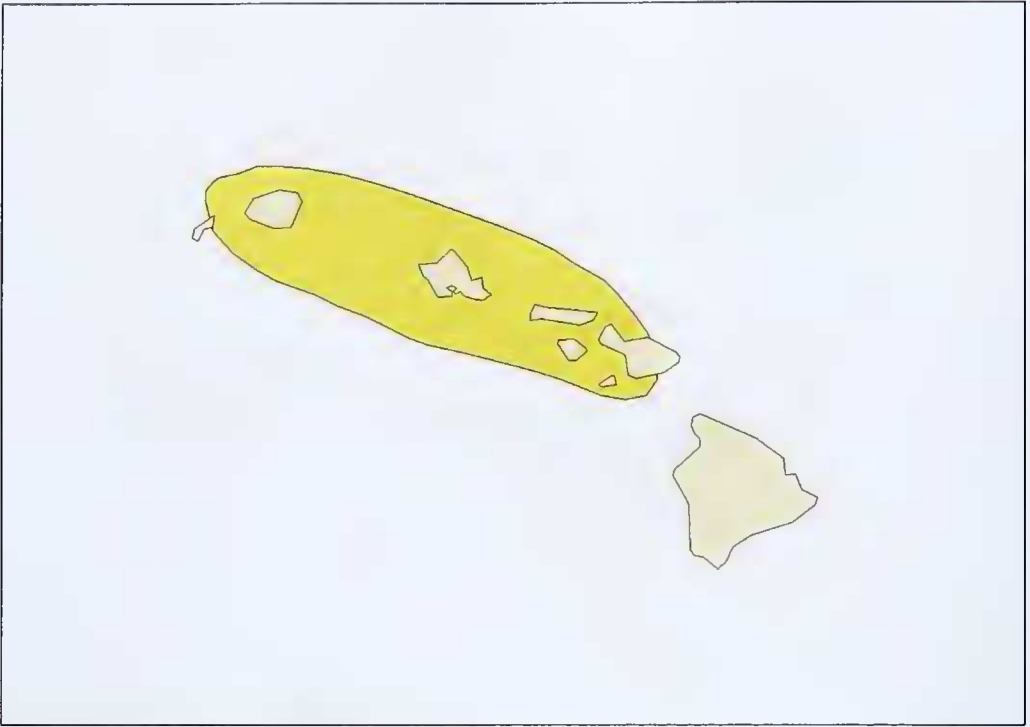
Halophila capricorni



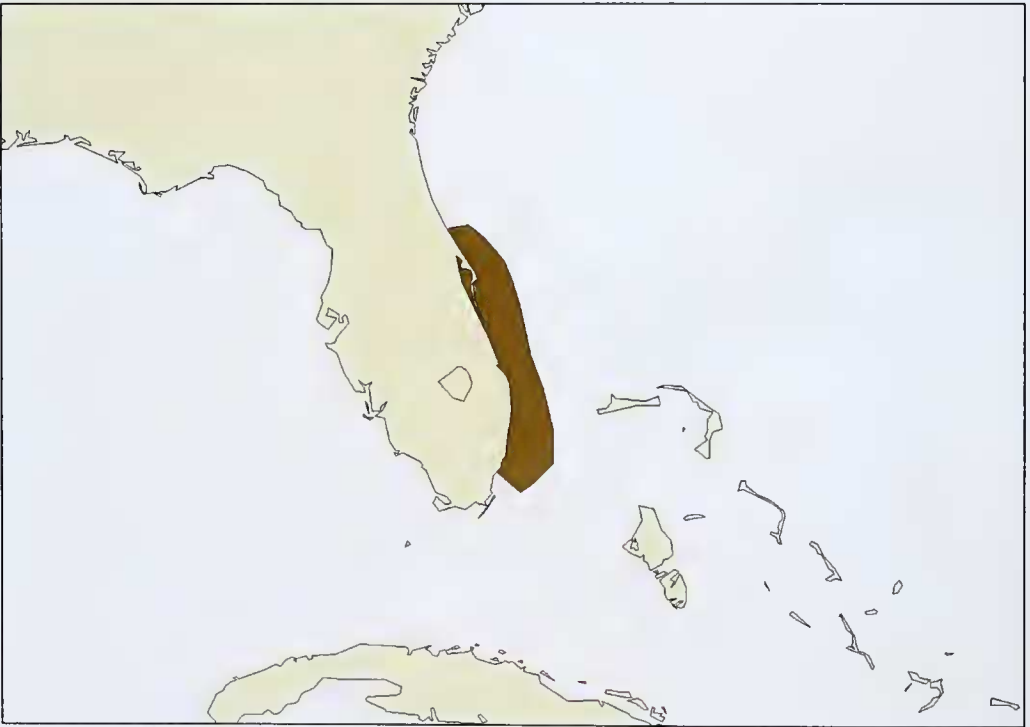
Halophila decipiens



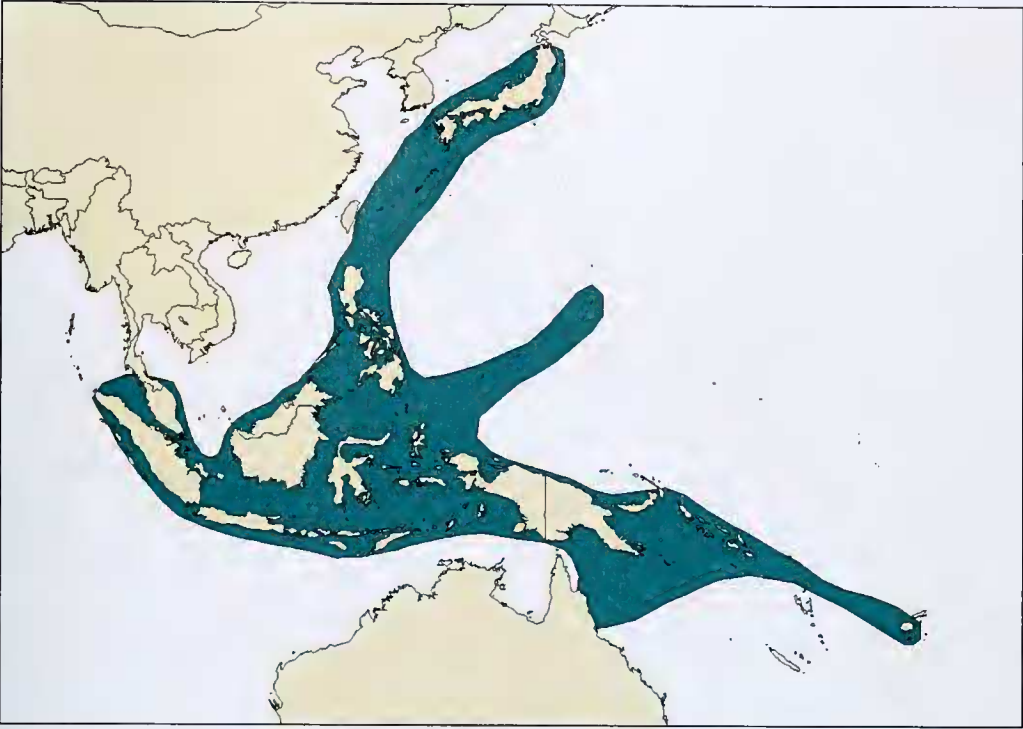
Halophila engelmannii



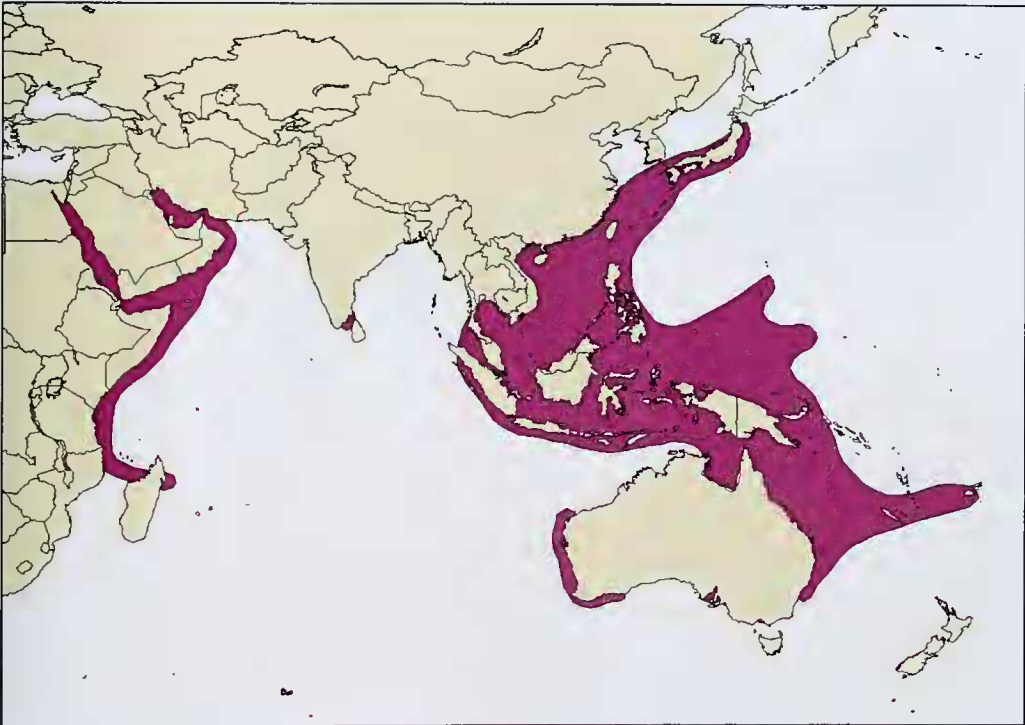
Halophila hawaiiiana



