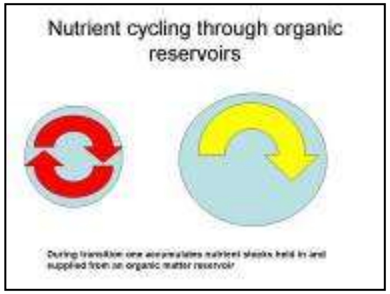
Seagrass meadows and their ecosystem services


Seagrass meadows support BIODIVERSITY and a productive coast
>350 species of fish found in tropical seagrass meadows
32 species of holothurian
>200 species of mollusc

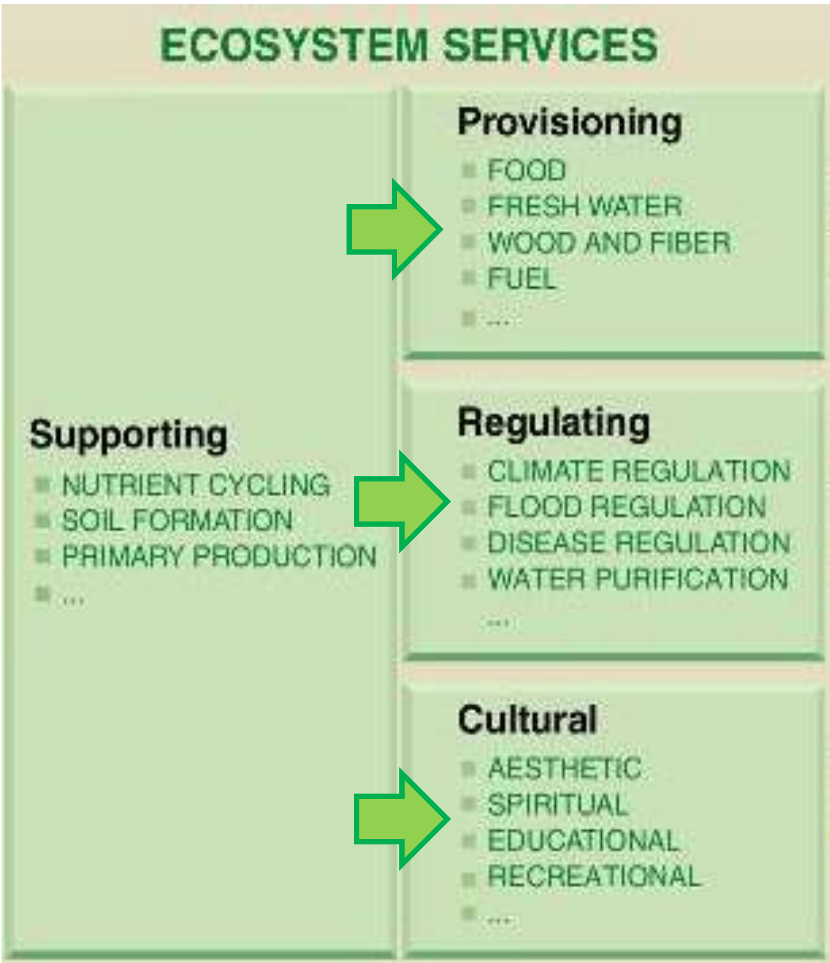
Importance of seagrass meadows

Economic value of seagrass meadows is <u>higher than that of coral reefs and tropical forests</u>



(see Watson et al. 1993, Costanza et al. 1997, Waycott et al. 2009)

Seagrass Ecosystem Services



Supporting
- Primary production and nutrient cycling
- Support high biodiversity important for resilience and stability of the wider ecosystem

Provisioning
- Habitat for commercially important species

Regulating
- Carbon sequestration
- Sediment stabilisation
- Erosion prevention

Cultural
- Habitat for culturally important species
- Educational value

Source: *Millennium Ecosystem Assessment*

Assumed but poorly quantified in many locations

SEAGRASS ECOSYSTEM RESEARCH GROUP

Seagrass Ecosystem Services:
amongst most valuable on earth

- Costanza et al 1997

Biome	Number services valued	Total value per ha ($/ha/yr)	Total global value ($ x 10^9)
Estuaries	8	**22,832**	4,110
Swamps	10	**19,580**	3,231
Seagrass	2	**19,004**	3,801
Coral Reefs	*8*	***6,075***	*375*
Tropical forest	*14*	***2,007***	*3,813*

Ecosystem	Area (10^6 ha)	Loss (% $year^{-1}$)	Value (US$ ha^{-1} $year^{-1}$)
Seagrass	18	2–5	19 004
Salt marsh	140	1–2	9 990

Creates Complex habitat to hide in

Pump oxygen into the sediments

Create enormous surface area for micro-algae to grow on

Cleanse water

Make water less turbulent

ANIMALS want to live in seagrass

SEAGRASS ECOSYSTEM RESEARCH GROUP

Why are seagrasses important?

