Tropical Seagrass Meadows and their Management

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What are seagrasses?

Marine plants:

- **produce flowers, fruits and seeds**

Flowering plants = angiosperms

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Algae (seaweed)

- No Vascular System
- Often Floating
- Do not seed and flower

Courtesy: Julie Phillips, UQ

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What are seagrasses?

Seagrasses are marine plants that have

•a true root system

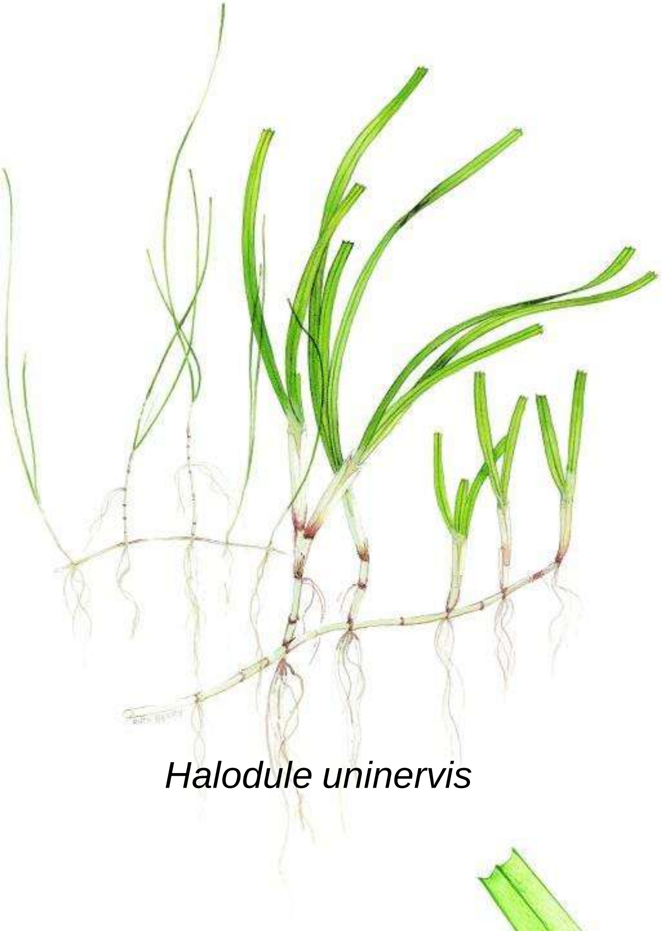
•an internal vascular system

*Vascular system - tissue that conducts water and nutrients through the plant body in higher plants

Clonal, rhizomatous plants (a necessary adaptation for angiosperm growth in the high-energy marine environment)

Rhizome is responsible for the extension of the clone in space, as well as for connecting neighbouring ramets, thereby maintaining integration within the clone

Monoecious perennials but may be annuals under stressful conditions



Halodule uninervis

Monoecious, an individual that has both male and female reproductive units (flowers, conifer cones, or functionally equivalent structures) on the same plant

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Where are seagrasses found?

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About 60 species globally

found in tropical and temperate regions

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Where are seagrasses found?

<u>**Five species in the Caribbean seas of Colombia**</u>

Thalassia testudinum dominated beds in shallow waters

Within these beds are found patches of *Syringodium filiforme* and, less frequently, *Halodule wrightii* and *Halophila baillonis*.

In deeper waters stands of *Halophila decipiens* also occur.

About 60 species globally

found in tropical and temperate regions

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A seagrass clone can be very old………….

OPEN ACCESS Freely available online

PLoS one

Implications of Extreme Life Span in Clonal Organisms: Millenary Clones in Meadows of the Threatened Seagrass *Posidonia oceanica*

Sophie Arnaud-Haond[1,2]*, Carlos M. Duarte[3,4], Elena Diaz-Almela[3], Núria Marbà[3], Tomas Sintes[5], Ester A. Serrão[2]

1 Ifremer, DEEP-Centre de Brest, Plouzané, France, 2 CCMAR, Laboratório BEE, Universidade do Algarve, Faro, Portugal, 3 Department of Global Change Research, IMEDEA (CSIC-UIB), Mallorca, Spain, 4 Oceans Institute, University of Western Australia, Australia, 5 Instituto de Fisica Interdisciplinar y Sistemas Complejos, IFISC (CSIC-UIB), Mallorca, Spain

Abstract

The maximum size and age that clonal organisms can reach remains poorly known, although we do know that the largest natural clones can extend over hundreds or thousands of metres and potentially live for centuries. We made a review of findings to date, which reveal that the maximum clone age and size estimates reported in the literature are typically limited by the scale of sampling, and may grossly underestimate the maximum age and size of clonal organisms. A case study presented here shows the occurrence of clones of slow-growing marine angiosperm *Posidonia oceanica* at spatial scales ranging from metres to hundreds of kilometres, using microsatellites on 1544 sampling units from a total of 40 locations across the Mediterranean Sea. This analysis revealed the presence, with a prevalence of 3.5 to 8.9%, of very large clones

Some seagrass found to have a minimum age estimate of between **80,000 and 200,000 years old**

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Growth and Reproduction

Sexual

Pollen and seeds are carried by currents (maybe faeces)

Asexual

Producer runners (**Stolons**) - increase size of meadow - limited dispersion. Runners originally attached but make break-away from parent.

Example of vertical growth - *Syringodium filiforme* 17 cm y^{-1}

Example of horizontal growth - 1.2 - 574 cm y^{-1} - new shoot every 1.1 - 7.5 cm of rhizome produced.