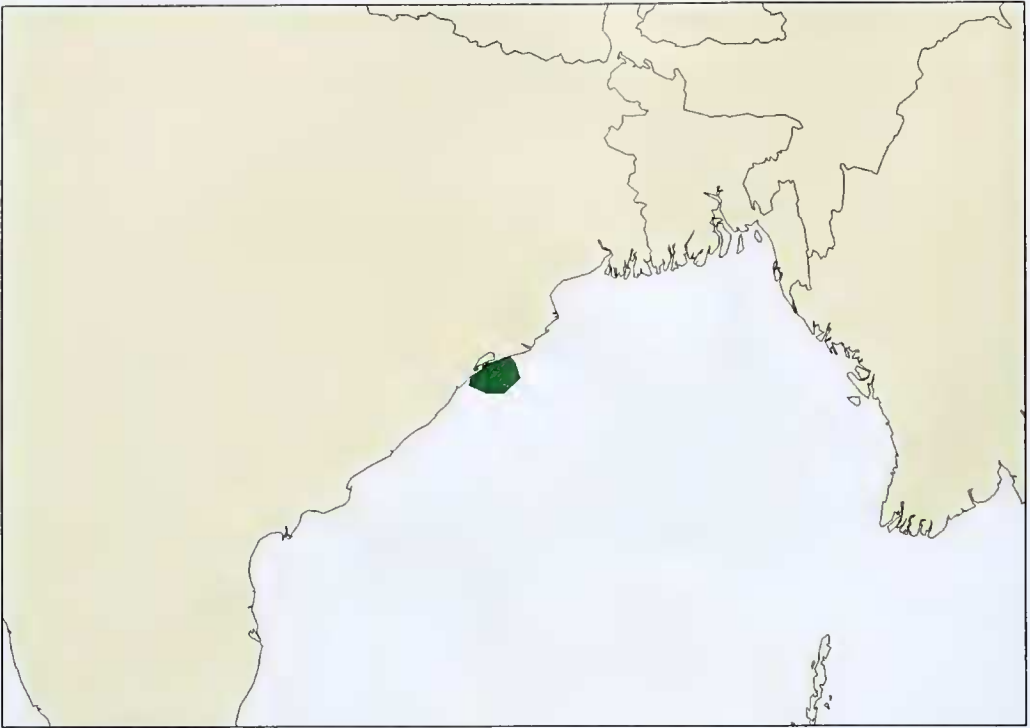
Halophila johnsonii



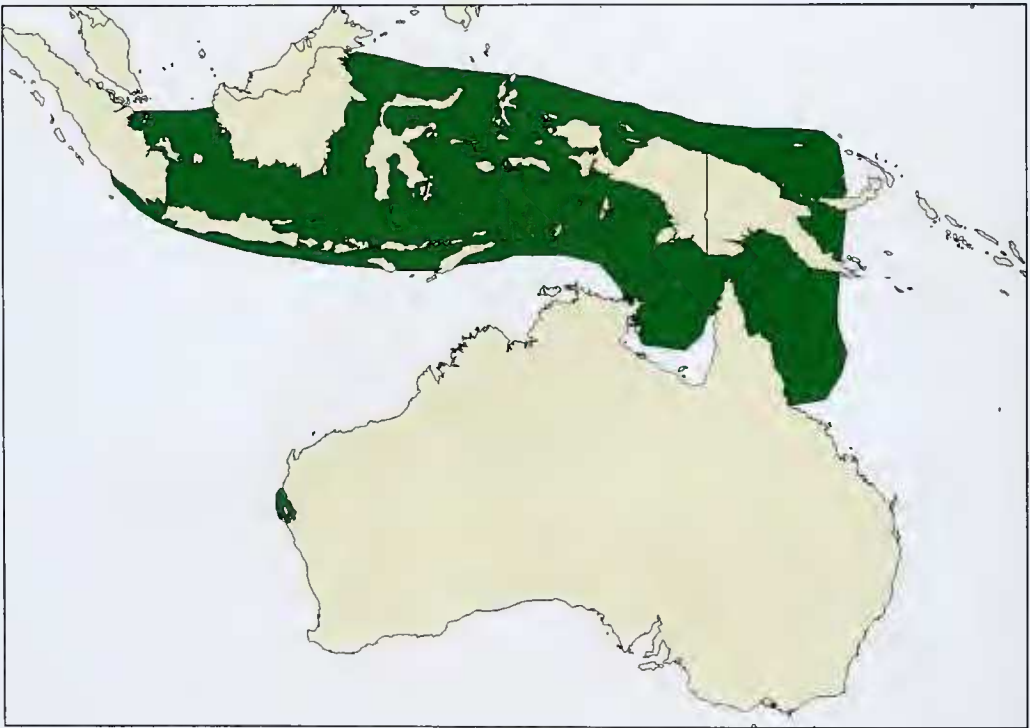
Halophila minor



Halophila ovalis



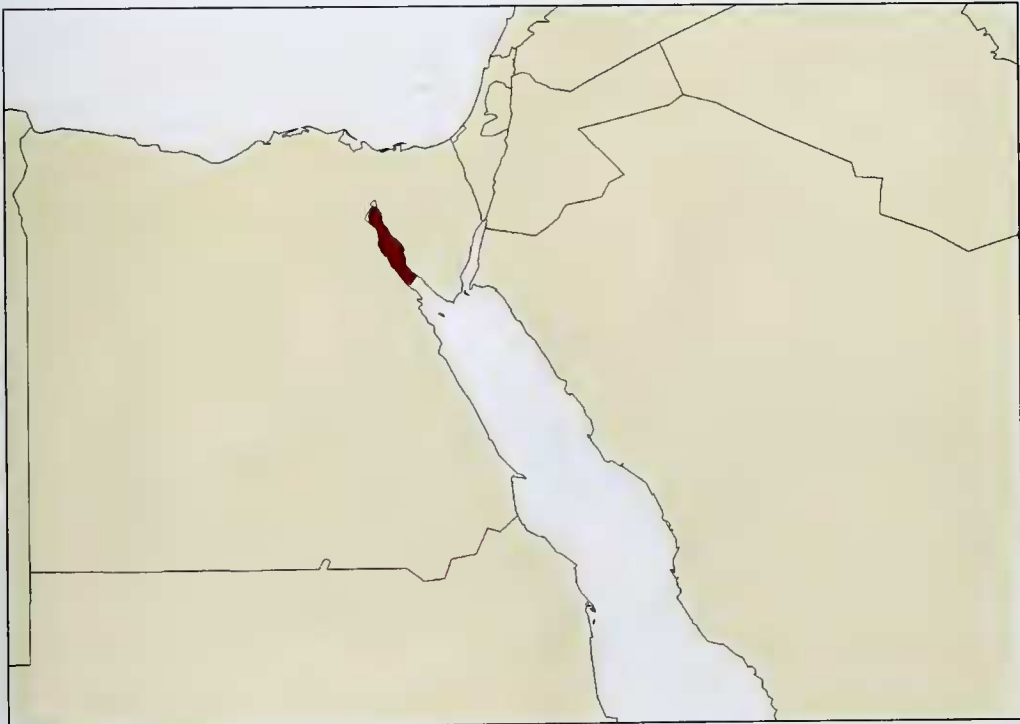
Halophila ovata (a)



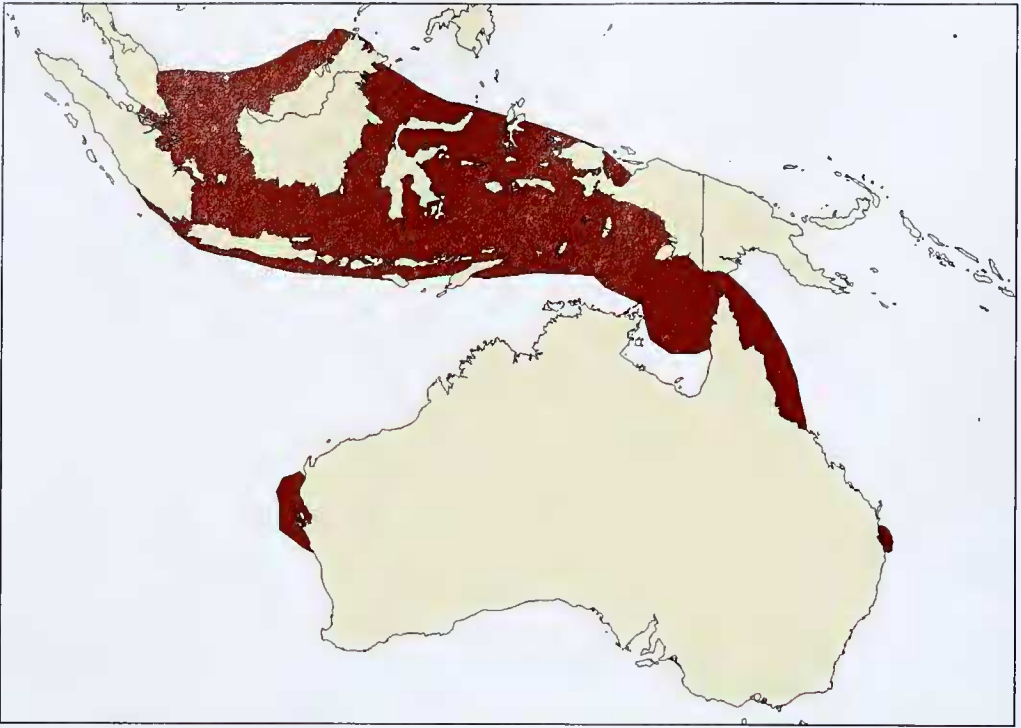
Halophila ovata (b)