By creating a benthic environment for animals to live in

- **Food & shelter for invertebrates**

sea hare

sea cucumber

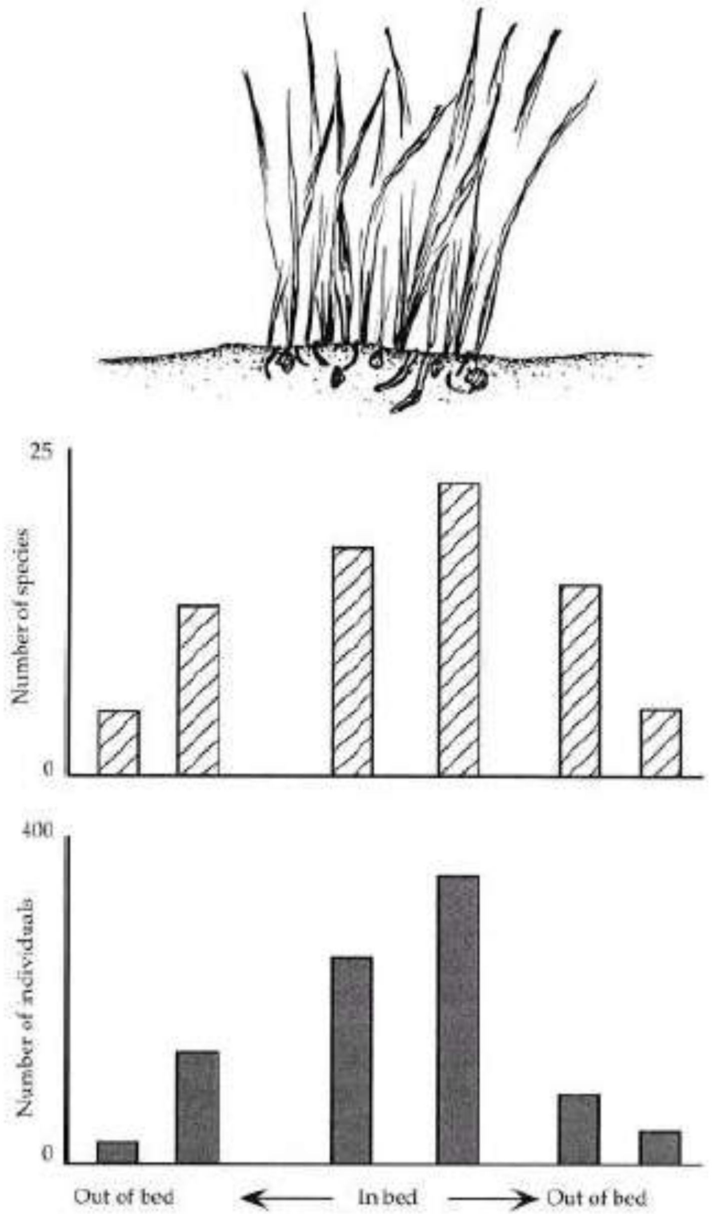
spider conch

40 times more animals occur in seagrass compared to adjacent bare sand

SEAGRASS ECOSYSTEM RESEARCH GROUP

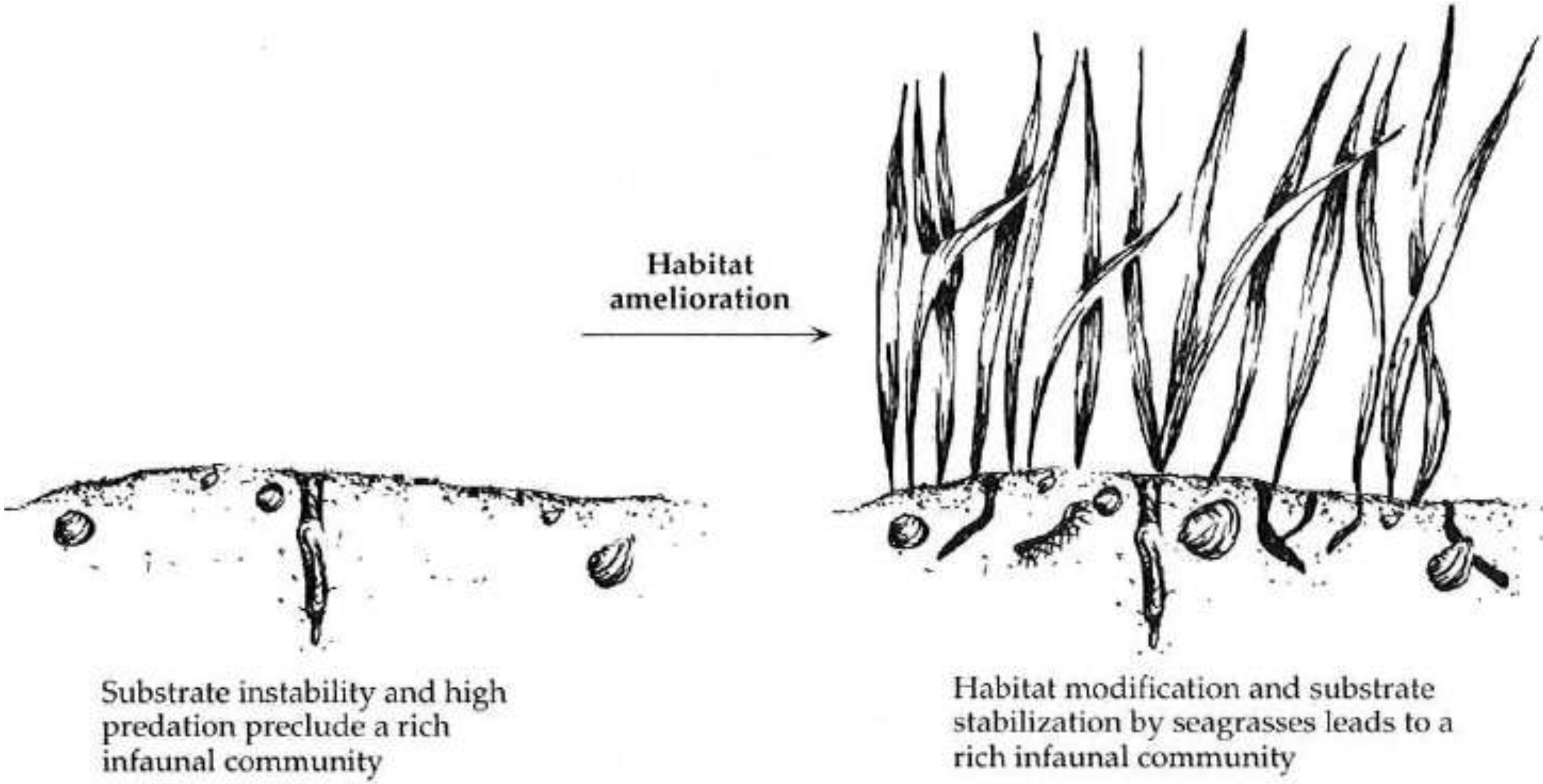
Why are seagrasses important?

- Food & shelter for invertebrates



51 Effects of seagrass beds on species richness and abundances. (After Orth 1977.)

SEAGRASS ECOSYSTEM RESEARCH GROUP



18 Habitat amelioration by seagrasses. Seagrass colonization stabilizes sediments, decreasing disturbance and limiting consumer access. This enhances further colonization and the development of a rich infaunal and epifaunal community.

SEAGRASS ECOSYSTEM RESEARCH GROUP

Habitat provision for species of conservation concern

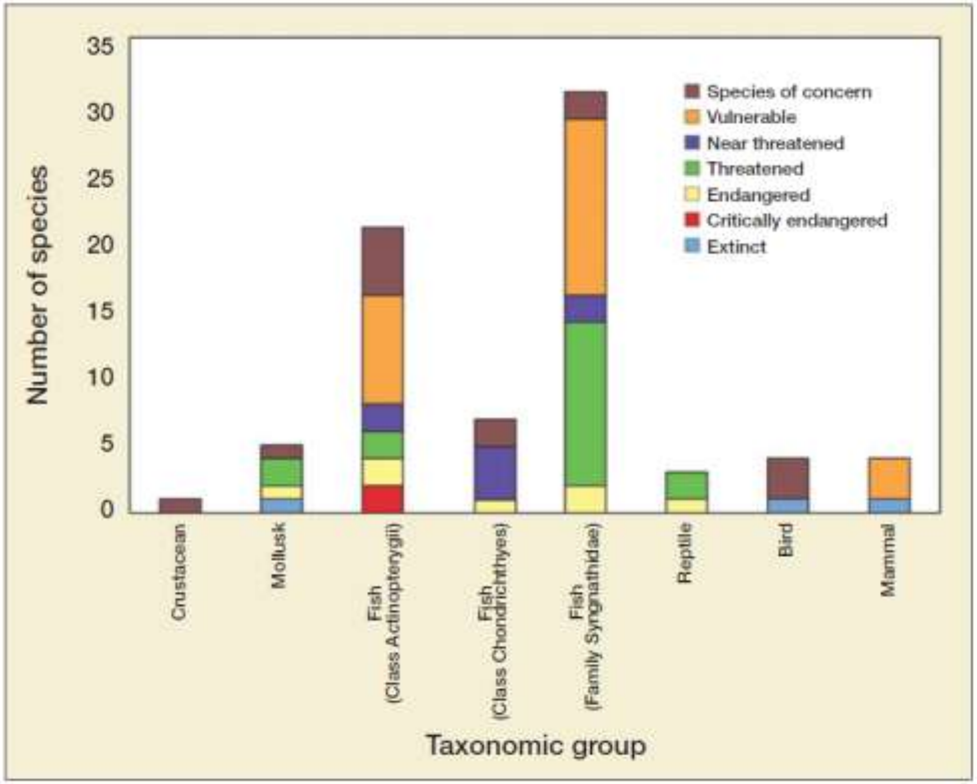


Figure 2. *Species of concern associated with seagrasses. The number of species is categorized by taxonomic group and level of concern.*

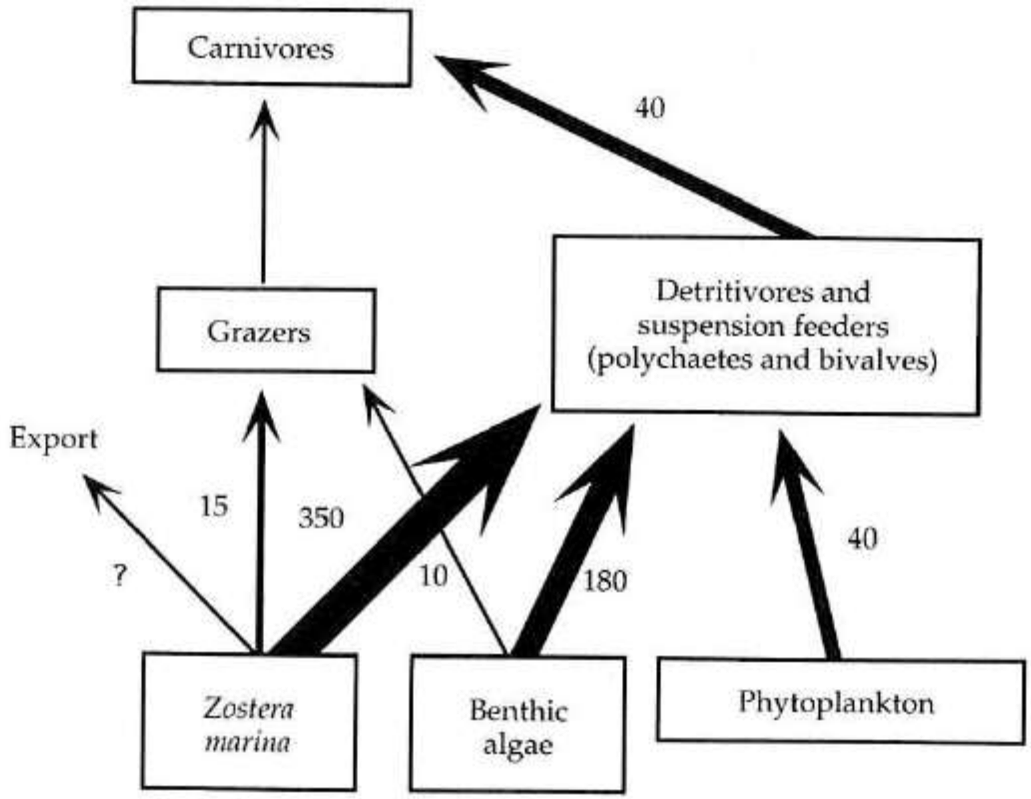
Eelgrass limpet (*Lottia alveus*):

Hughes et al. 2009

Trophic Support

- Large amounts of primary productivity
  - Supports detrital food webs
    - Large amount exported to adjacent habitats & ecosystems
  - Supports some grazing food webs
    - Direct grazing on roots & rhizomes
    - Epiphytes grazed