Interspecific variation = differing competitive abilities

Seagrass Flowers

Halophila capricorni

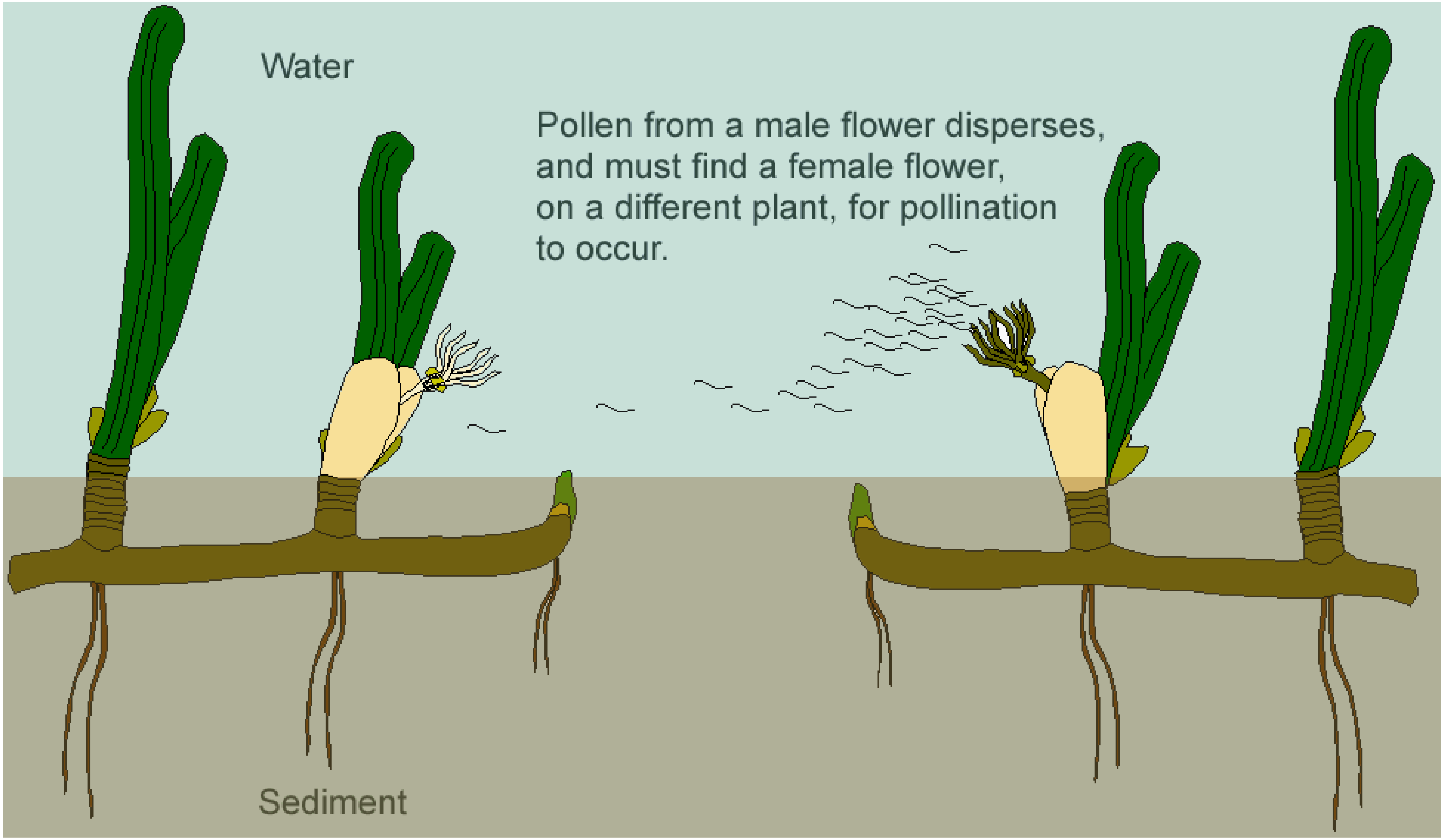
Syringodium isoetifolium

Enhalus acoroides

Halodule uninervis

Halophila ovalis

Pollination in the sea



Courtesy: Michelle Waycott JCU

Hydrophilous pollination

Seagrass Seeds

Halophila ovalis

Halodule wrightii

Thalassia testudinum

syringodium filiforme

Parts of a seagrass plant

Stem

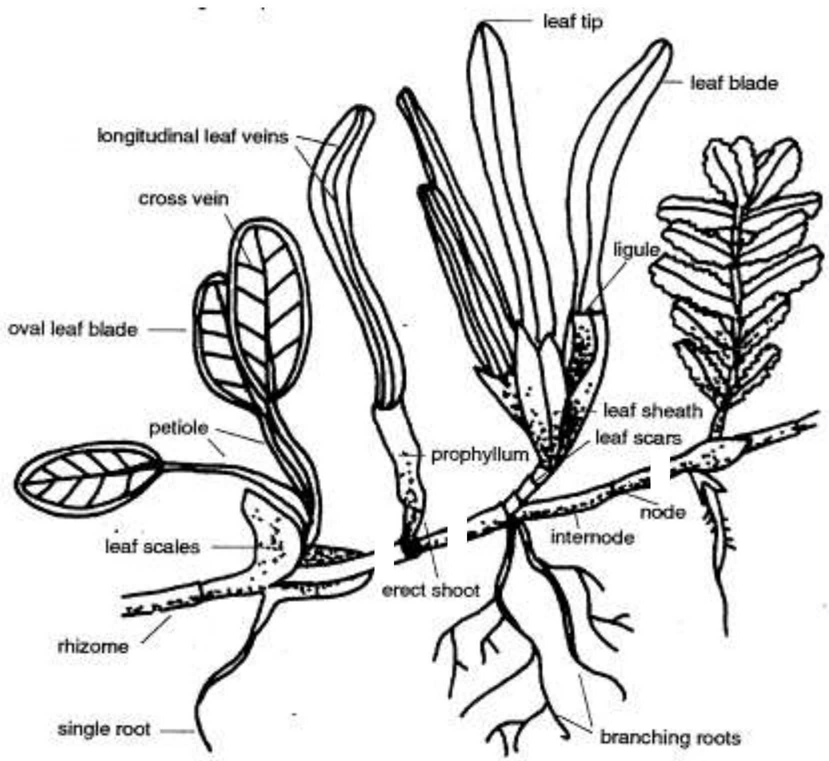
The vertical stem, found in some species, is the upright axis of the plant from which leaves arise. The remnants of leaf attachment are seen as scars.

Rhizome

The horizontal axis of the seagrass plant, usually in sediment. It is formed in segments, with leaves or vertical stem arising from the joins of the segments, the nodes. Sections between the nodes are called internodes. Rhizomes can be fragile, thick and starchy or feel almost woody and may have scars where leaves were attached.

Root

Underground tissues that grow from the node, important for nutrient uptake and stabilisation of plants. The size and thickness of roots and presence of root hairs (very fine projections) are used for identification.



from Lanyon (1986)

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Seagrasses-Anatomical Adaptations

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Leaves

- Lack stomata; thin cuticle to allow gas and nutrient exchange
- Large thin-walled aerenchyma (air channel) facilitate gas diffusion within the leaf & provides buoyancy to the leaves

Roots and Rhizomes

- Oxygen transport to the roots creates an oxic environment

around the roots, facilitating nutrient uptake

- All produce root hairs

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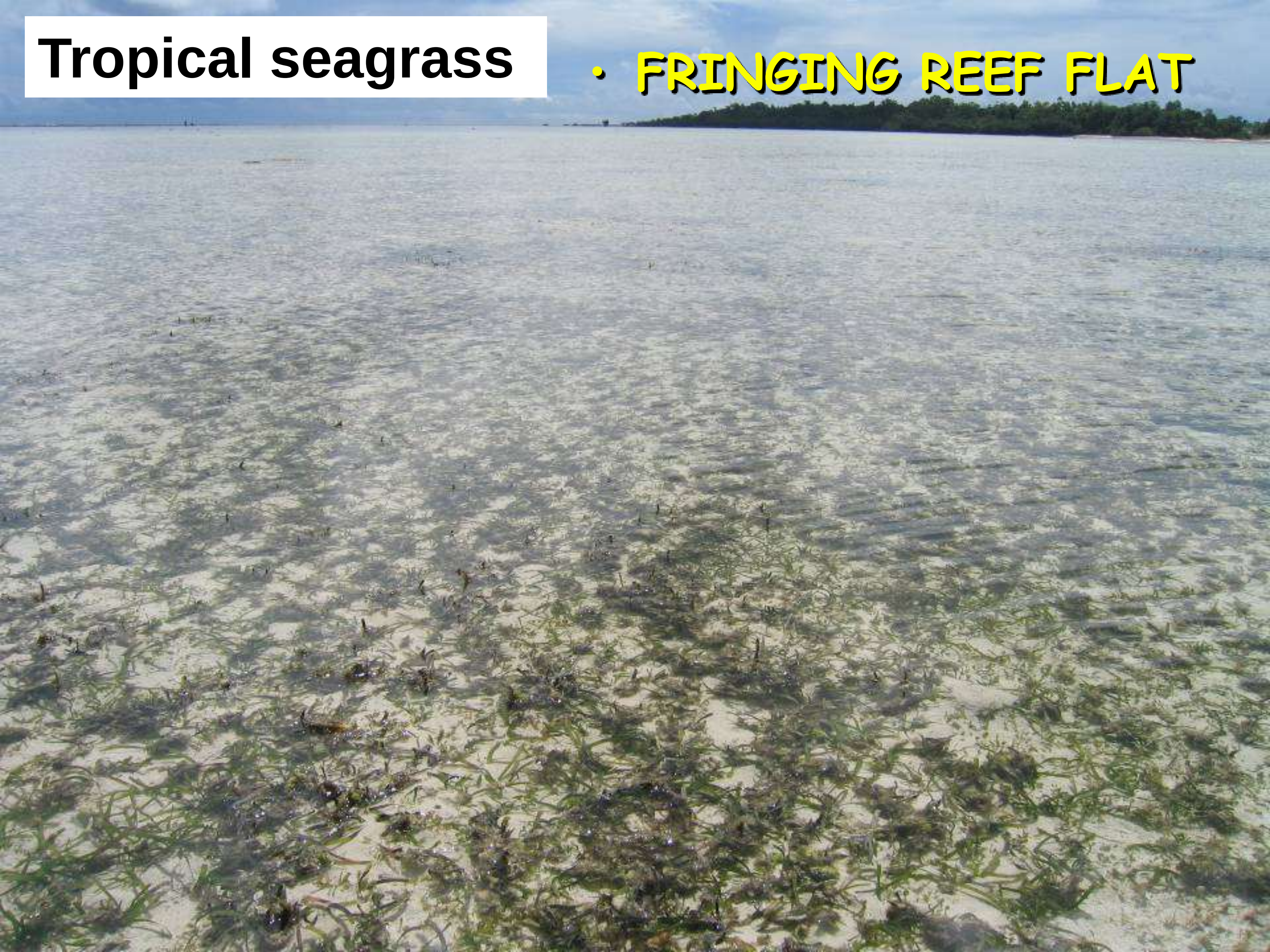
SEAGRASSES are Foundation Species

Tropical seagrass


Tropical seagrass
• FRINGING REEF FLAT

Tropical seagrass

Tropical seagrass

Tropical seagrass

- MAINLAND COASTAL
  -intertidal

Tropical seagrass

- DEEPWATER (>15m depth)

Tropical seagrass

- REMOTE ATOLL

Ecophysiology

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- Wide temperature tolerance
  - 0-36 degrees C (tolerance)
  - 0-30 degrees C (growth)
- Wide salinity tolerance
  - 0-90 ppt (tolerance)
  - 0-56 ppt (growth)