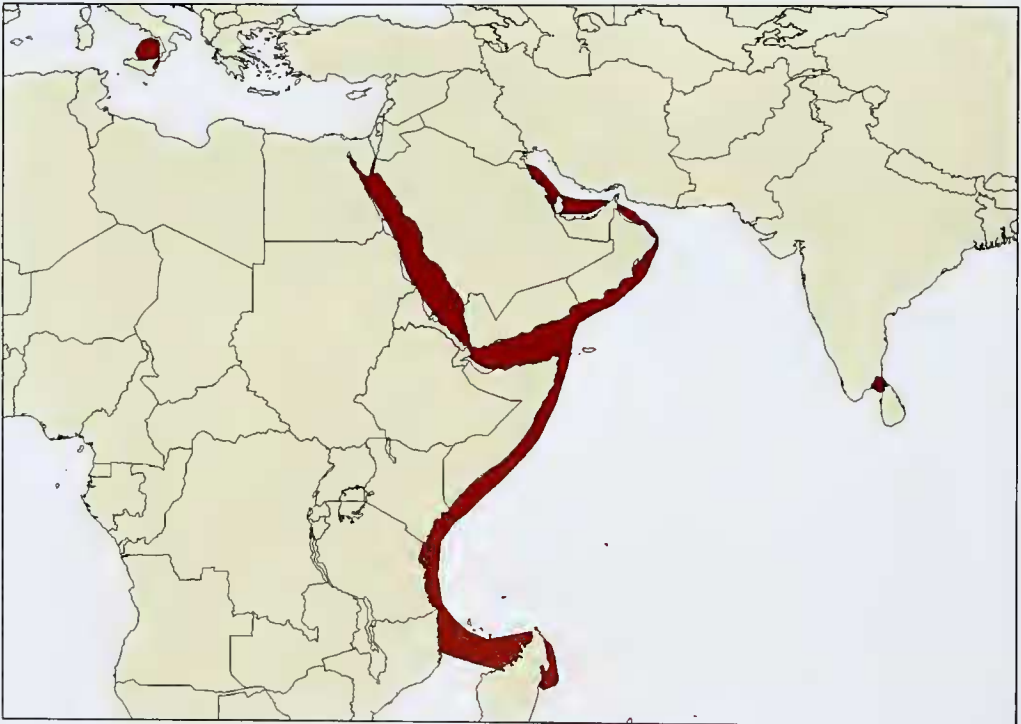
Halophila ovata (c)



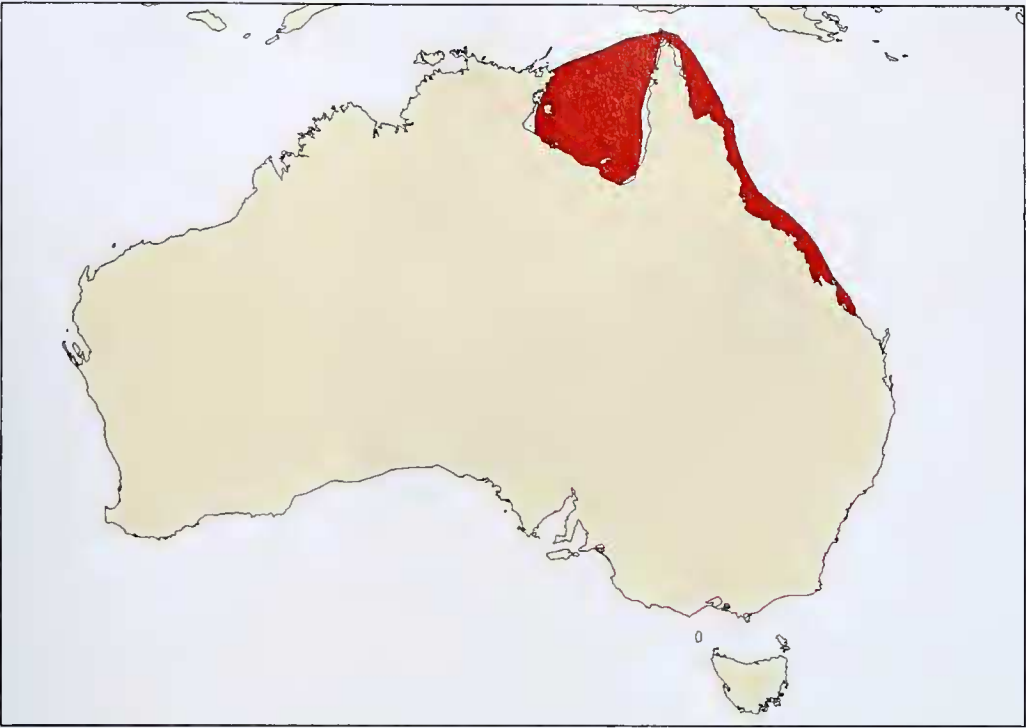
Halophila spinulosa (a)



Halophila spinulosa (b)