SEAGRASS ECOSYSTEM
RESEARCH GROUP

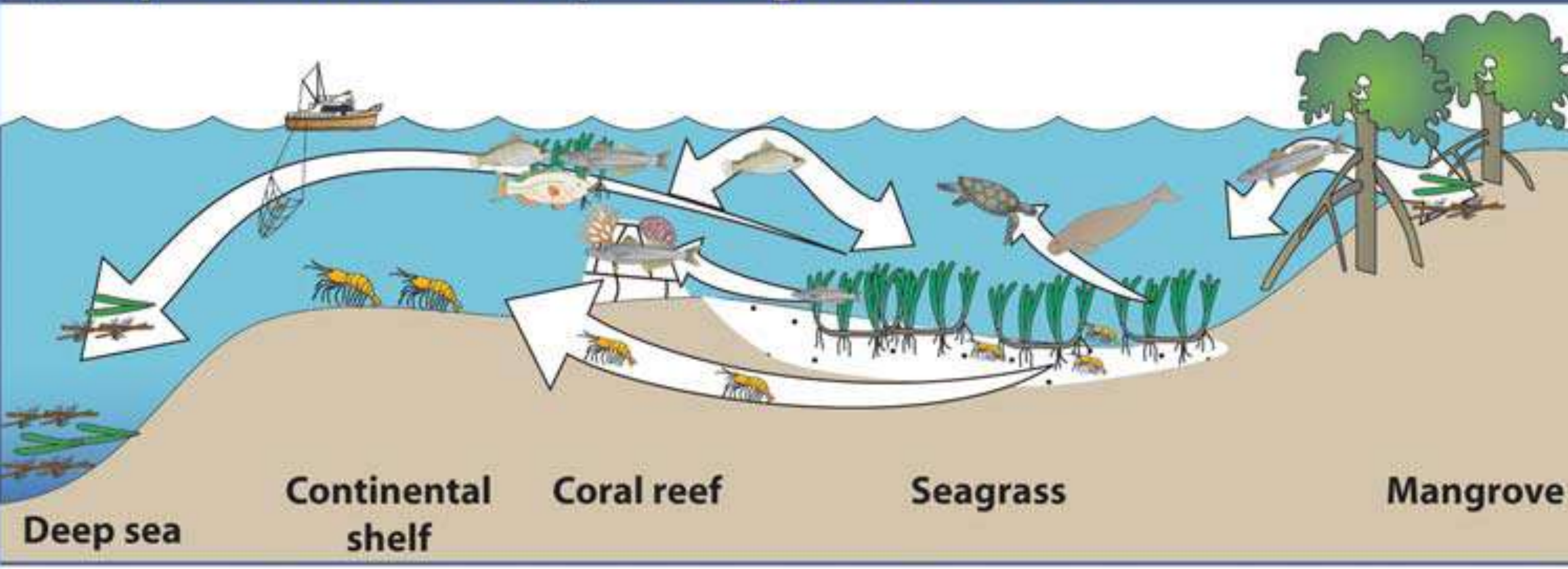


47 Energy flow in a seagrass bed (in grams of carbon per square meter per year. (After Thayer et al. 1975; Raffaelli and Hawkins 1996.)

SEAGRASS ECOSYSTEM RESEARCH GROUP

a) Trophic transfers of tropical seagrass meadows

Heck et al. 2008 Ecosystems



Seagrass detritus is common in the oceans deep trenches and supports deep sea food webs (1,3)

Shelf penaid shrimp fisheries are supported by export of juvenile shrimp from seagrass meadows (2)

Adult fish abundance and species richness increases when closely associated with seagrass meadows (10,11)

Seagrass is an important energy source for macro-fauna such as turtles, dugongs and manatees (14,15)

Large predators such as groupers and snappers use seagrass as juvenile habitat then migrate to reefs (8, 9)

Fish living amongs mangroves feed over seagrass meadows (12) and there is an import of materials from seagrass to mangrove forests (13)

Predatory (grunts) and herbivorous (parrotfishes) live on coral reefs but feed in seagrass meadows (4,5,6), this import of nutrients can enhance coral growth rates (7)

References

1. Vetter et al, 1998
2. Erhardt et al., 2001
3. Suchanek et al., 1985
4. Ogden and Ehrlich, 1977
5. Eggleston et al., 1998
6. Overholtzer and Motta, 1999
7. Meyer et al., 1983
8. Starck and Shroeder, 1971
9. Coleman et al, 1999
10. Dorenbosch et al., 2006
11. Grober-Dunsmore et al., 2007
12. Marguiller et al., 1997
13. Hemminga et al., 1994
14. Valentine and Heck, 1999
15. Valentine and Duffy, 2006

TABLE 4.10

Net Exchange of Particulate Materials Between Representative Seagrass and Seaweed Systems and Adjacent Coastal Areas

Habitat/ Location	Net Exchange	Rate/ Volume (g DW m^{-2} d^{-1})	% of Net Primary Production (NPP)	Ref.
Seagrass/ Virgin Islands	Export	0.02	1% (*Thalassia*)	292
		0.18–0.36	60–100% (*Syringodium*)	
Seagrass/Fiji	Export	6.96	88% (*Syringodium*)	293
Kelp/South Africa	Export	0.32[a]	10% (mixed kelps)	195
Seagrass/ North Carolina	Export	0.01–0.26[b]	1–8% (sheltered *Zostera*)	294
		0.23–0.57[b]	10–30% (exposed *Zostera*)	
Seagrass/Florida	Export	0.14–0.38	8–22% (*Syringodium*)	295
Seagrass/ Mediterranean	Export	0.05–0.36[a]	35–55% (exposed *Posidonia*)	245
Embayment/ Philippines	Import	0.45	8% (mangroves)	283
	Export	0.76–1.3	6.5–6.7% (mixed seagrasses)	
Coral Island/ Indonesia	Export	0.08	35.5% (*Cymodocea*)	293
			1.6% (*Enhalus*)	
			22.9% (*Thalassia*)	

[a] Units are g C m^{-2} d^{-1}.

[b] Units are g AFDW m^{-2} d^{-1}.

SEAGRASS ECOSYSTEM RESEARCH GROUP

Why are seagrasses important?

- Feeding place for shorebirds

Seagrass as a fish nursery

School master snapper (*Lutjanus apodus*) uses seagrass as a nursery habitat

Nassau grouper *(Epinephelus striatus*) uses seagrass as a juvenile

Nursery and spawning ground for a range of economically important species

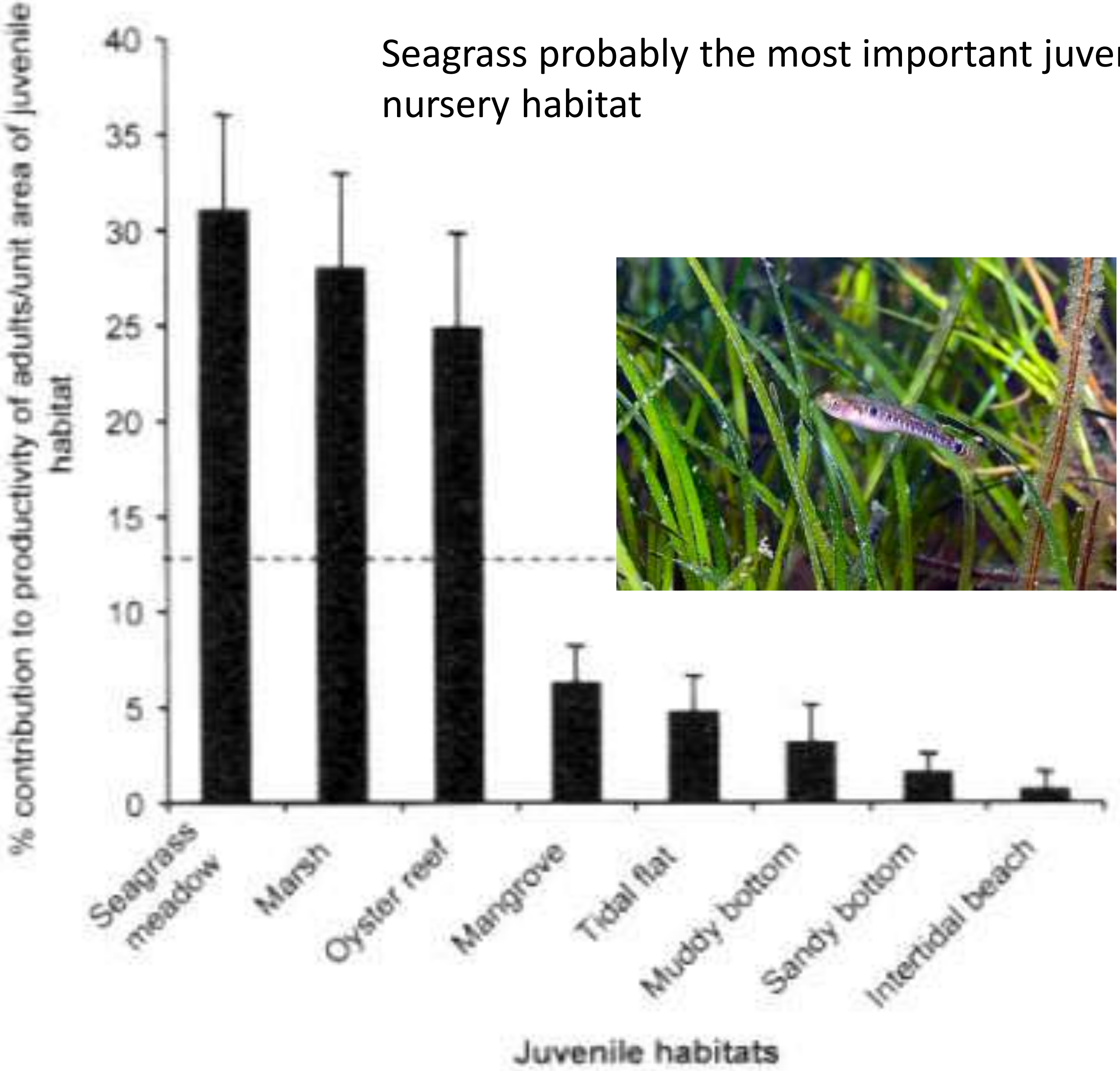
SEAGRASS ECOSYSTEM RESEARCH GROUP

Seagrass provides coastal protection

- Leaf canopies baffle water currents and waves, increases sedimentation
- Network of rhizomes stabilize the sediment and reduce resuspension
- Influenced by the diversity of the landscape (patch arrangement, fragmentation), but also by the diversity of primary producers (epiphyte, associated drift algae)

SEAGRASS ECOSYSTEM RESEARCH GROUP

Seagrass probably the most important juvenile nursery habitat



SEAGRASS ECOSYSTEM RESEARCH GROUP

A juvenile fish that settles in seagrass will:

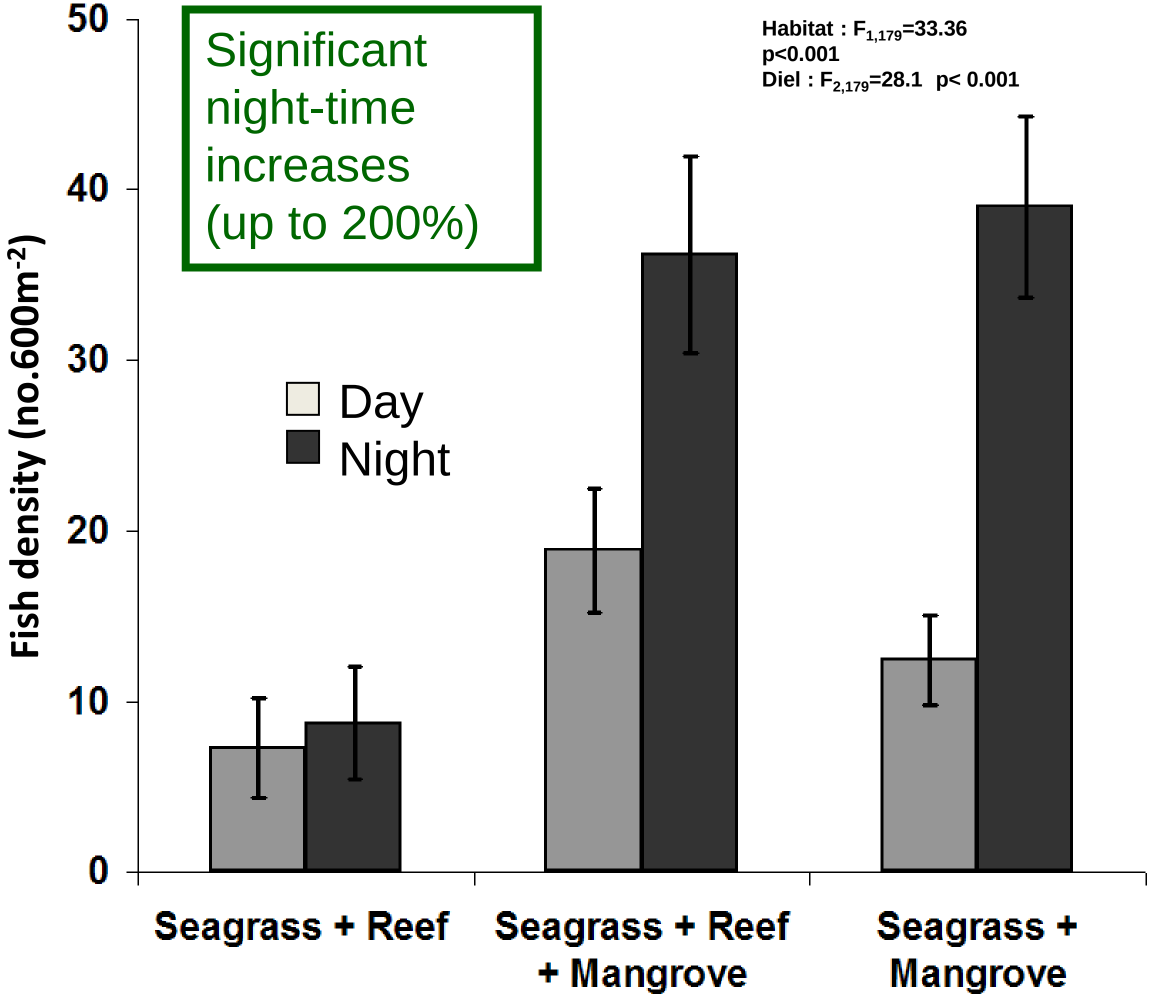
Grow faster

Have better chances of survival in first year

Will be fitter and healthier as it migrates to deeper water

SEAGRASS ECOSYSTEM
RESEARCH GROUP

Habitat connections – seagrass- mangrove –reef

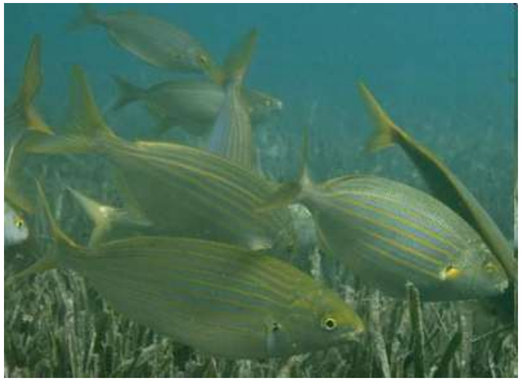


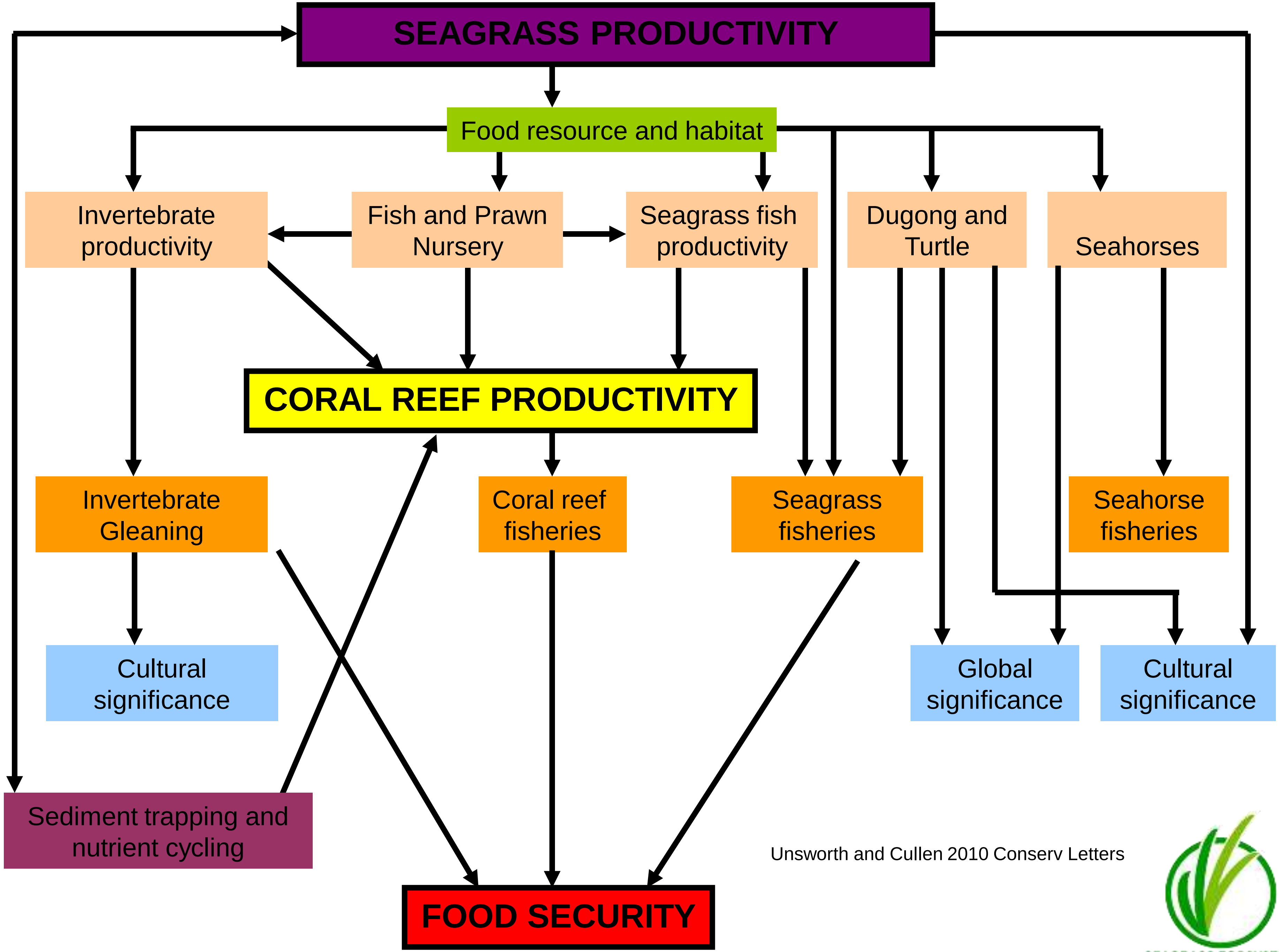
Not all seagrass the same – some more important for fish

Significant difference between all three different habitat types
•Seagrass + mangrove + reef = highest abundance