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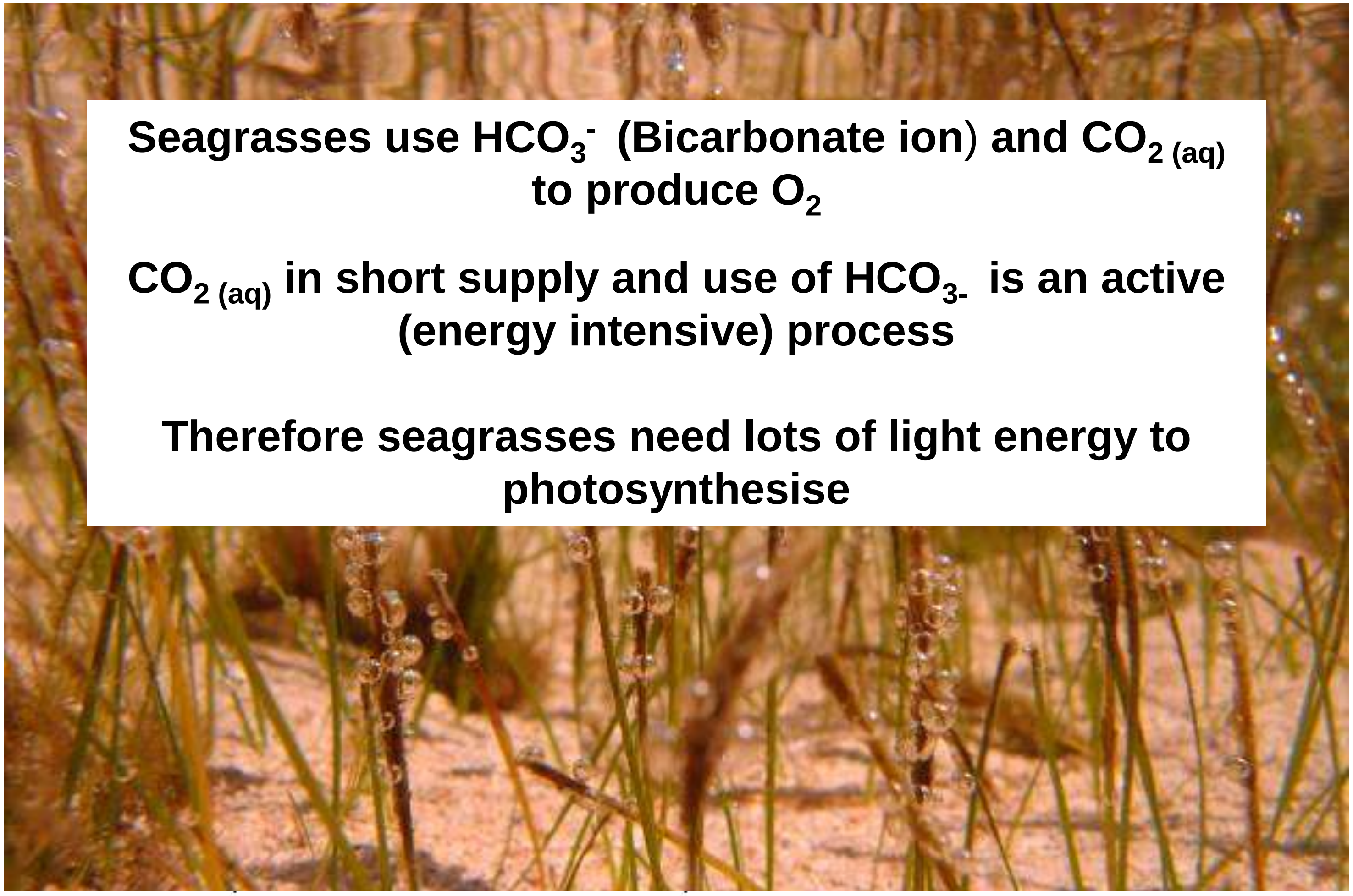
Seagrass Photosynthesis



Seagrasses use HCO_3^- (Bicarbonate ion) and $CO_{2\,(aq)}$ to produce O_2

$CO_{2\,(aq)}$ in short supply and use of HCO_{3^-} is an active (energy intensive) process

Therefore seagrasses need lots of light energy to photosynthesise

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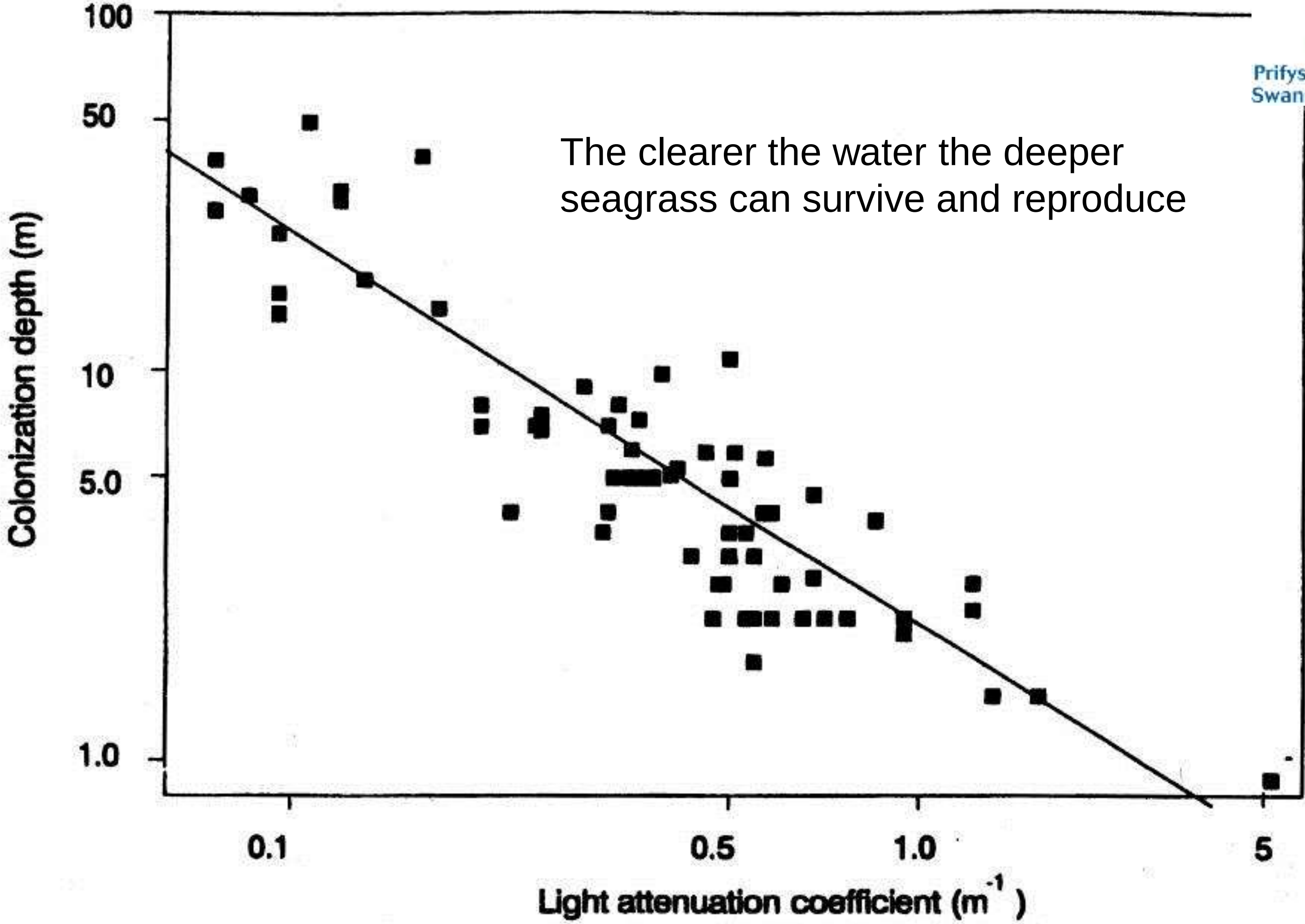
Seagrass Needs High Light

- Light Requirements (% surface irradiance)
  - Minimum 5% (most species need >18%)
- Depth
  - Intertidal to 60 m
- Substrate composition
  - Mud to sand (species specific)
- Wave energy
  - Low

The clearer the water the deeper seagrass can survive and reproduce



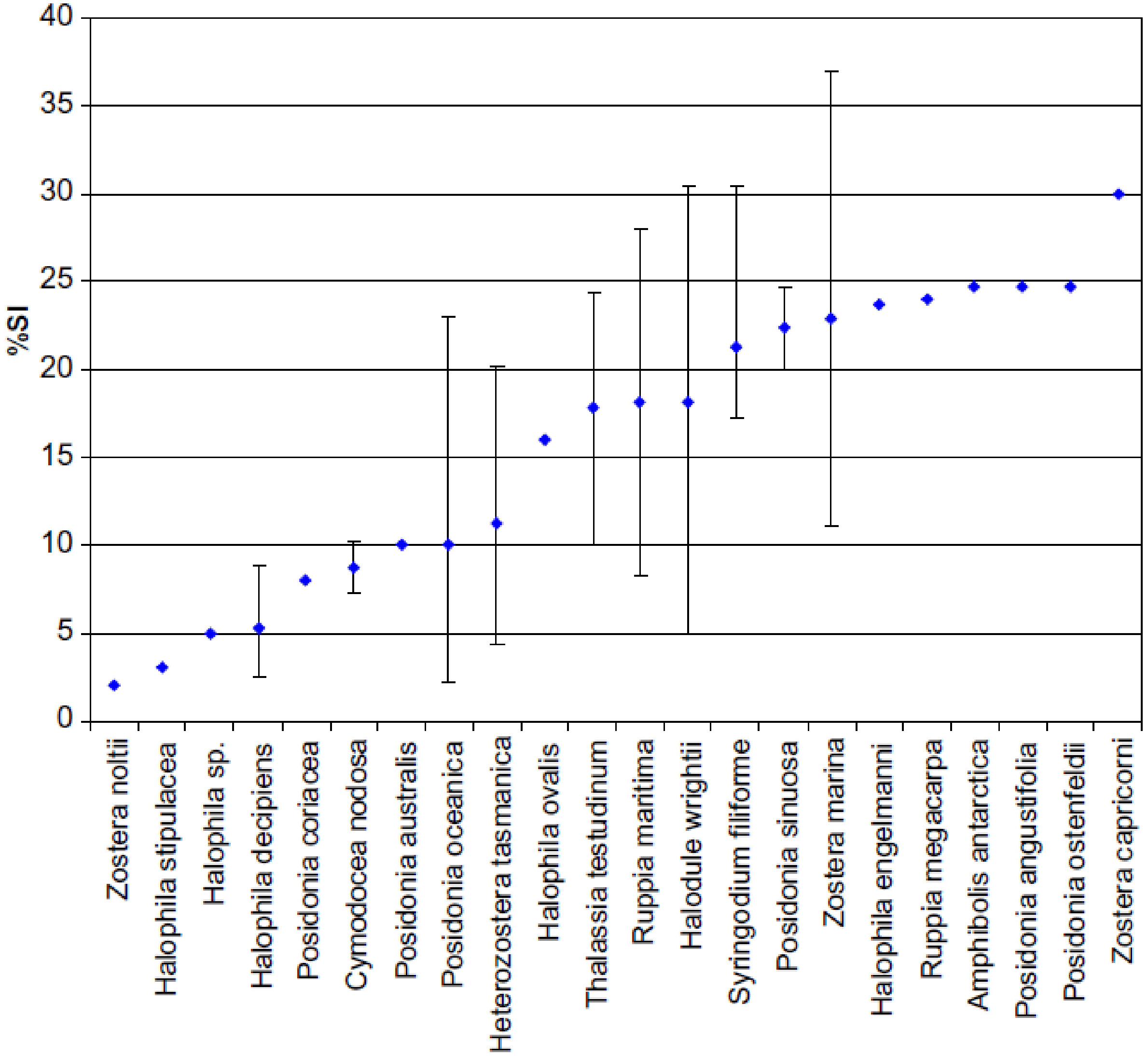


Fig. 1. Range of critical threshold values for light availability (as % surface irradiance SI) reported in the literature for various seagrass species.