Halophila stipulacea



Halophila tricostata

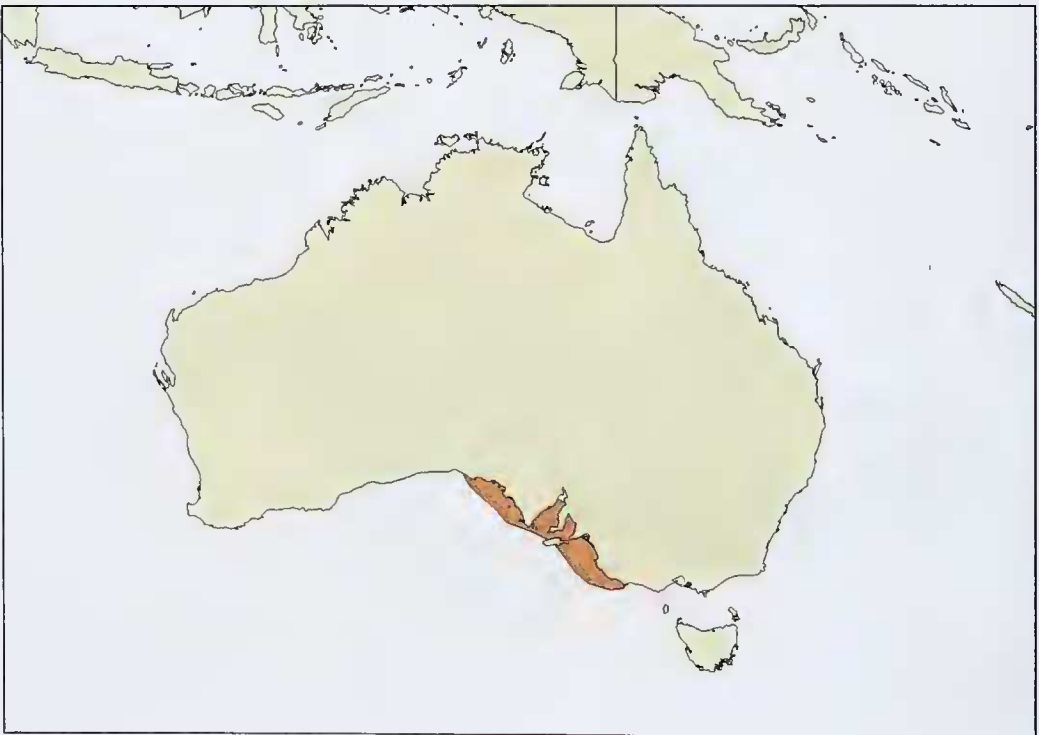


Thalassia hemprichii

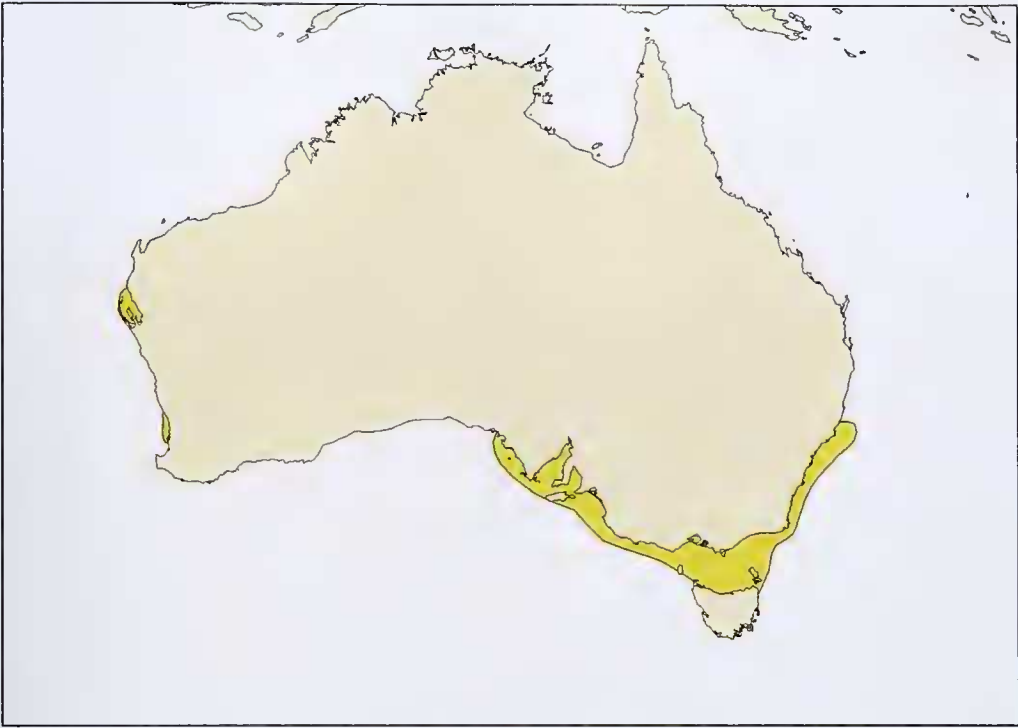


Thalassia testudinum

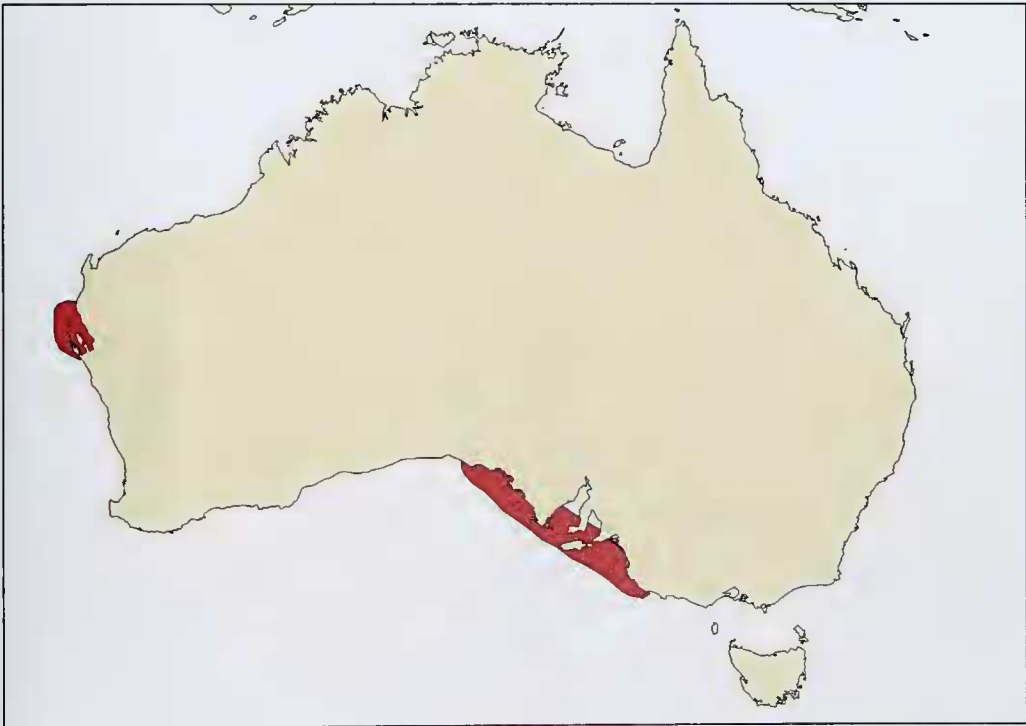
Posidoniaceae



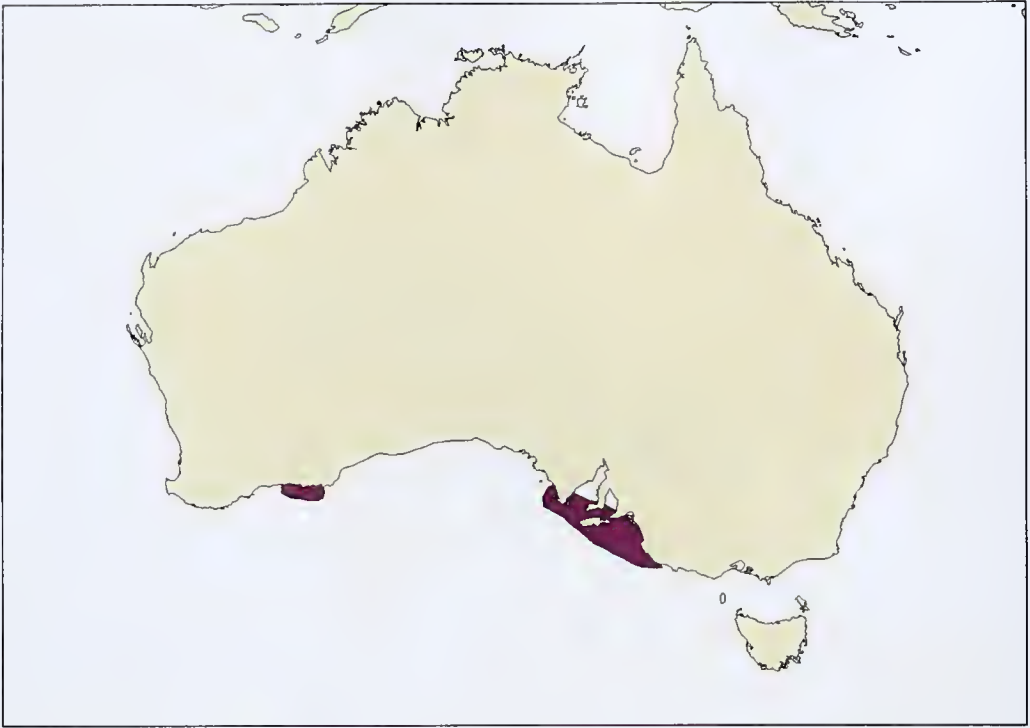
Posidonia angustifolia



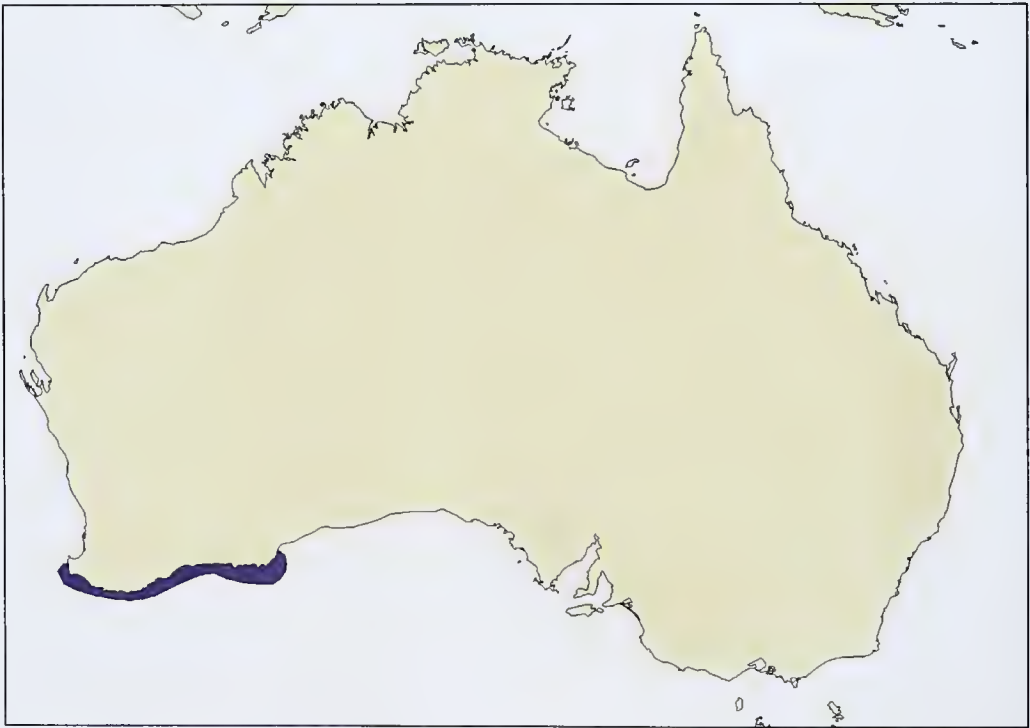
Posidonia australis