Unsworth et al 2008 MEPS

Seagrass herbivory

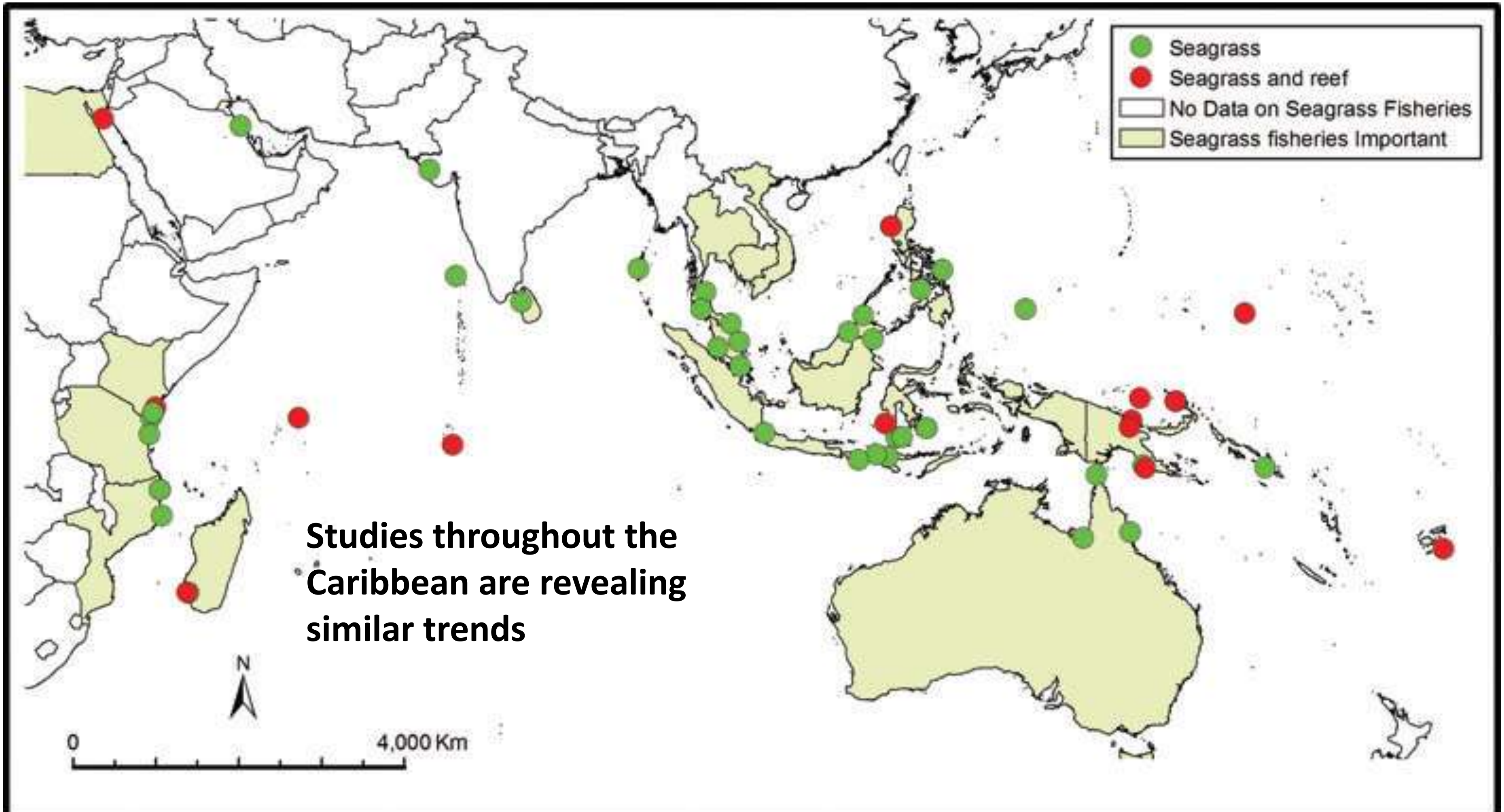




Unsworth and Cullen 2010 Conserv Letters

SEAGRASS ECOSYSTEM RESEARCH GROUP

Seagrass fisheries an important source of regional food security



Studies throughout the Caribbean are revealing similar trends

In some locations 100% of daily protein needs come from seagrass meadows

Seagrass Productivity

Highly productive: global average biomass 180 g C m^{-2}

Average net production of about 400 g C m^{-2} yr^{-1}, ranking amongst the most productive ecosystems in the biosphere.

Contribution 1.13% of the total marine primary production

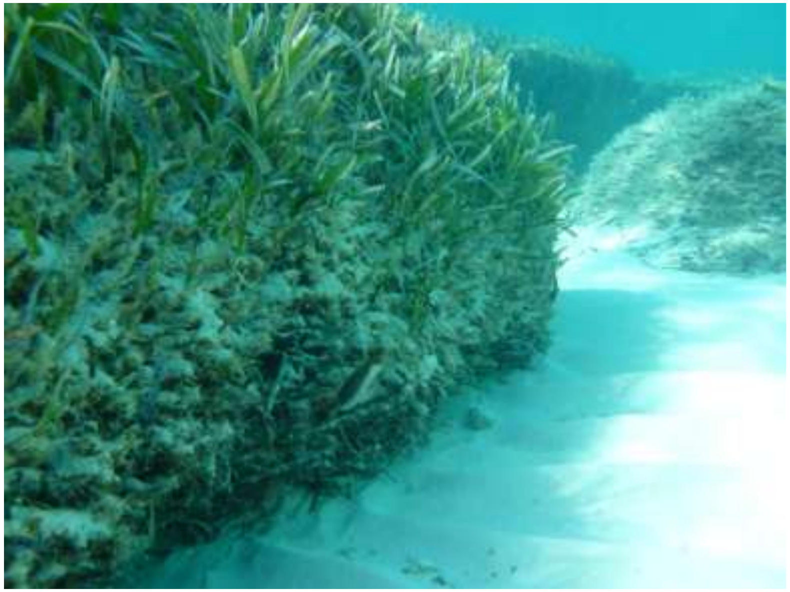
But cover 0.15% of the global ocean

Table 15. Net annual primary production of a range of different plant communities g C m^{-2}

Ecosystem	Location	Authors	Production (gCm^{-2} per annum)
Grasslands	Global	(Duarte and Chiscano 1999)	182
Tropical Mangrove	Global	(Lugo 1988)	335
Temperate Forest	Europe	(Luyssaert *et al.*)	447
Tropical Rainforest	Amazon	(Malhi *et al.* 2009)	1150
Tropical Reef Seagrass	Torres Strait	(Rasheed *et al.* 2008b)	434
Seagrass Average	Global	(Duarte and Chiscano 1999)	344
Tropical Coastal Seagrass	**Abbot Point**	**Present study**	**237**

SEAGRASS ECOSYSTEM RESEARCH GROUP

Seagrass as a carbon sink



Seagrass bury up to 27 Tg C year^{-1}, or about 12% of the total carbon storage in marine ecosystems.

Seagrasses are important components of the marine carbon cycle, being responsible for a significant fraction of the net CO_2 uptake by marine biota.

SEAGRASS ECOSYSTEM RESEARCH GROUP

Carbon sink and nutrient cycling

*An estimated **27.4 TgCyr^{-1}** is buried in seagrass beds (12% of total Carbon burial in the seas)*

High primary production

Particle trapping

Slow tissue turnover

Absorb and transform nutrients

Low levels of herbivory

- Despite significance of seagrass in global carbon budgets (Fourqurean et al., 2011) we do not know what controls delivery and storage of organic matter.

- Dense seagrass beds fix more carbon than they release: Global estimates - threshold of GPP (186 mmol O_2 m^{-2} d^{-1}) (seagrass biomass of 41gDW m^{-2}) above which seagrass communities act as CO_2 sink (Duarte et al. 2010).