Erftemeijer and Lewis 2006 MPB

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Seagrass can not survive long-periods without light

Table 2
Duration of time that seagrass species can survive in light intensities below their minimum light requirements

Species	Light availability	Period survived (month)	Reference
Halodule pinifolia	0	3–4	Longstaff and Dennison (1999)
Halodule wrightii	13–15% SI	9	Czerny and Dunton (1995)
Halophila ovalis	0	1	Longstaff et al. (1999)
Heterozostera tasmanica	9% SI	10	Bulthuis (1983)
Heterozostera tasmanica	2% SI	2–4	Bulthuis (1983)
Posidonia sinuosa	12% ambient	24	Gordon et al. (1994)
Thalassia testudinum	10% SI	11	Czerny and Dunton (1995)
Zostera capricomi	5% SI	1	Grice et al. (1996)
Zostera noltii	<2% SI	0.5	Peralta et al. (2002)

Erftemeijer and Lewis 2006 MPB

Too many suspended sediments = low light

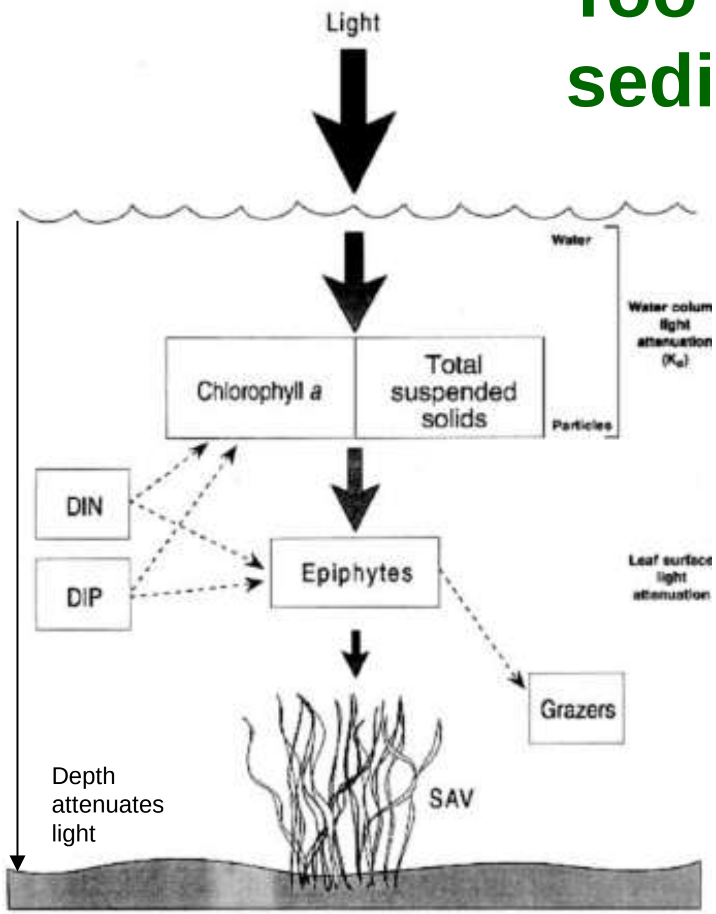
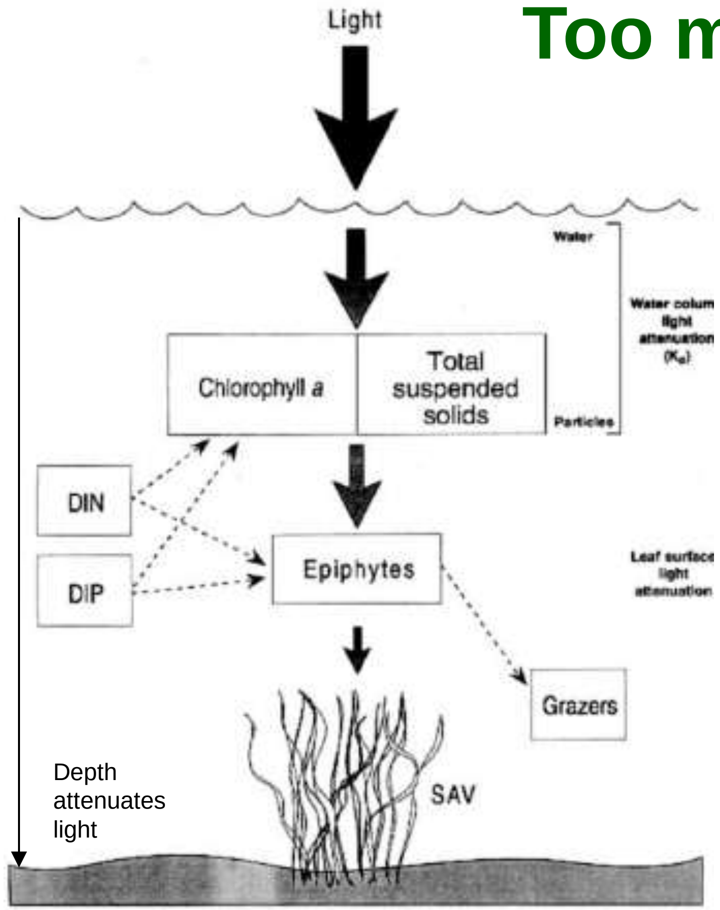


Figure 3. Availability of light for submersed aquatic vegetation (SAV) is determin by light attenuation processes. Water column attenuation, measured as the lig attenuation coefficient (K_d), results from absorption and scatter of light by particl in the water (phytoplankton, measured as chlorophyll *a*, and total organic a inorganic particles, measured as total suspended solids) and by absorption of light water itself. Leaf surface attenuation, largely due to algal epiphytes growing submersed leaf surfaces, also contributes to light attenuation. Dissolved inorgar

Factors effecting light availability to seagrass

Too many nutrients = low light



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Nutrients cause excess algal growth

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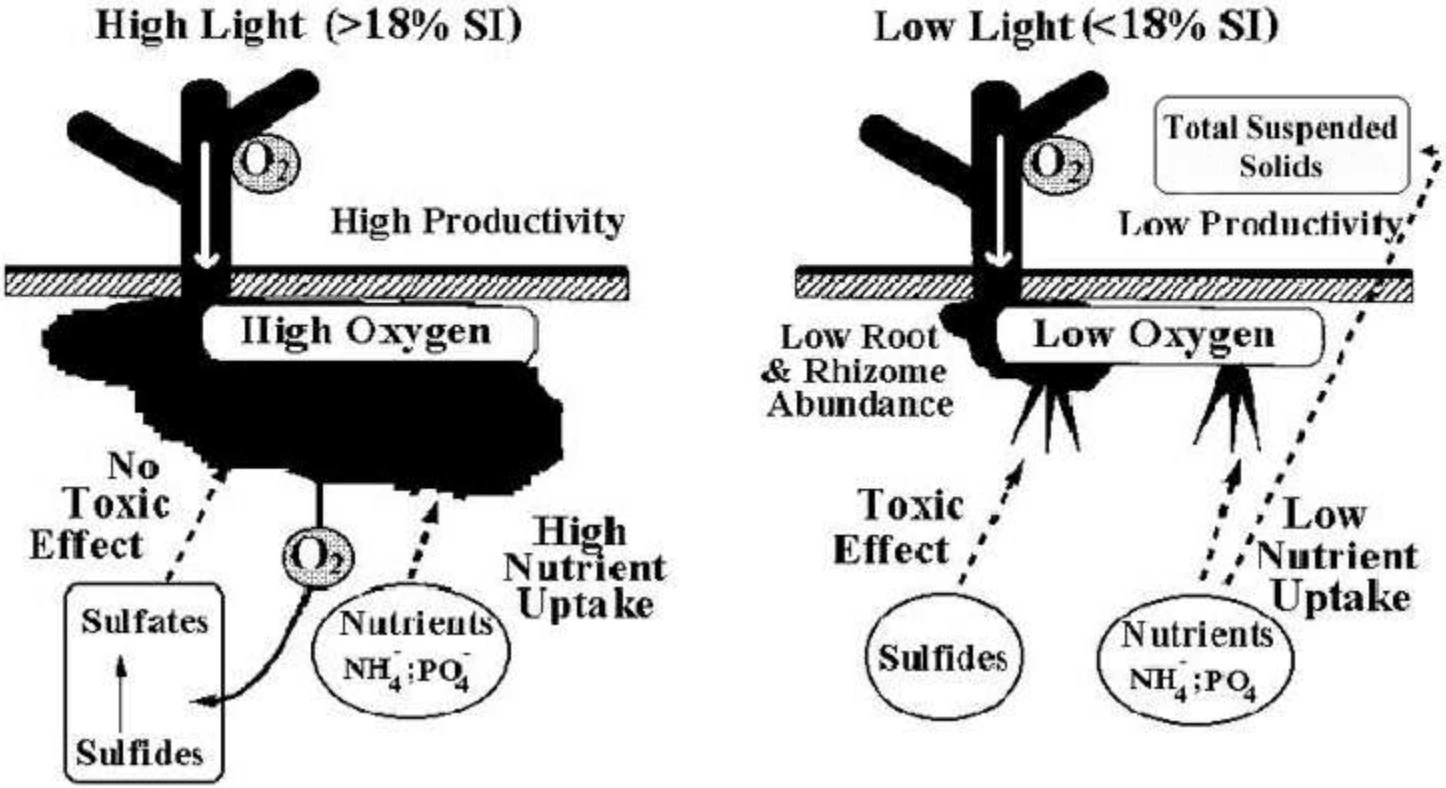