Posidonia coriacea



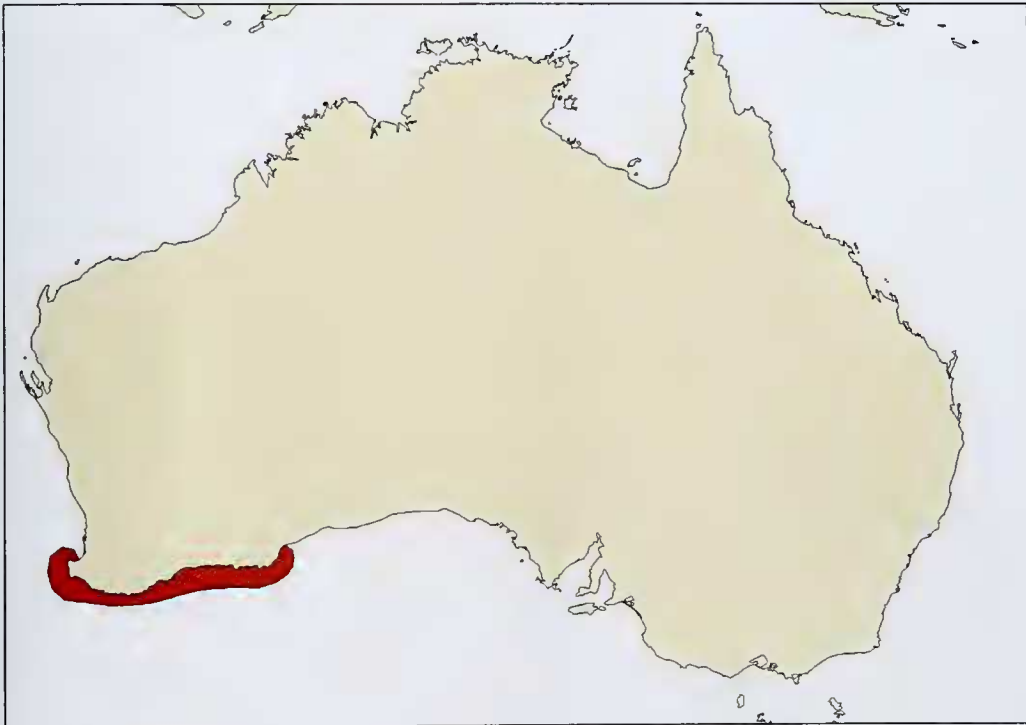
Posidonia denhartogii



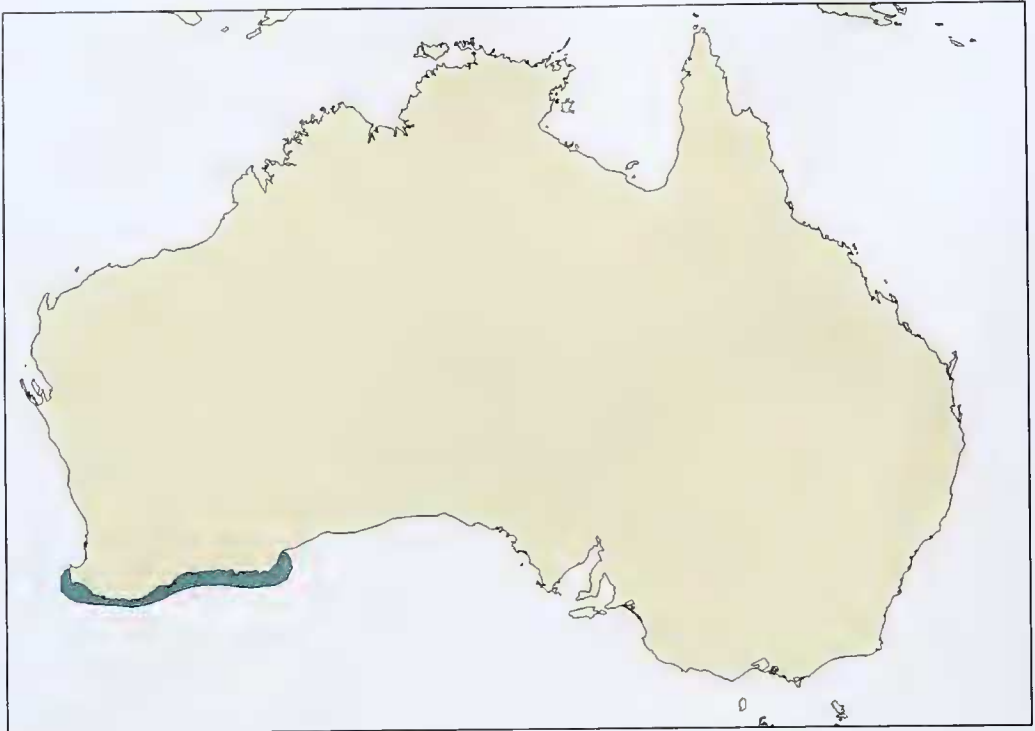
Posidonia kirkmanii



Posidonia oceanica



Posidonia ostenfeldii



Posidonia robertsonae



Posidonia sinuosa

Zosteraceae



Heterozostera tasmanica(a)



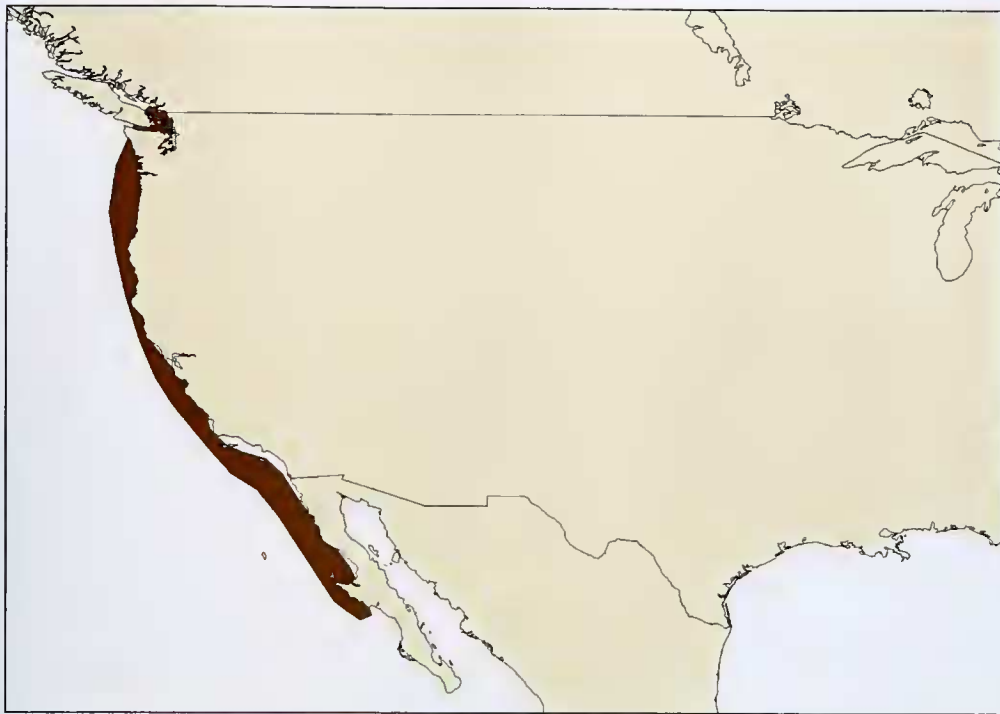
Heterozostera tasmanica(b)