SEAGRASS ECOSYSTEM RESEARCH GROUP

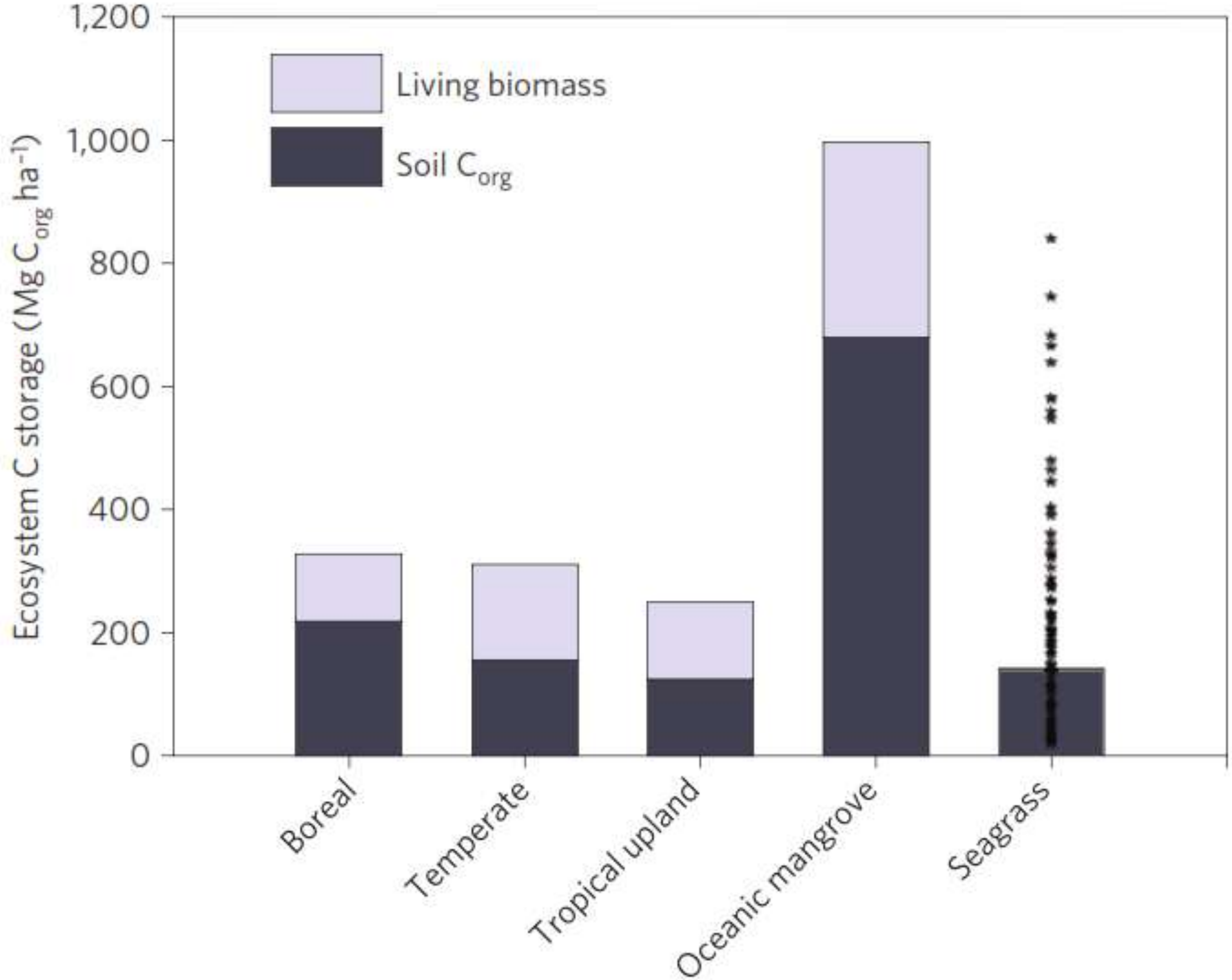
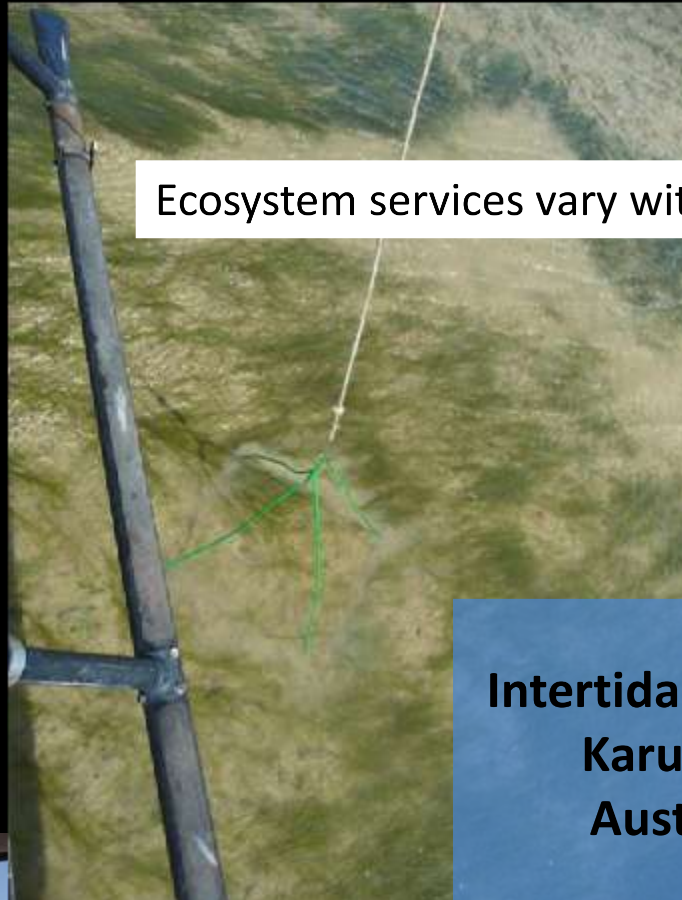


Figure 5 | A comparison of seagrass soil C_{org} storage in the top metre of the soil with total ecosystem C_{org} storage for major forest types.

SEAGRASS ECOSYSTEM RESEARCH GROUP

Research Example

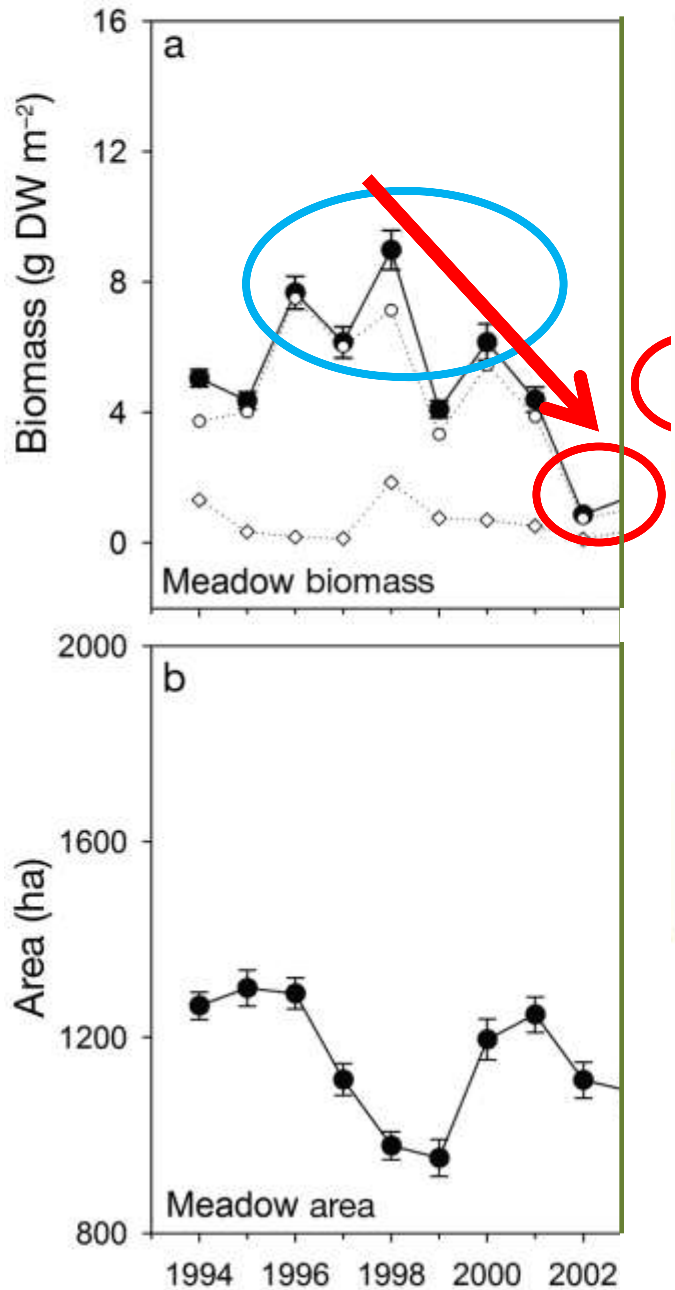
Ecosystem services vary with space, time and species