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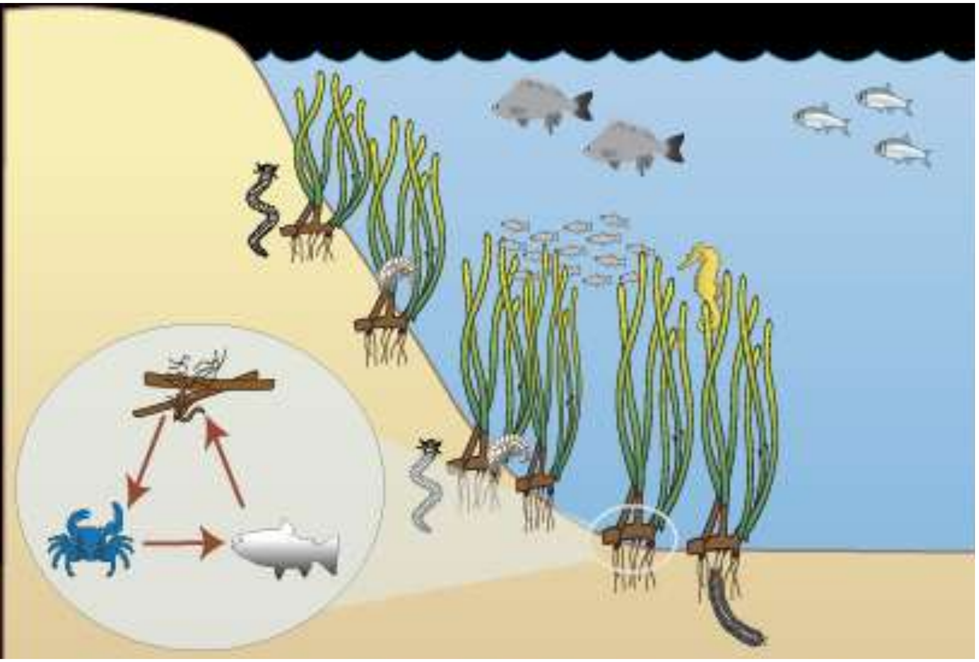
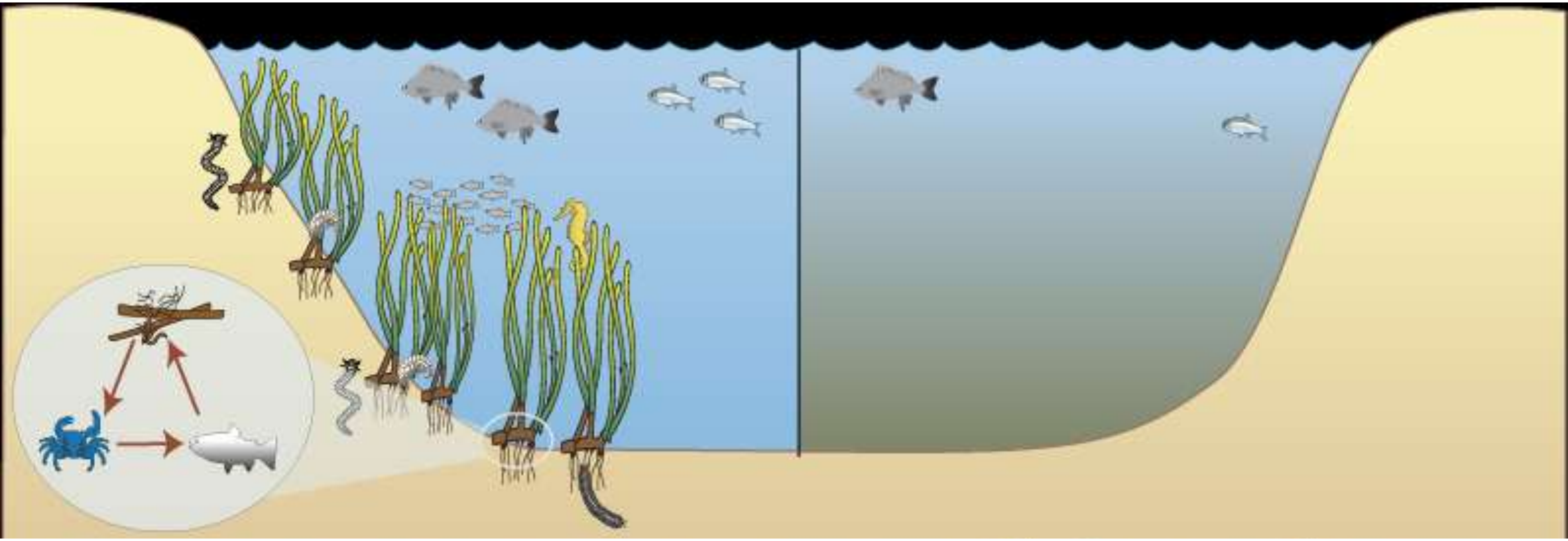
The effect of damage to seagrass meadows



Productive & diverse habitat

Good fish habitat

The effect of damage to seagrass meadows



Productive & diverse habitat → Unproductive & low diversity habitat

Good fish habitat **Poor fish habitat**

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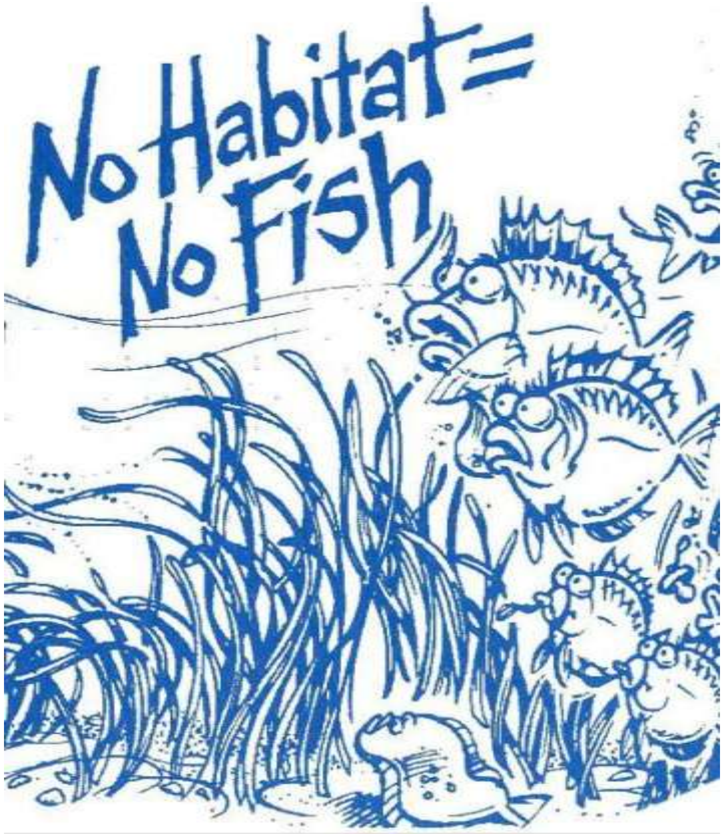

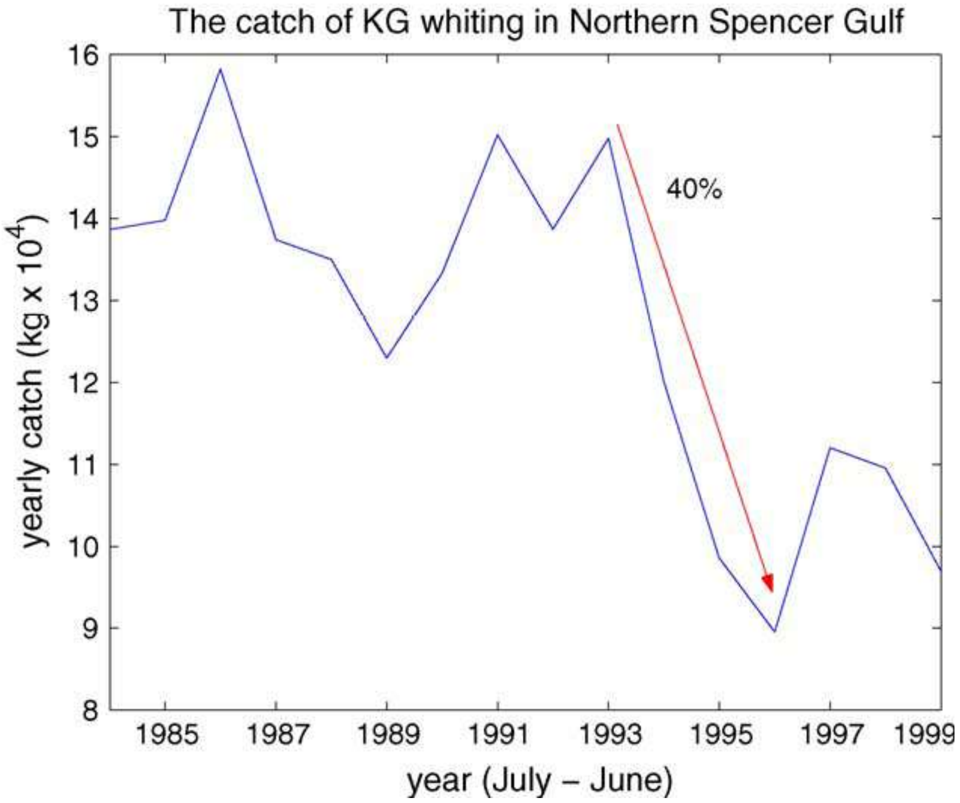

In South Australia:

A 16% loss of seagrass area resulted in a 40% reduction in fisheries catch

How can oil and gas exploration and production damage seagrass?