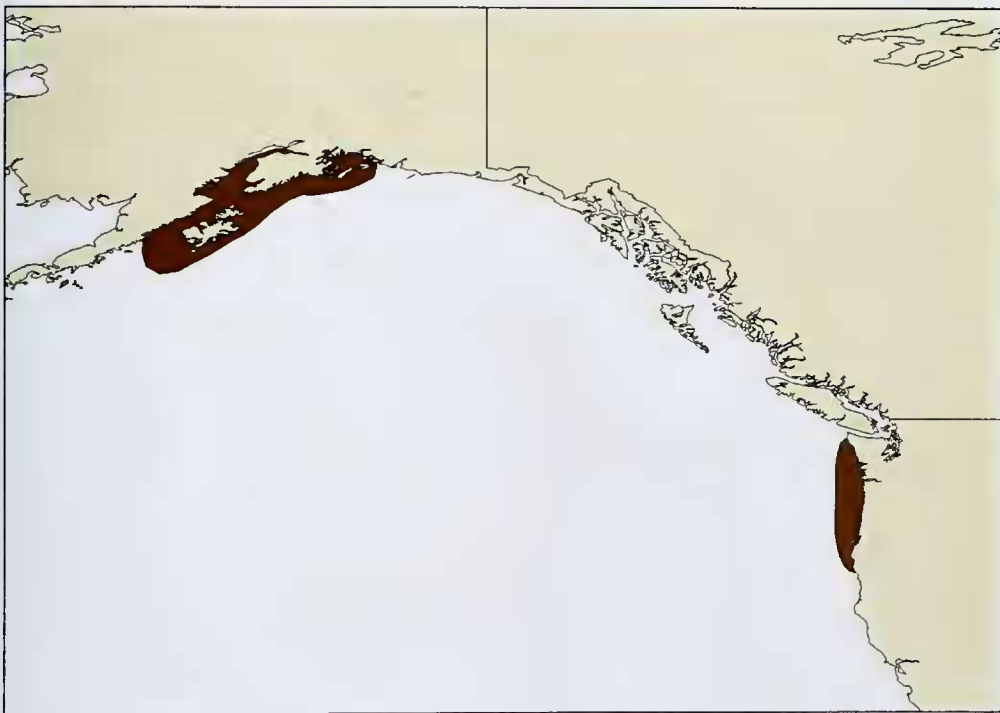
Phyllospadix iwatensis



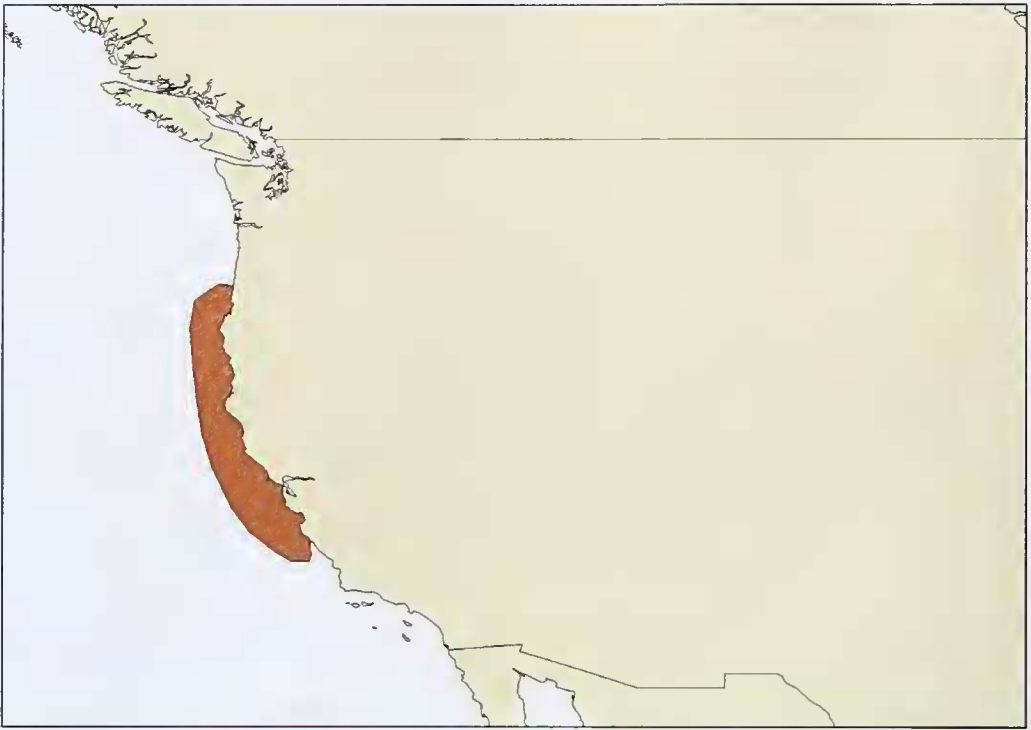
Phyllospadix japonicus



Phyllospadix scouleri



Phyllospadix serrulatus



Phyllospadix torreyi



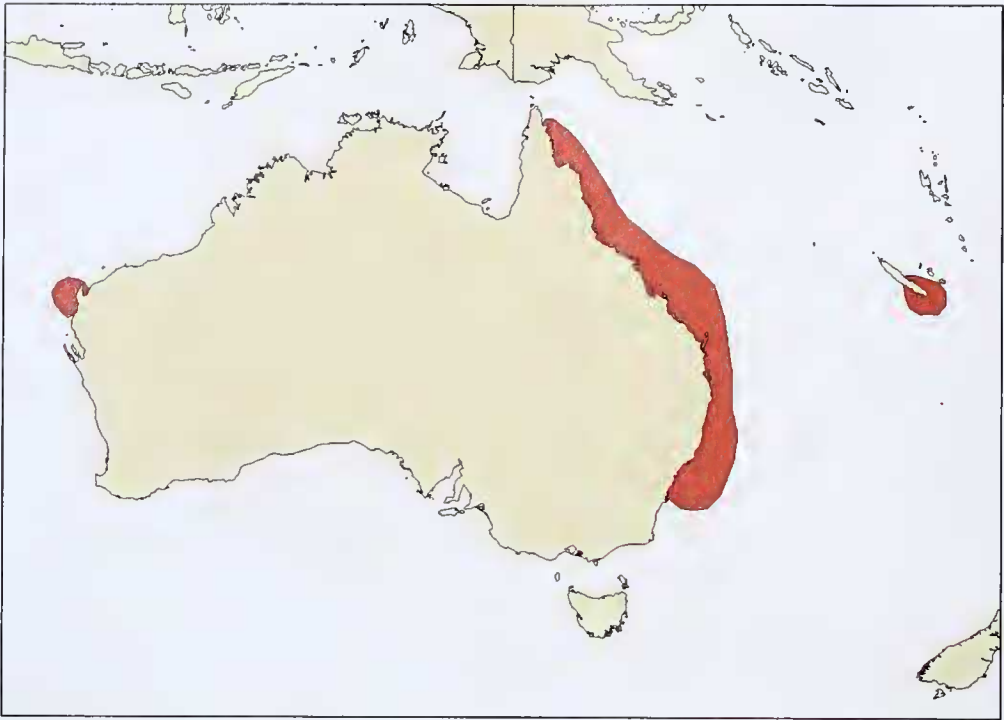
Zostera asiatica



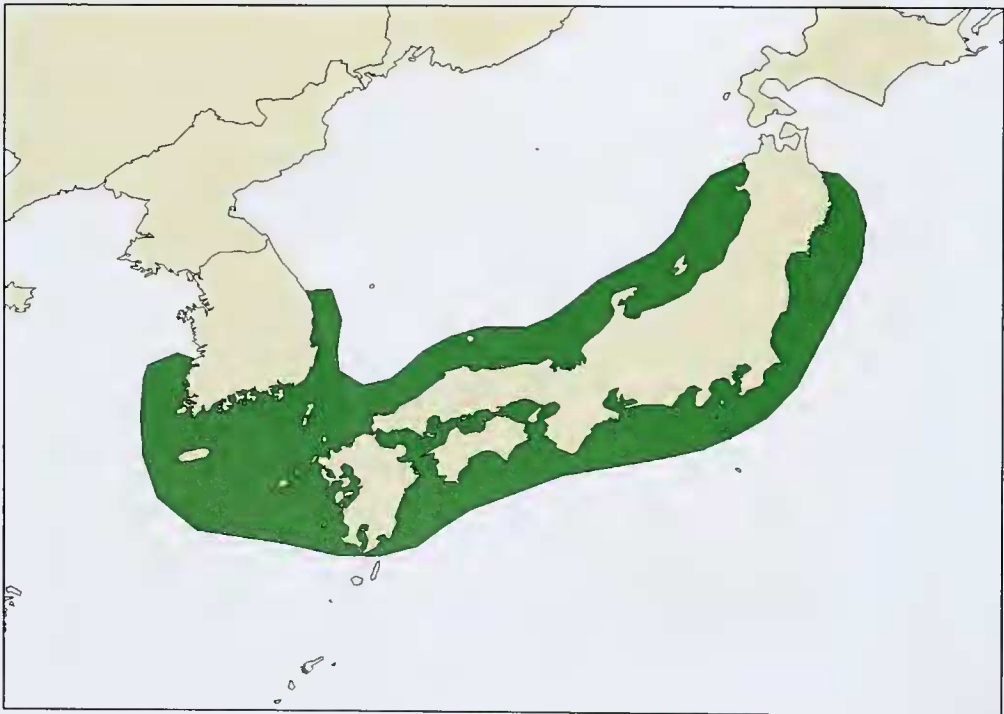
Zostera caespitosa



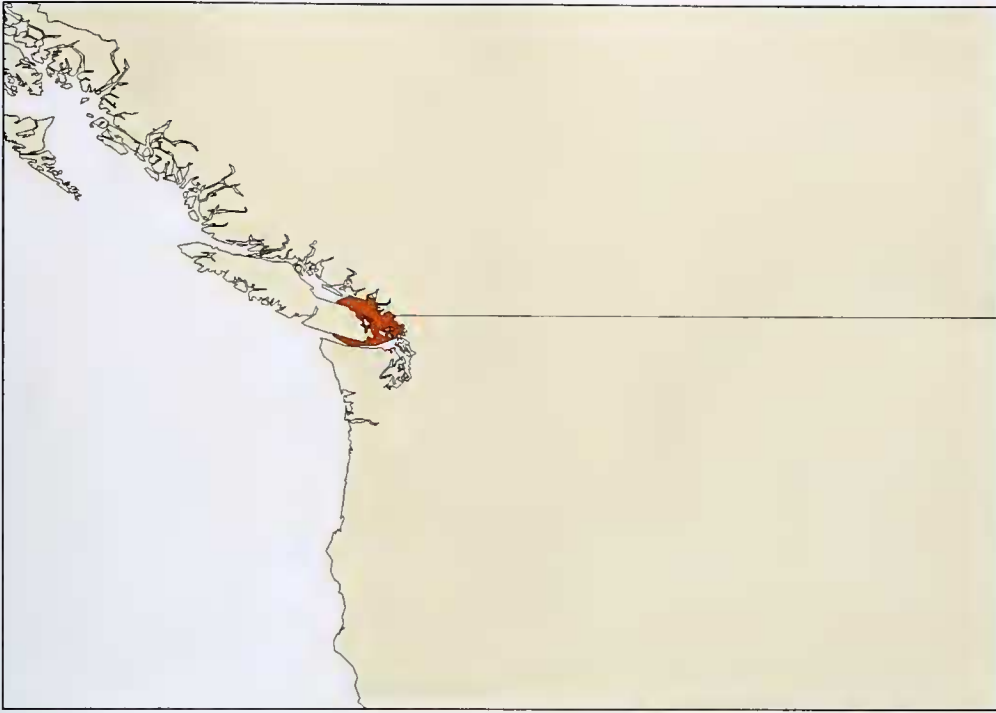
Zostera capensis



Zostera capricorni



Zostera caulescens



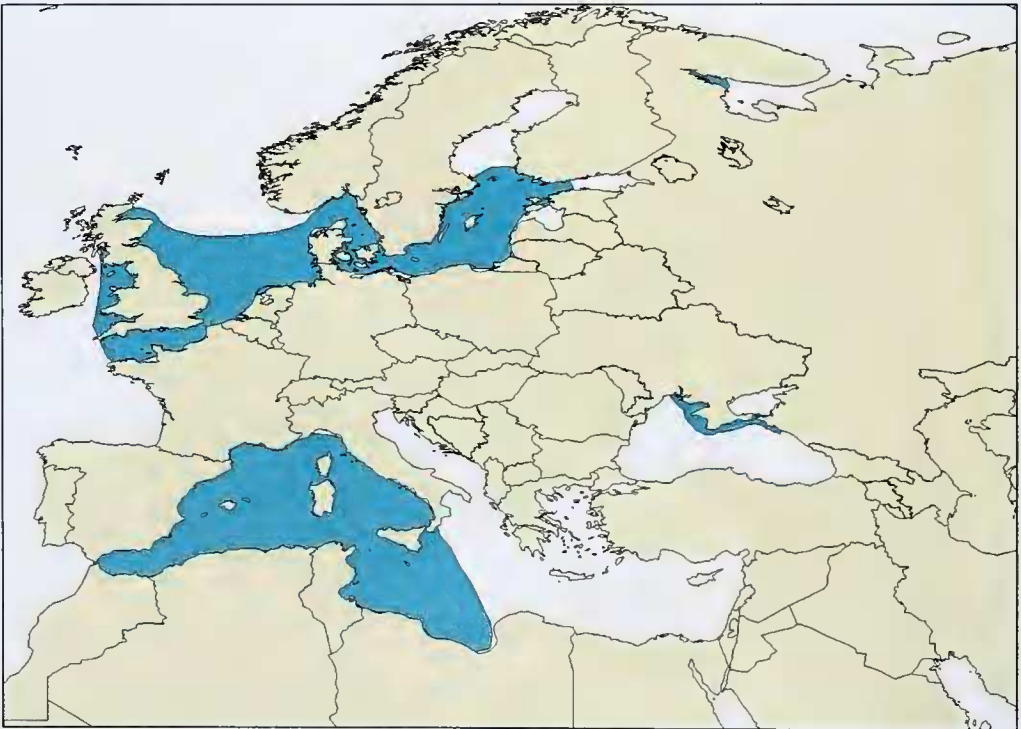