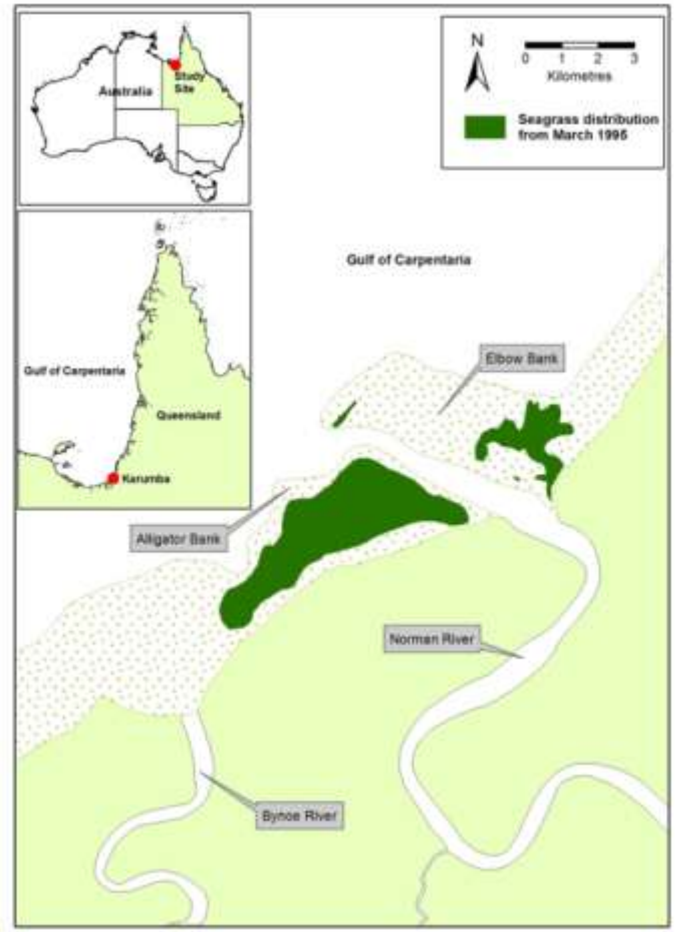


Intertidal seagrass
Karumba,
Australia

Seagrass dynamics 1994-2009

Drought





Karumba, Australia

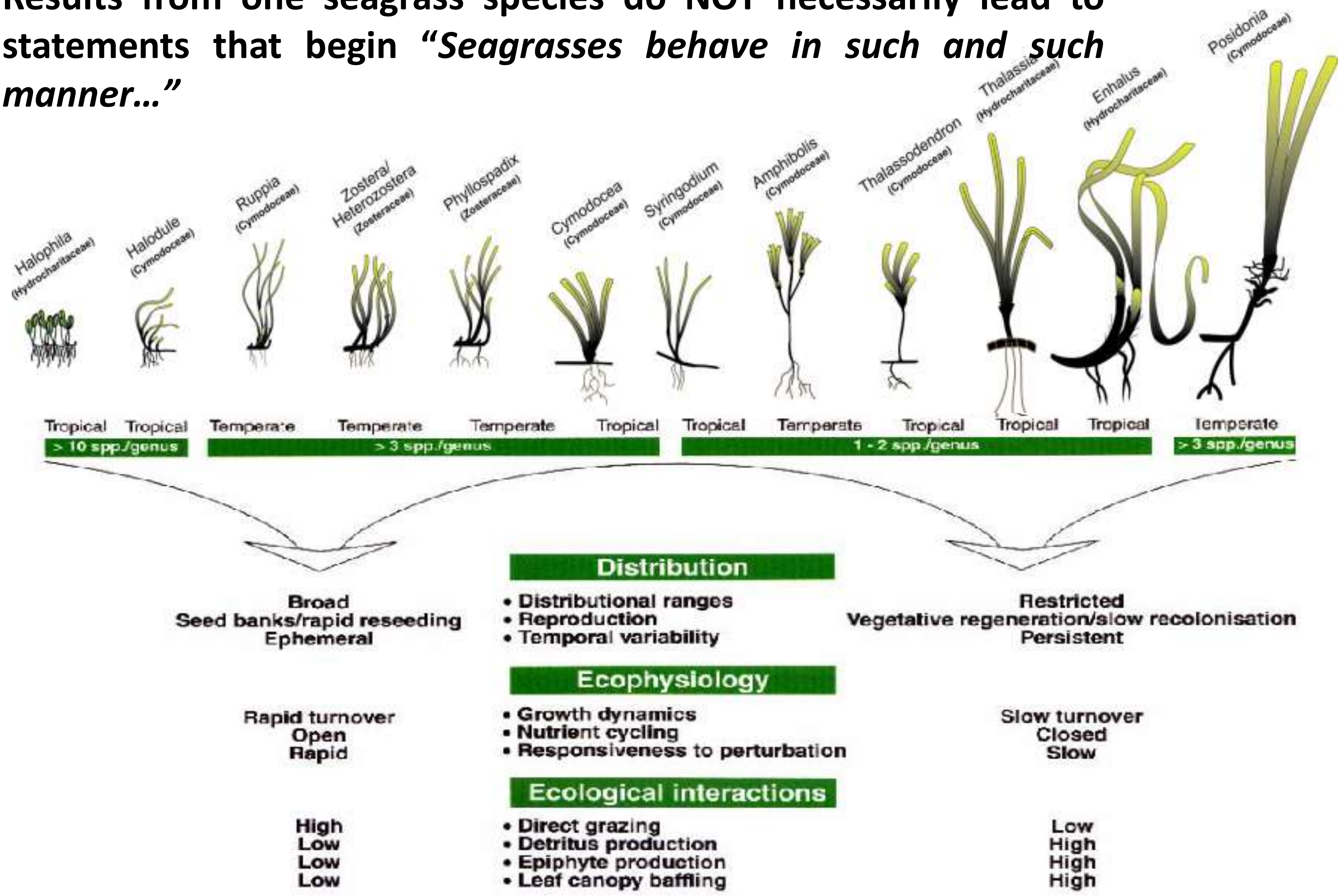
(turbid low light environment)

Rasheed & Unsworth 2011 MEPS

SEAGRASS ECOSYSTEM RESEARCH GROUP

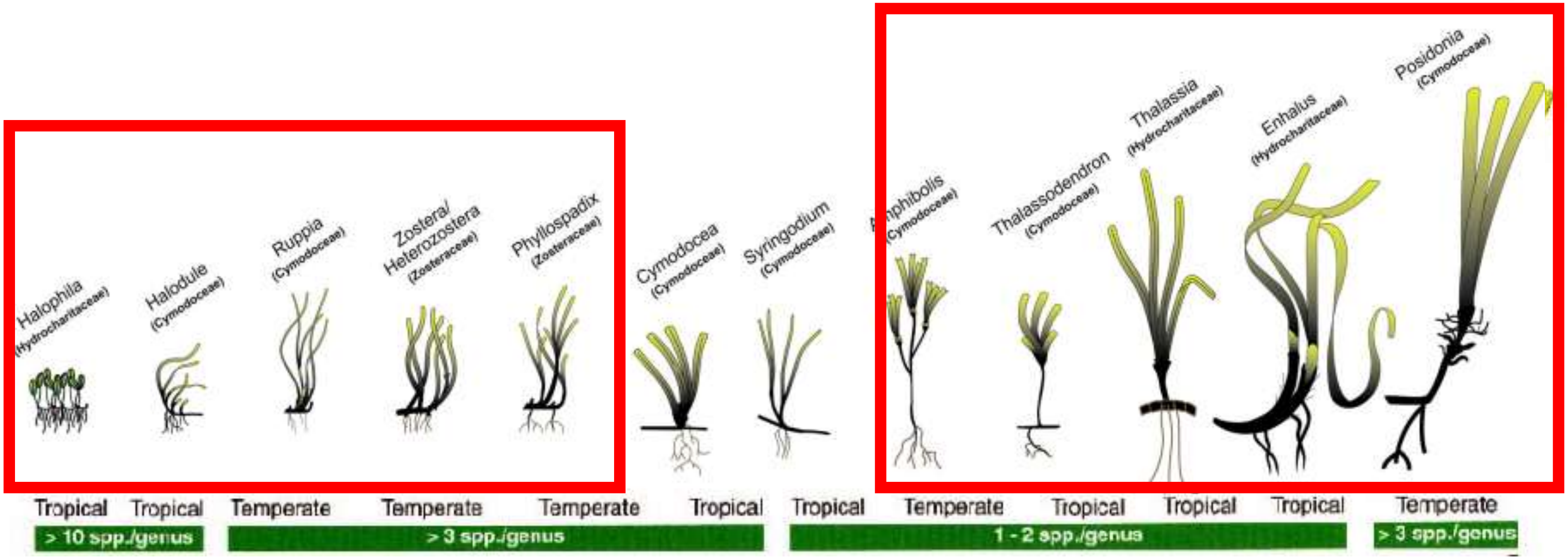
Seagrasses are not all alike!

- **Results from one seagrass species do NOT necessarily lead to statements that begin "*Seagrasses behave in such and such manner…*"**