And how can they co-exist?

The bad and the good of Gladstone Harbour

http://www.abc.net.au/catalyst/stories/3593812.htm

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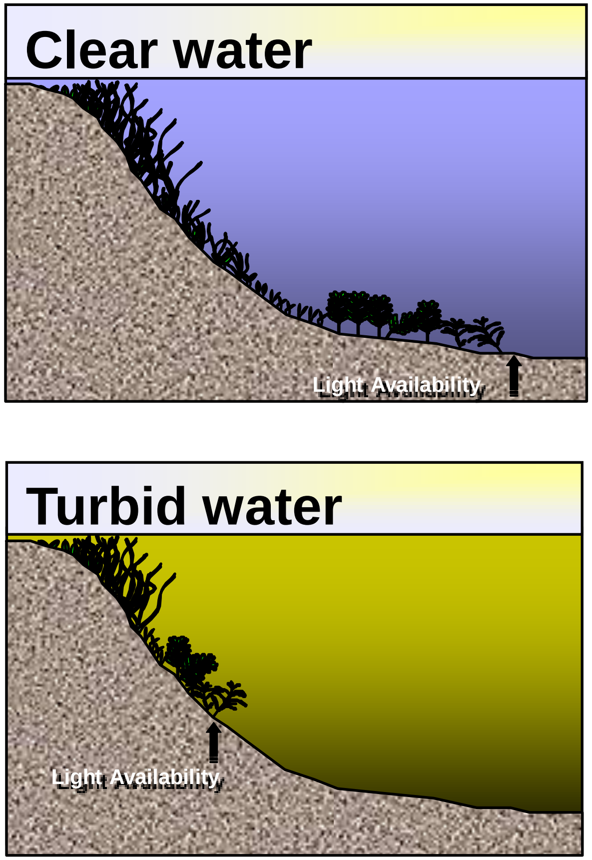
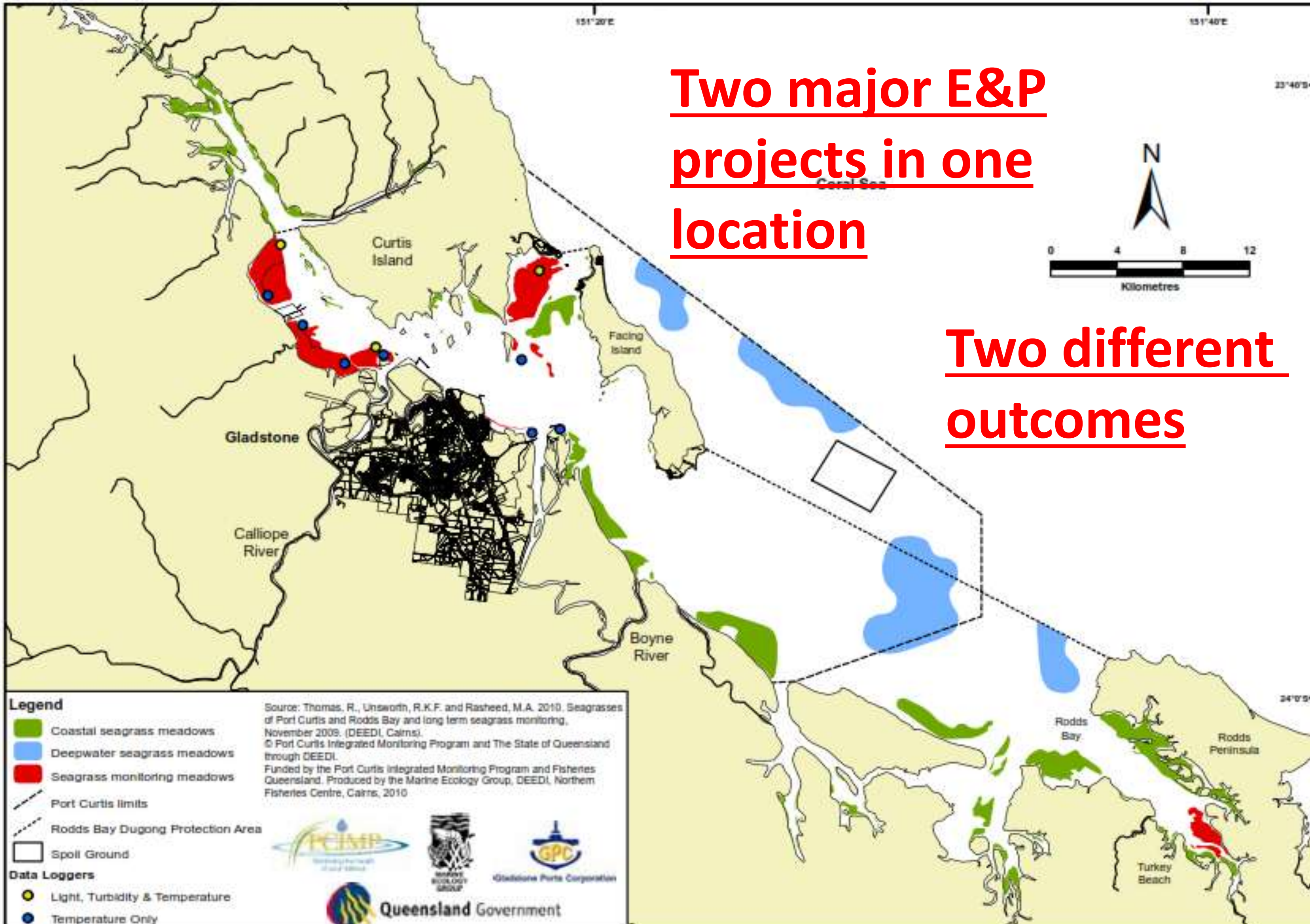
Most near-shore oil, gas and mineral exploitation require dredging or some form of marine sediment disturbance



Physical disturbance causes smothering of seagrass and/or loss of light

Map 2. Distribution of seagrass meadows in Port Curtis and Rodds Bay, November 2009



Two major E&P projects in one location

Two different outcomes

Major project 1
Land reclamation for LNG

Gladstone Harbour
Queensland
Australia

Little engagement with environmental scientists until detailed plans had been developed – too late!!

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Large unnecessary loss of seagrass

Dugong and Green Turtle Washed up dead on beaches

(Australia has one of the lowest population densities on the planet – why does it need more land?)

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ENVIRONMENTAL MANAGEMENT FAILURE

Large unnecessary loss of seagrass

Dugong and Green Turtle
Washed up dead on beaches

(Australia has one of the lowest population densities on the planet – why does it need more land?)

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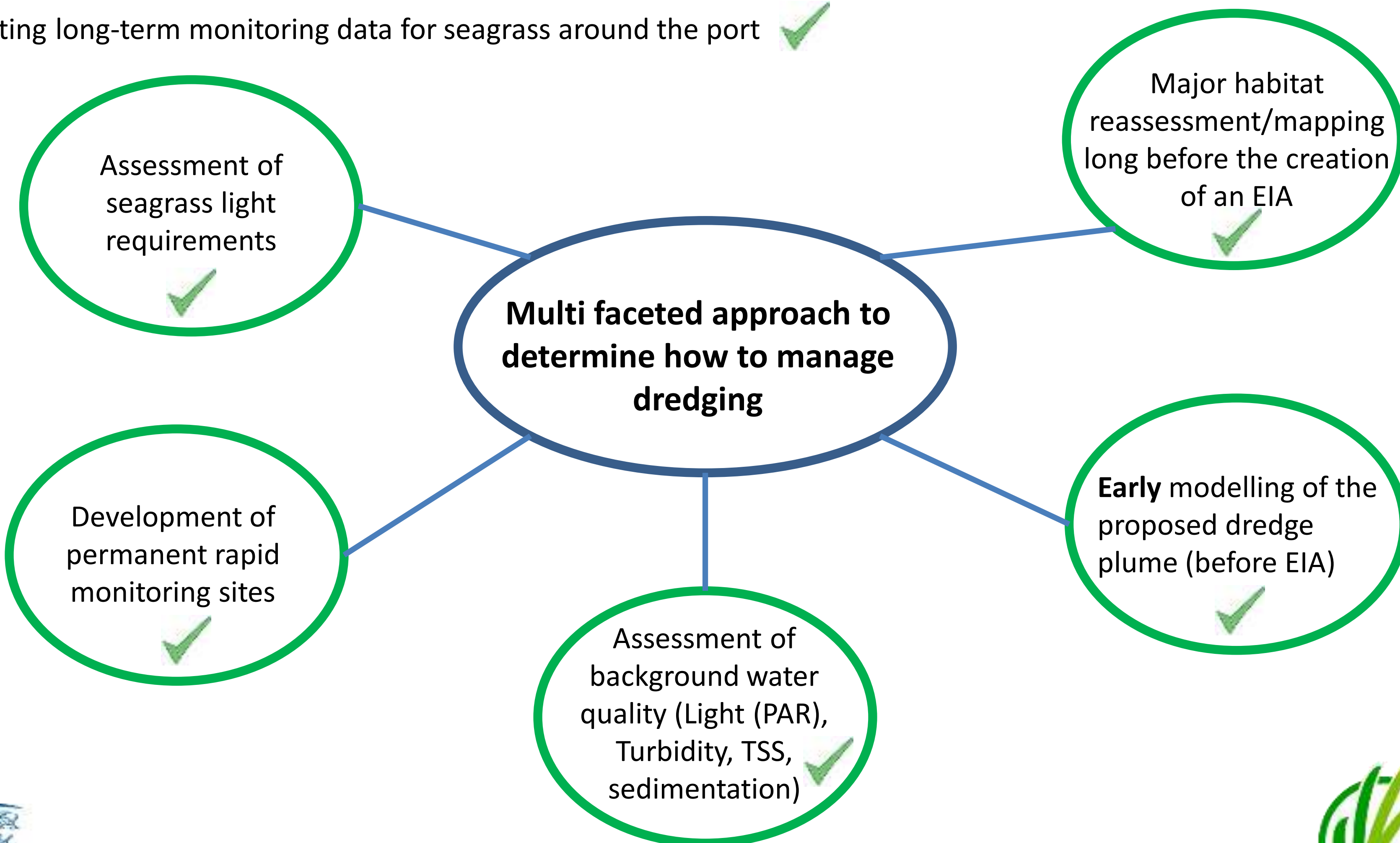
Major project 2
Channel widening for more coal and LNG ships