Zostera japonica(a)



Zostera japonica(b)



Zostera marina(a)



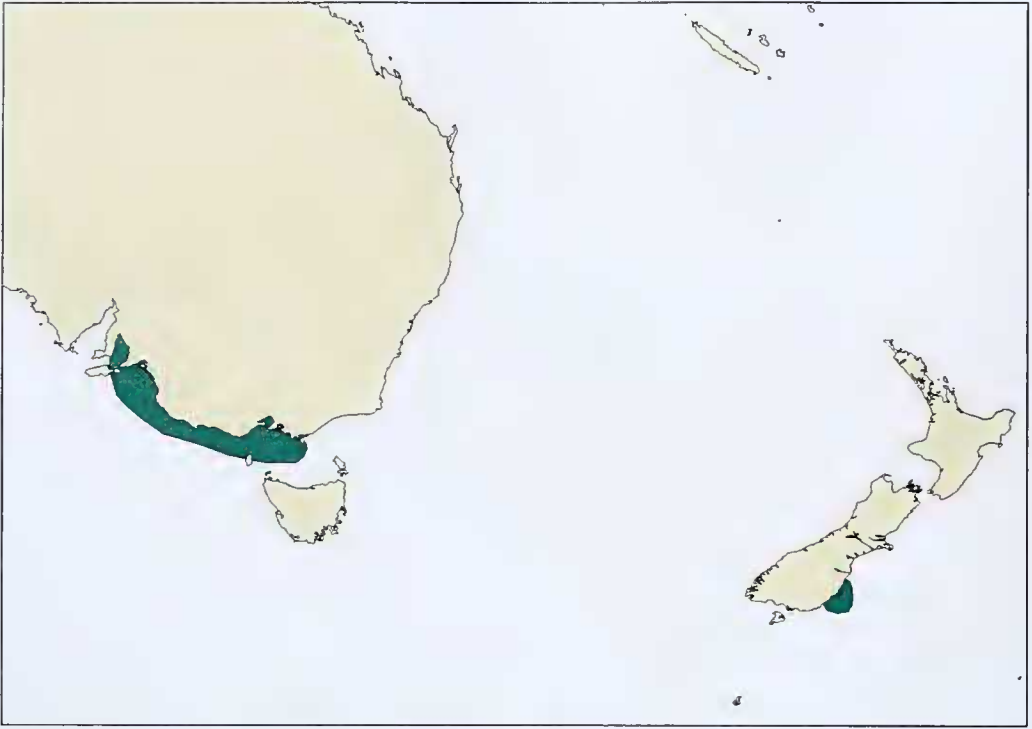
Zostera marina(b)



Zostera marina(c)



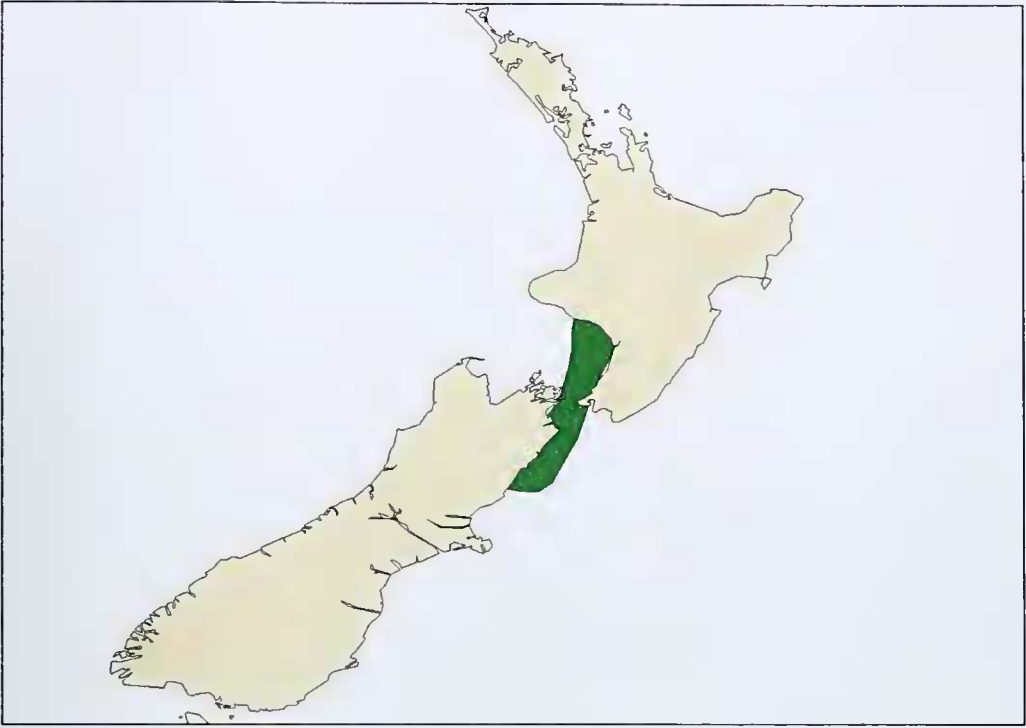
Zostera mucronata



Zostera muelleri



Zostera noltii



Zostera novazelandica

Annex 3 – Seagrass distribution maps

Map A3.1: Caribbean



Map A3.2: Europe



Map A3.3: Indian Ocean



Map A3.4: Eastern Asia



Map A3.5: Australia



Map A3.6: Brazil



Great Barrier Reef!