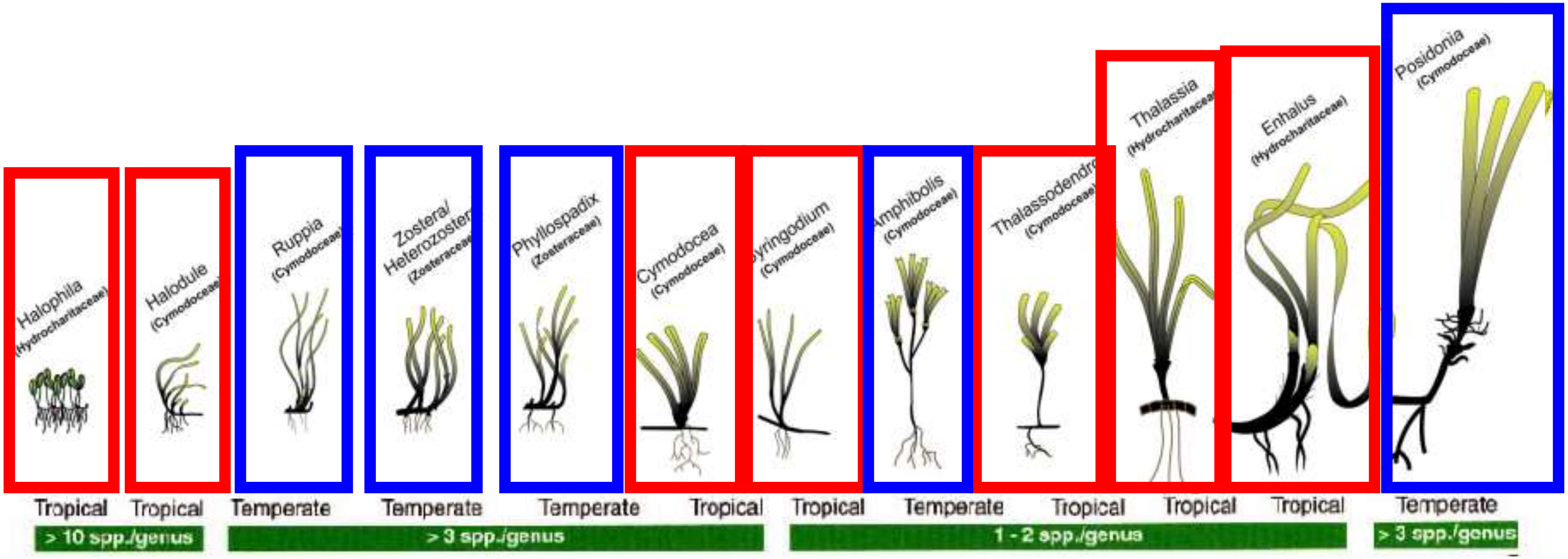


Seagrasses are not all alike! – ***small vs. large species differences***

Variable habitat value

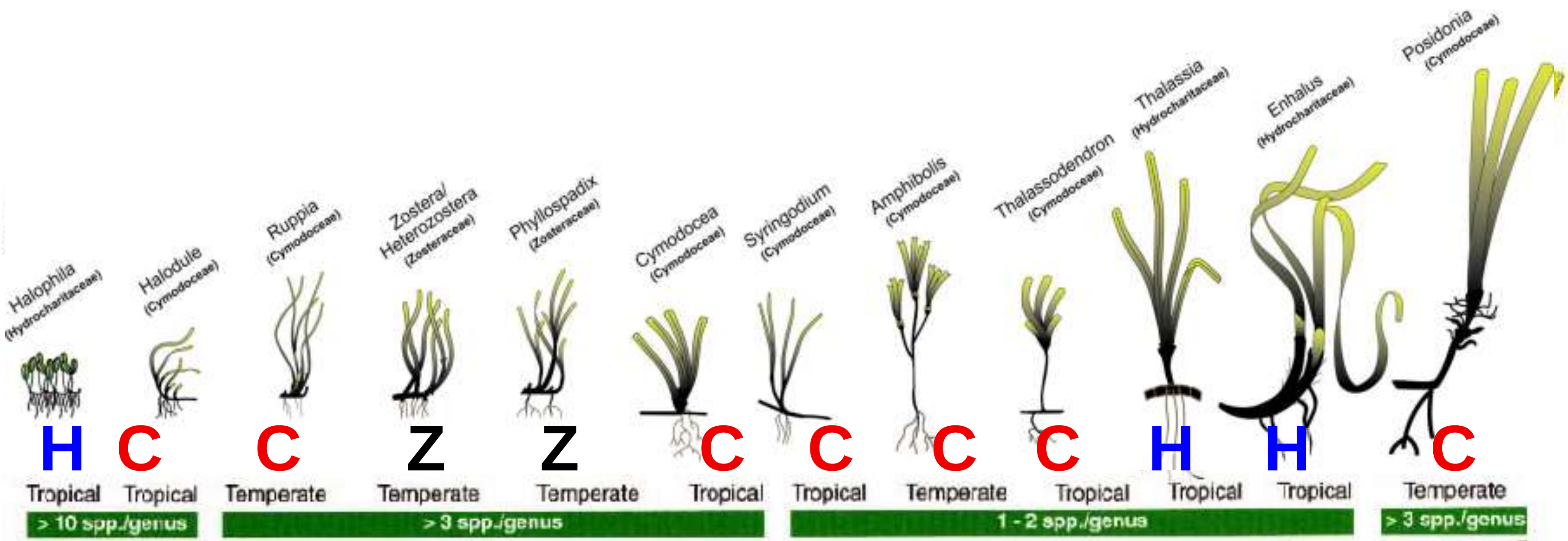


Seagrasses are not all alike! – *Tropical vs. temperate species differences*



Seagrasses are not all alike! – *Evolutionary history differences*

Different capacity to adapt to change

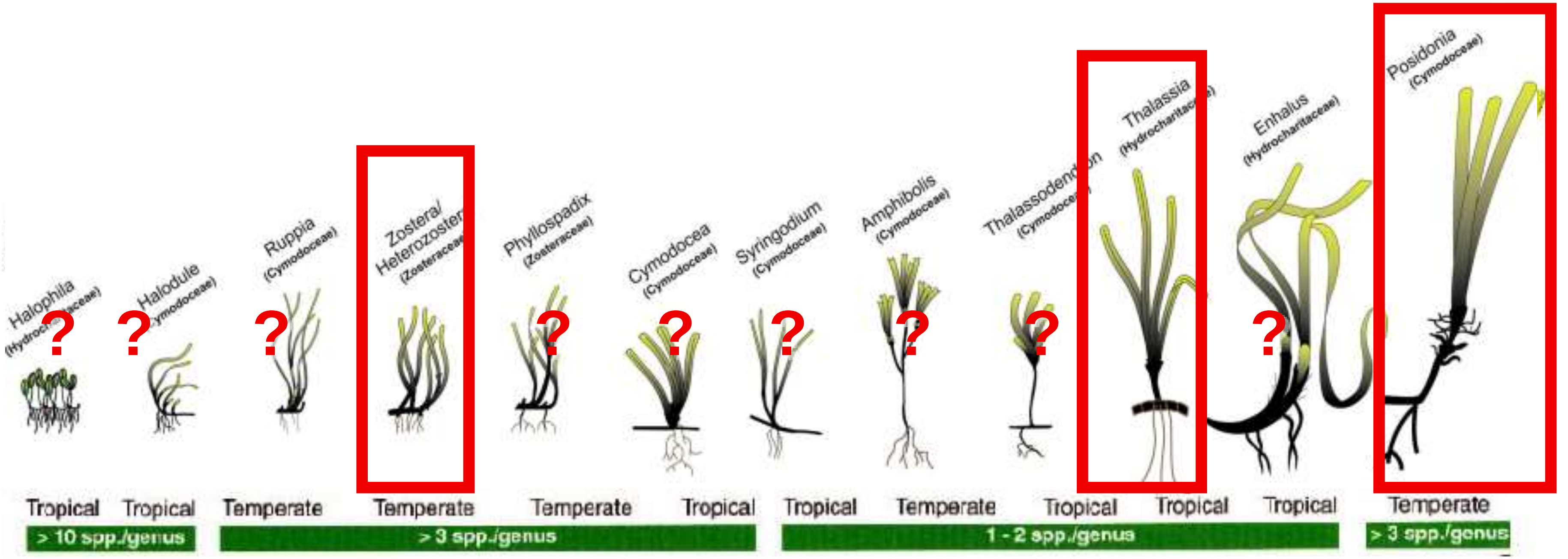


H = Hydrocharitaceae

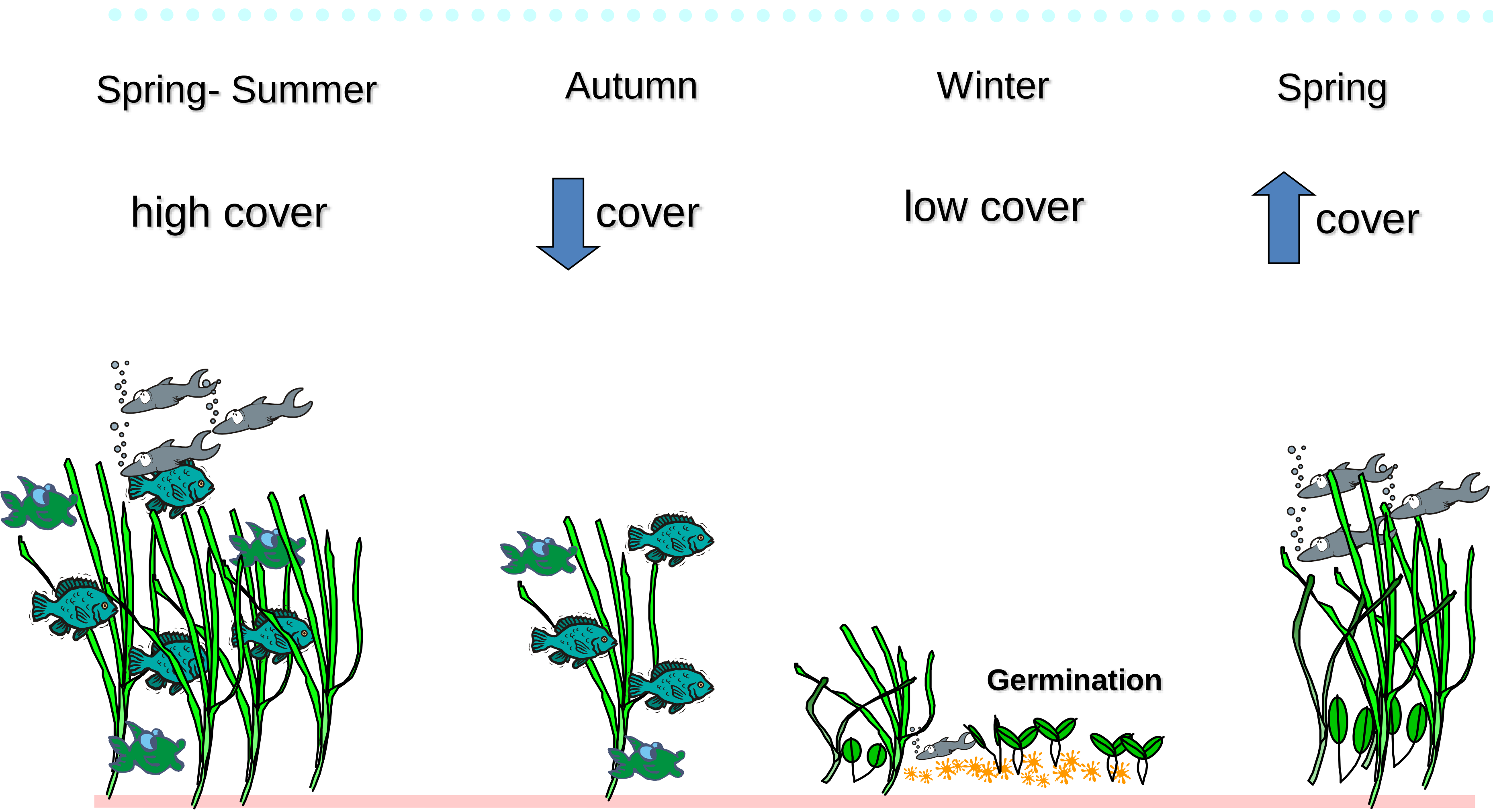
C = Cymodoceae

Z = Zosteraceae

Seagrasses are not all alike! – *Well studied vs. less studied differences*



Seagrasses are not all alike! – *but similar natural cycles*



In Summary: Why are seagrasses important?

- **Stop beach erosion** *(stabilise sediments)*
- **Stop lots of land based pollution** *(act as nutrient, sediment, chemical, filter/buffer)*
- **Provide substrate for other marine plants & animals**
- **Important nursery habitat**

- **Oxygen pumps (i.e they pump O_2 into the sediments and release it to the water column)**
- **Sequester *carbon dioxide***
- **Supplies a basis for a detrital food chain**
- **Major source of primary production/ biodiversity**