Very early engagement of engineers and geologists with environmental scientists

Existing long-term monitoring data for seagrass around the port ✓



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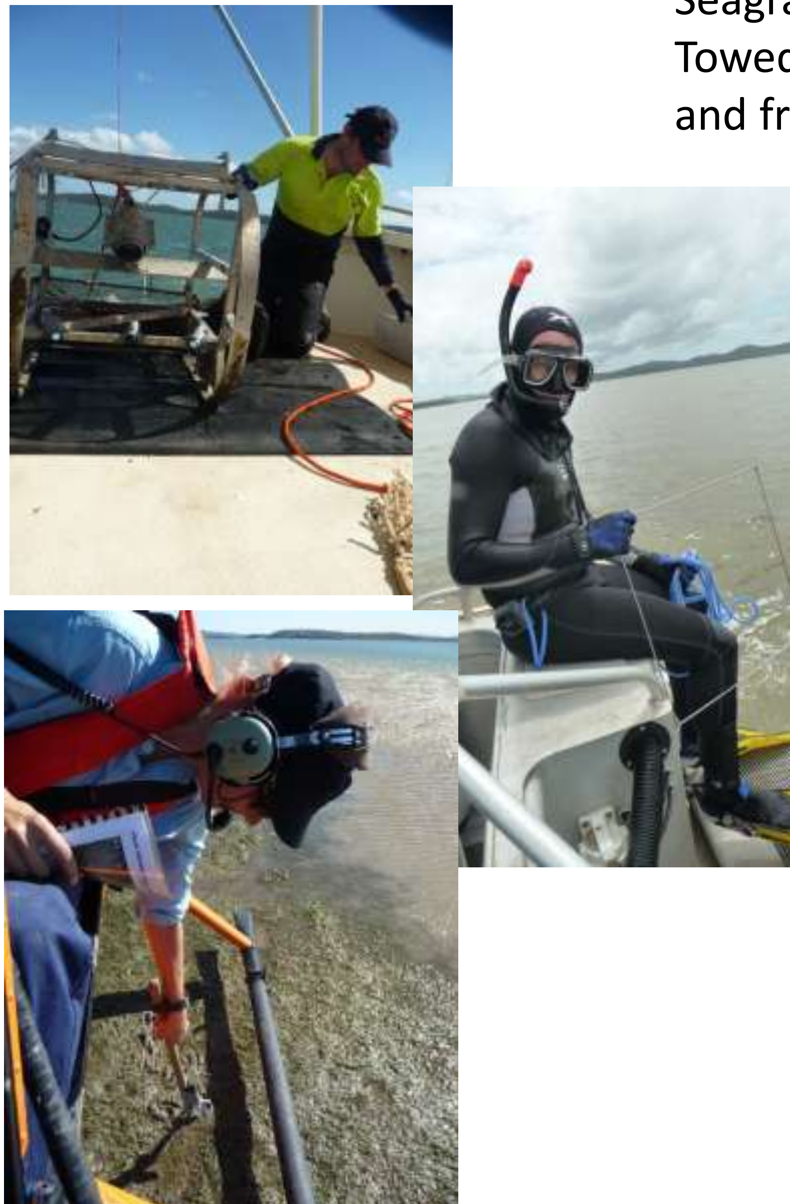
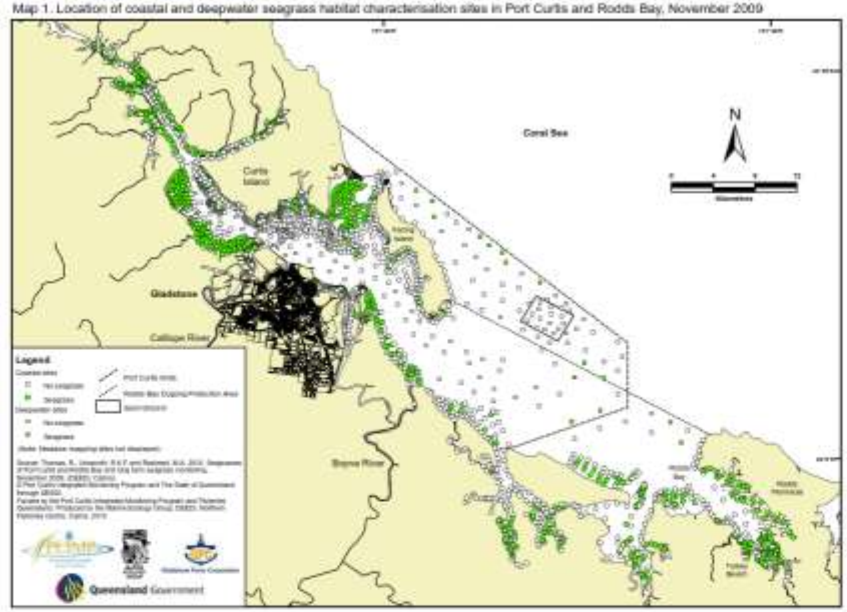
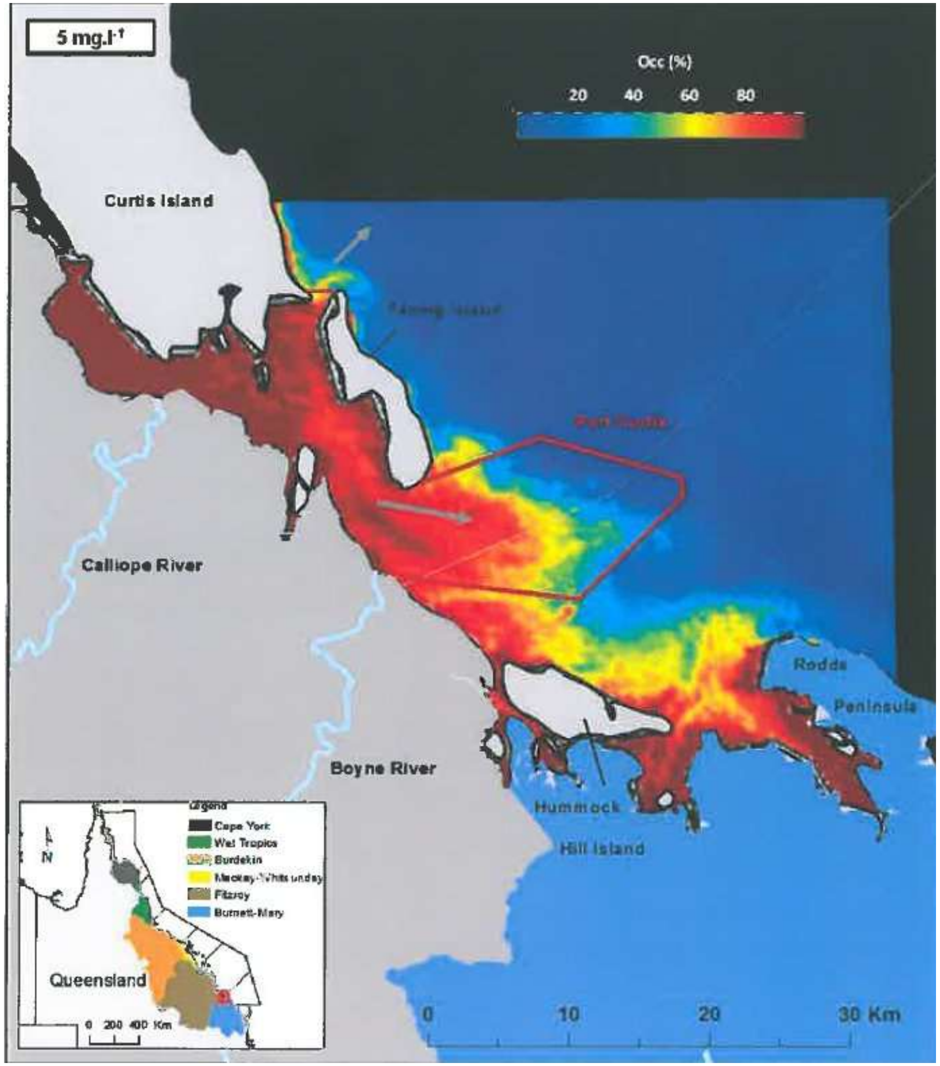
Seagrass mapping using:
Towed video, drop down camera, helicopter survey and free diving