Annex 4 – Full list of MPAs by country

COUNTRY	AREA NAME	DESIGNATION	IUCN CAT	SIZE (ha)	YEAR
Antigua and Barbuda	Cades Bay	Marine Reserve			1999
Australia	Corner Inlet	Marine and Coastal Park	VI	18	1986
Australia	Hinchinbrook Island	National Park	II	399	1989
Australia	Wilsons Promontory	National Park	II	49	1898
Bahamas	Union Creek	Managed Nature Reserve	Ia	1,813	1965
Belize	Half Moon Caye	National Monument	III	3,925	1982
Belize	Hol Chan	Marine Reserve	IV	411	1987
Belize	Port Honduras	Marine Reserve	IV	847	2000
Belize	South Water Caye	Marine Reserve	IV	298	1996
Brazil	Saltinho	State Forest Reserve 2		1	1986
British Indian Ocean Territory	Diego Garcia	Restricted Area	V		1994
Cambodia	Ream	National Park	II	15	1993
Cayman Islands	Little Sound (Grand Cayman)	Environmental Zone	Ib	1,731	1986
Cayman Islands	North Sound (Grand Cayman)	Replenishment Zone	IV	331	1986
Cayman Islands	South Sound (Grand Cayman)	Replenishment Zone	IV	317	1986
Cayman Islands	Spott Bay (Cayman Brac)	Replenishment Zone	IV	33	1986
China	Shan Kou	Nature Reserve	V	8	1990
Colombia	Corales del Rosario y de San Bernardo	Natural National Park	II	12	1977
Colombia	Old Providence McBean Lagoon	Natural National Park	II	995	1996
Colombia	Tayrona	Natural National Park	II	15	1964
Costa Rica	Cahuita	National Park	II	1,422	1970
Costa Rica	Gandoca-Manzanillo	National Wildlife Refuge	IV	9,449	1985
Cuba	Punta Francés - Punta Pederales	Parque Nacional Marino	II	17,424	1985
Cyprus	Lara-Toxeftra	Marine Reserve	IV	65	1989
Dominica	Cabrits	National Park	II	531	1986
Dominican Republic	Del Este	National Park	II	88	1975
Dominican Republic	Jaragua	National Park	II	1,374	1983
Dominican Republic	Los Haitises	National Park	II	1,543	1976
Dominican Republic	Montecristi	National Park	II	1,395	1983
France	Cote Bleue	Marine Park	VI	37	1982
France	Scandola	Nature Reserve (by Decree)	IV	1,669	1975
French Polynesia	Scilly (Manuae)	Territorial Reserve	IV	113	1992
Germany	Strelasund Sound/Greifswald lagoon/Isle Greifswald	Wetland Zone of National Importance	V		1980
Germany	Wismar bight/Salzhafter area	Wetland Zone of National Importance	V		1980
Guadeloupe	Grand Cul de Sac Marin	Nature Reserve	IV	3,736	1987
Guam	Guam	Territorial Seashore Park	VI	6,135	1978
Honduras	Jeanette Kawas	National Park	II	78,162	1988
Honduras	Punta Izopo	Wildlife Refuge	IV	112	1992
India	Gulf of Mannar	Biosphere Reserve (National)	VI	15	1989
Indonesia	Arakan Wowontulap	Nature Reserve	Ia	138	1986
Indonesia	Bali Barat	National Park	II	77,727	1982
Indonesia	Pulau Bokor	Nature Reserve	Ia	15	1921
Indonesia	Pulau Rambut	Nature Reserve	Ia	18	1939
Indonesia	Ujung Kulon	National Park	II	122,956	1992
Jamaica	Montego Bay	Marine Park	II	153	1991
Jamaica	Negril	Marine Park			1998

COUNTRY	AREA NAME	DESIGNATION	IUCN CAT	SIZE (ha)	YEAR
Jamaica	Ocho Rios	Protected Area	V		1966
Kenya	Malindi	Marine National Park	II	63	1968
Kenya	Malindi-Watamu	Marine National Reserve	VI	177	1968
Martinique	Caravelle	Nature Reserve	IV	422	1976
Mauritania	Banc d'Arguin	National Park	II	1,173	1976
Mauritius	Flacq	Fishing Reserve	IV	6	1983
Mauritius	Trou d'Eau Douce Fir	Fishing Reserve	IV	7	1983
Mexico	Arrecifes de Puerto Morelos	National Park	II	1,828	1998
Mexico	Banco Chinchorro	Biosphere Reserve (National)	VI	14,436	1996
Mexico	El Vizcaíno	Biosphere Reserve (National)	VI	254,679	1988
Mexico	Ría Lagartos	Other area		4,784	1979
Mexico	Sistema Arrecifal Veracruzano	National Marine Park	II	52,239	1992
Mozambique	Bazaruto	National Park	II	15	1971
Mozambique	Ilhas da Inhaca e dos Portugueses	Faunal Reserve	IV	2	1965
Mozambique	Marromeu	Game Reserve	IV	1	1969
Mozambique	Zambezi	Wildlife Utilization Area	VI	1	1981
Netherlands Antilles	Bonaire	Marine Park		26	1979
Netherlands Antilles	Saba	Marine Park		82	1987
Nicaragua	Cayos Miskitos	Marine Reserve	Ia	5	1991
Palau	Ngerukewid Islands		III	12	1956
Panama	Comarca Kuna Yala (San Blas)	Indigenous Commarc		32	1938
Papua New Guinea	Kamiali	Wildlife Management Area	VI	47,413	1996
Papua New Guinea	Maza (I)	Wildlife Management Area	VI	18,423	1978
Papua New Guinea	Talele Islands	Provincial Park	IV	4	1973
Philippines	St Paul Subterranean River	National Park	II	5,753	1971
Puerto Rico	Boqueron	Wildlife Refuge (Refugio de Vida Silvestre)	IV	237	1964
Puerto Rico	Cayos de la Cordillera	Nature Reserve	IV	88	1980
Puerto Rico	Estuarina Nacional Bahía Jobos	Hunting Reserve	IV	1,133	1981
Puerto Rico	Isla Caja de Muerto	Nature Reserve	IV	188	1988
Puerto Rico	Jobos Bay	National Estuarine Research Reserve	IV	1,168	1981
Puerto Rico	La Parguera	Nature Reserve	IV	4,973	1979
Réunion	Iles Glorieuses	Nature Reserve	IV		1975
Réunion	Ilot d'Europa	Nature Reserve	IV		1975
Saint Lucia	Maria Islands	Nature Reserve	IV	12	1982
Saint Lucia	Pigeon Island	Other area	III	2	1978
Saint Lucia	Soufriere	Marine Reserve			
Saudi Arabia	Dawat Ad-Dafl, Dawat Al- Musallamiyah & Coral Islands	Other area		21	
Saudi Arabia	Farasan Islands	Protected Area	Ia	696	1989
Seychelles	Port Launay	Marine National Park	II	158	1979
Seychelles	St. Anne	Marine National Park	II	1,423	1973
Singapore	Southern Islands	Marine Nature Area		98	1996
Slovenia	Strunjan	Landscape Park	V	192	1990
Spain	Doñana	National Park (State Network)	II	572	1969
Tanzania	Chumbe Island Coral Park (CHICOP)	Marine Sanctuary	II	3	1994
Tanzania	Mafia Island	Marine Park	VI	822	1995
Tanzania	Misali Island	Conservation Area	VI	2,158	1998
Thailand	Hat Chao Mai	National Park	II	2,386	1981
Tonga	Fanga'uta and Fanga Kakau Lagoons	Marine Reserve	VI	2,835	1974
Tonga	Pangaimotu Reef	Reserve	IV	49	1979

COUNTRY	AREA NAME	DESIGNATION	IUCN CAT	SIZE (ha)	YEAR
Trinidad and Tobago	Buccoo Reef	Nature Reserve	Ia	65	1973
Tunisia	Ichkeul	National Park	II	126	1980
Turks and Caicos Islands	West Caicos Marine	National Park	IV	397	1992
United Kingdom	Helford River	Voluntary Reserve			1987
United Kingdom	Isles of Scilly	Area of Outstanding Natural Beauty	V	16	1976
United Kingdom	Skomer	Marine Nature Reserve	IV	15	1990
United Kingdom	Skomer	National Nature Reserve	IV	37	1959
United States	Bahia Honda	State Park	V	212	1961
United States	Biscayne	National Park	II	729	1980
United States	Breton	National Wildlife Refuge	IV	3,661	1904
United States	Channel Islands	National Park	II	1,987	1980
United States	Dry Tortugas	National Park	II	2,623	1992
United States	Everglades	National Park	II	66,688	1947
United States	Florida Keys	Wilderness (Fish and Wildlife Service)	Ib	258	1975
United States	Galveston Island	State Park	Ia	786	
United States	Grand Bay	National Estuarine Research Reserve	IV	7,452	1999
United States	Gulf Islands (Florida)	National Seashore	V	54,928	1971
United States	Hawaiian Islands (8 sites)	National Wildlife Refuge	Ia	1,296	1945
United States	Izembek	National Wildlife Refuge	IV	12,266	1960
United States	John Pennekamp Coral Reef	State Park	V	22,684	1959
United States	Merritt Island	National Wildlife Refuge	IV	55,953	1963
United States	Padilla Bay	National Estuarine Research Reserve	IV	4,455	1980
United States	Pinellas	National Wildlife Refuge	IV	159	1956
United States	Rookery Bay	National Estuarine Research Reserve	IV	562	1978
United States	St. Marks	National Wildlife Refuge	IV	26,467	1931
United States Minor Outlying Island	Baker Island	National Wildlife Refuge	Ia	12,843	1974
Venezuela	Archipiélago Los Roques	National Park	II	22,112	1972
Venezuela	Médanos de Coro	National Park	II	9,128	1974
Venezuela	Mochima	National Park	II	94,935	1973
Venezuela	Morrocoy	National Park	II	329	1974
Viet Nam	Con Dao	National Park	II	1,543	1982
Virgin Islands (British)	Wreck of the Rhone	Marine Park	III	324	1980
Virgin Islands (U.S.)	Green Cay	National Wildlife Refuge	IV	6	1977
Virgin Islands (U.S.)	Sandy Point	National Wildlife Refuge	IV	134	
Virgin Islands (U.S.)	Virgin Islands	National Park	II	538	1956