Map 1. Location of coastal and deepwater seagrass habitat characterisation sites in Port Curtis and Rodds Bay, November 2009



Dredge plume modelling



Assessment of seagrass light requirements

Multiple shading experiments over 12 months (resistance and recovery)

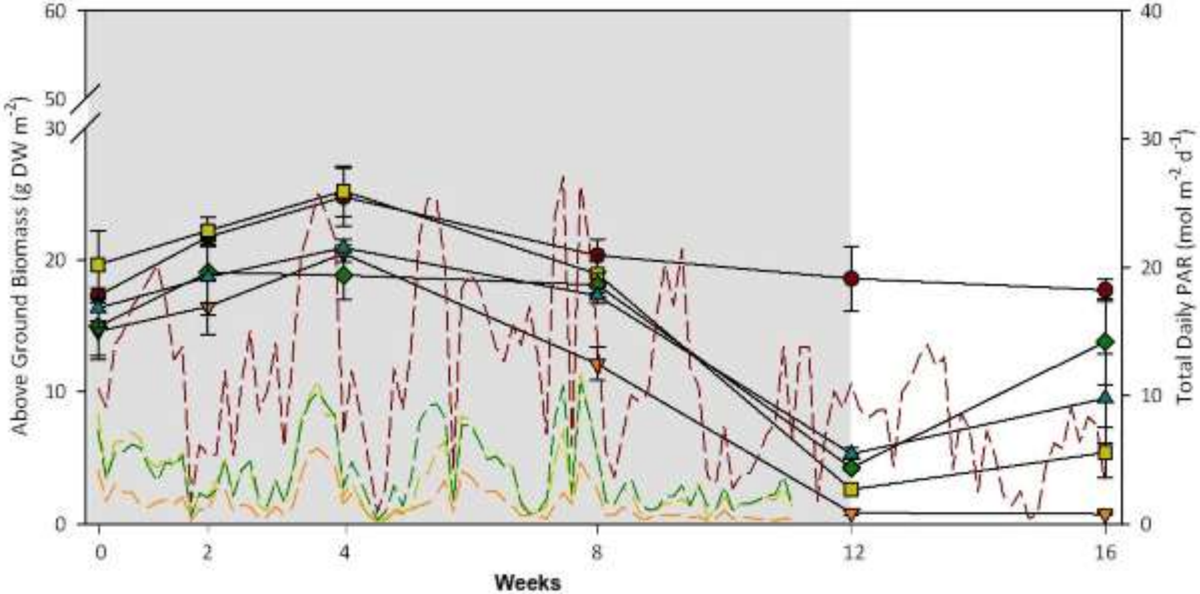


Figure 1. Estimates of above-ground biomass in growing season 1 (A) and growing season 2 (B) shading treatments. Data represent mean ± SEM (n=4). Total daily PAR is displayed on the right y-axis to show light availability under each shading treatment and controls. Gray shading indicates when shade screens were on.

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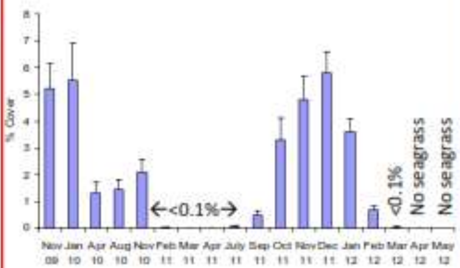
RESULTS IN BRIEF – Inner Harbour High Impact Zone

Redcliffe

Seagrass percent cover remained at a similar low level as the past three months. Seagrass percent cover for the period from February to May 2012 has been significantly lower than for the same period in 2011.

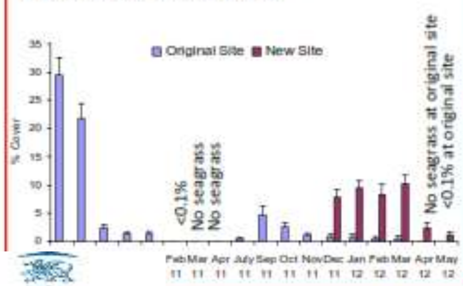
Fishermans Landing

Seagrass was again absent from transects in May 2012. Seagrass percent cover was extremely low at a similar time last year (<0.1%).



Wiggins Island

Only a couple of shoots of seagrass remained at the original site in May 2012. Seagrasses were absent from transects in April 2011 but were significantly higher in April 2010. Seagrass cover at the new site was similar to April 2012 but significantly lower than December 2011 to March 2012.



Rapid and regular monitoring of seagrass

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What did the research tell us that helped dredge management?

Slight modifications of the channel route and width were made to avoid sensitive seagrass meadows (based on habitat mapping and early dredge plume modelling)

Seagrass in that location needed 6 mol light m^{-2} day^{-1} (Colombia will be different) (set as water quality trigger value)

Seagrasses don't benefit from periods of intertidal exposure

Two weeks of low light with two weeks recovery caused no long-term damage to the seagrass (dredge could work 2 weeks at one end of the channel and then move to the other end for two weeks)

When seagrasses naturally senesce they don't need much light (good time to dredge)

Permanent monitoring sites were a great PR tool – data was uploaded onto the internet at the end of each assessment for the public to see. When water quality trigger value exceeded – seagrass could then be immediately assessed.

Very minor loss of seagrass with recovery likely

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ENVIRONMENTAL MANAGEMENT SUCCESS

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When things go wrong

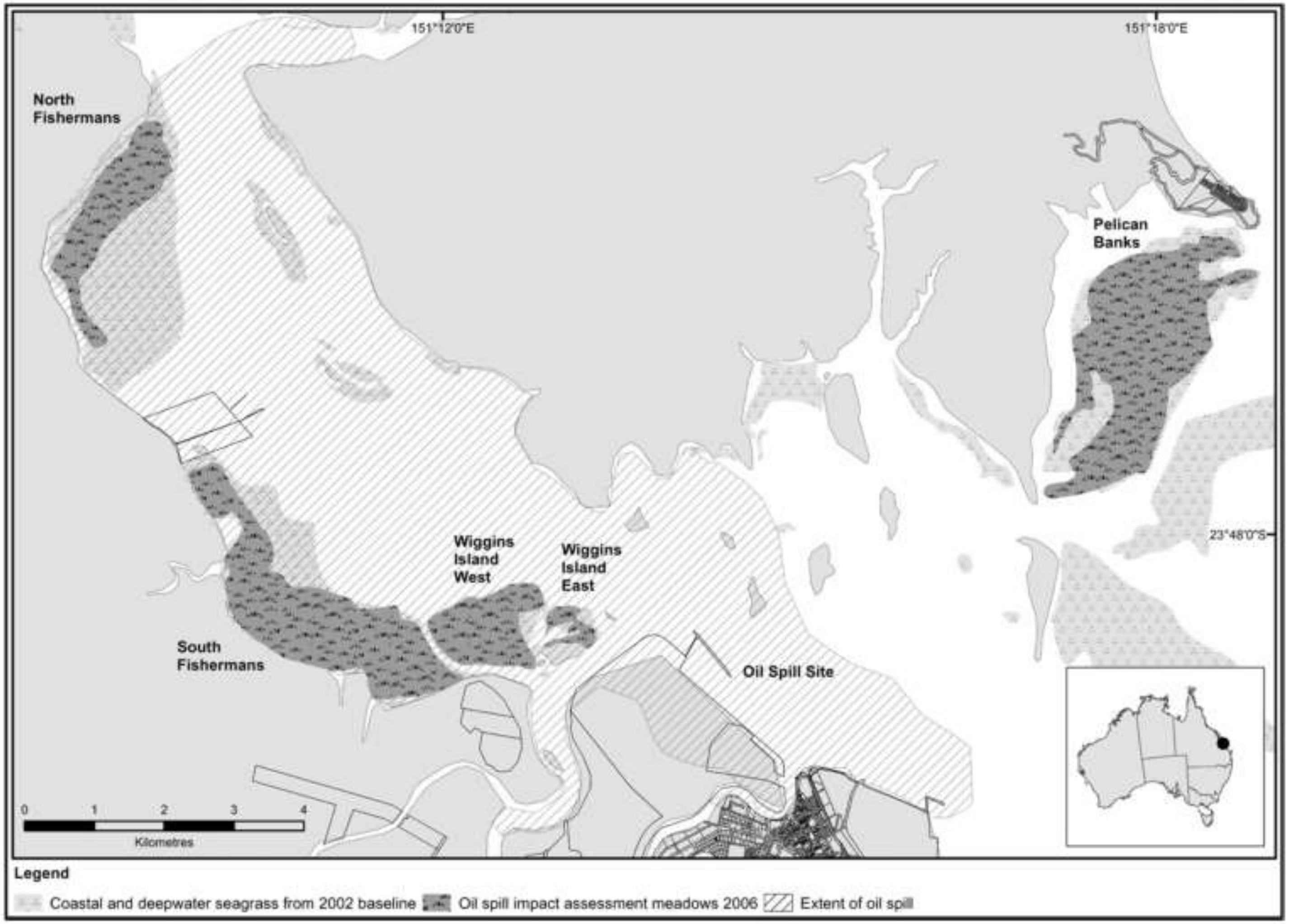

Fig. 2. Location of oil spill impact assessment seagrass meadows.

Conclusions

- Seagrass very sensitive to any disturbance in the marine environment
- Seagrass needs high light
- E&P activities require dialogue and research with Environmental Scientists very early on in a development
- Applied research and monitoring can minimise the impact of a development