Light Attenuation in Estuarine Mangrove Lakes

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Objectives

Evaluate the suitability of light environment in mangrove lakes for submerged aquatic vegetation (SAV)

Chara hornemannii

Halodule wrightii and *Acetabularia*

Identify the components of light attenuating components that contribute most to light attenuation

Introduction

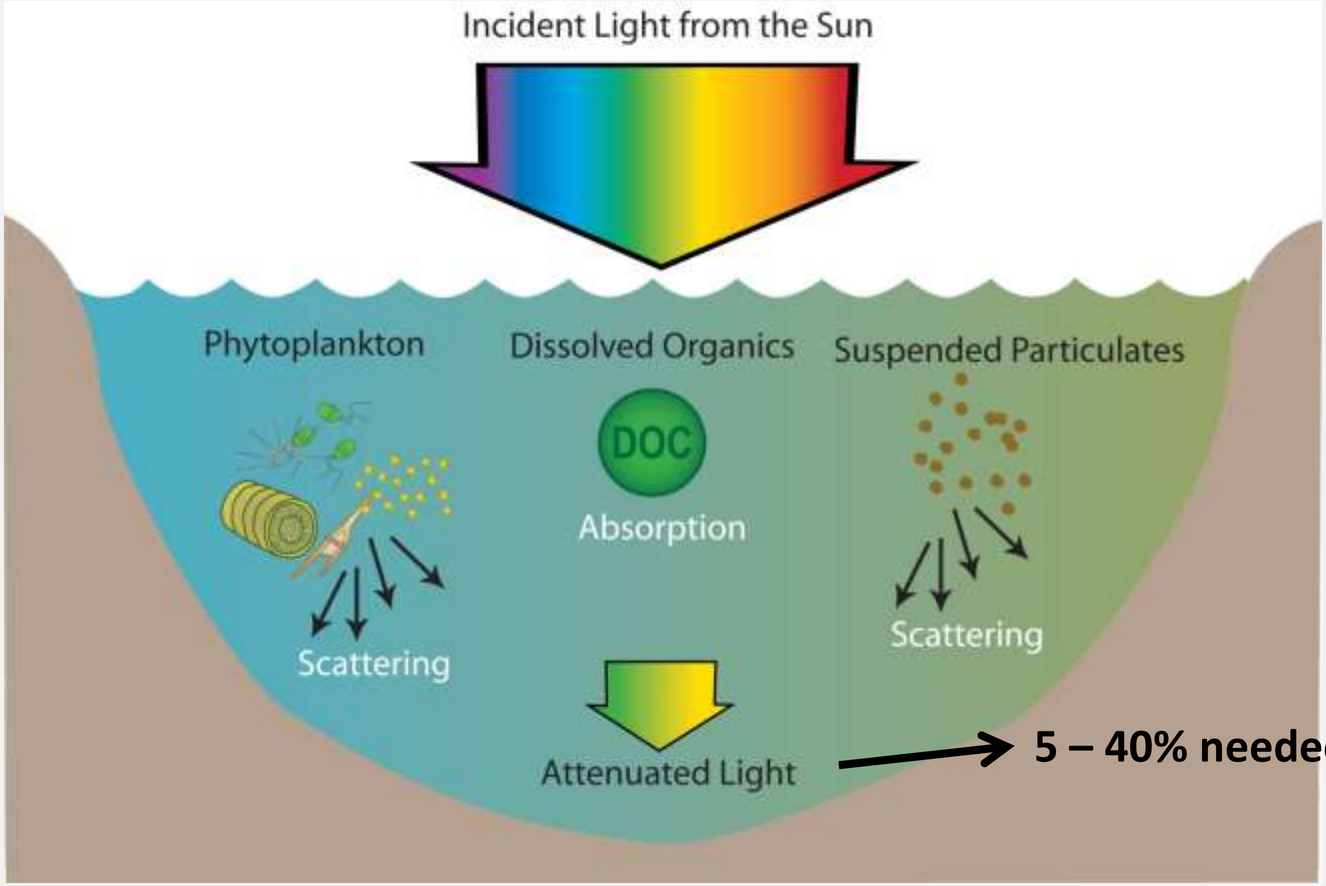
Previous studies in mangrove lakes identified light availability as most important in explaining spatial and temporal differences in SAV cover

Estuaries and Coasts 34: 20-31

Marine and Freshwater Research 63: 1005 – 1014

Introduction

Photosynthetically active radiation (PAR)



5 – 40% needed for SAV

Credit – Dr. Chuck Gallegos, http://ecosystemsontheedge.org/underwater-light-and-seagrass/

Light availability is fundamental for determining suitability of aquatic environments for aquatic vegetation

Introduction

$$Light_{depth} = Light_{surface}\ e^{(-K_t * depth)}$$

Lambert-Beer Equation

Downwelling light attenuation coefficient (K_t) is calculated to determine light availability

Introduction

K_t is an apparent optical property dependent on:

- ambient light field

  sun angle, cloudiness, sea surface

- inherent optical properties

  CDOM, chlorophyll, turbidity

Introduction

After correcting for ambient light field effects, linear partitioning model can be used to quantify relative contributions of inherent optical constituents:

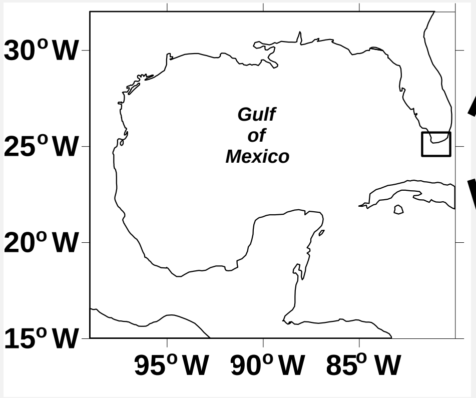
$$K_t \text{ (corrected)} = K_{sw} + K_{turb} + K_{chl} + K_{CDOM}$$

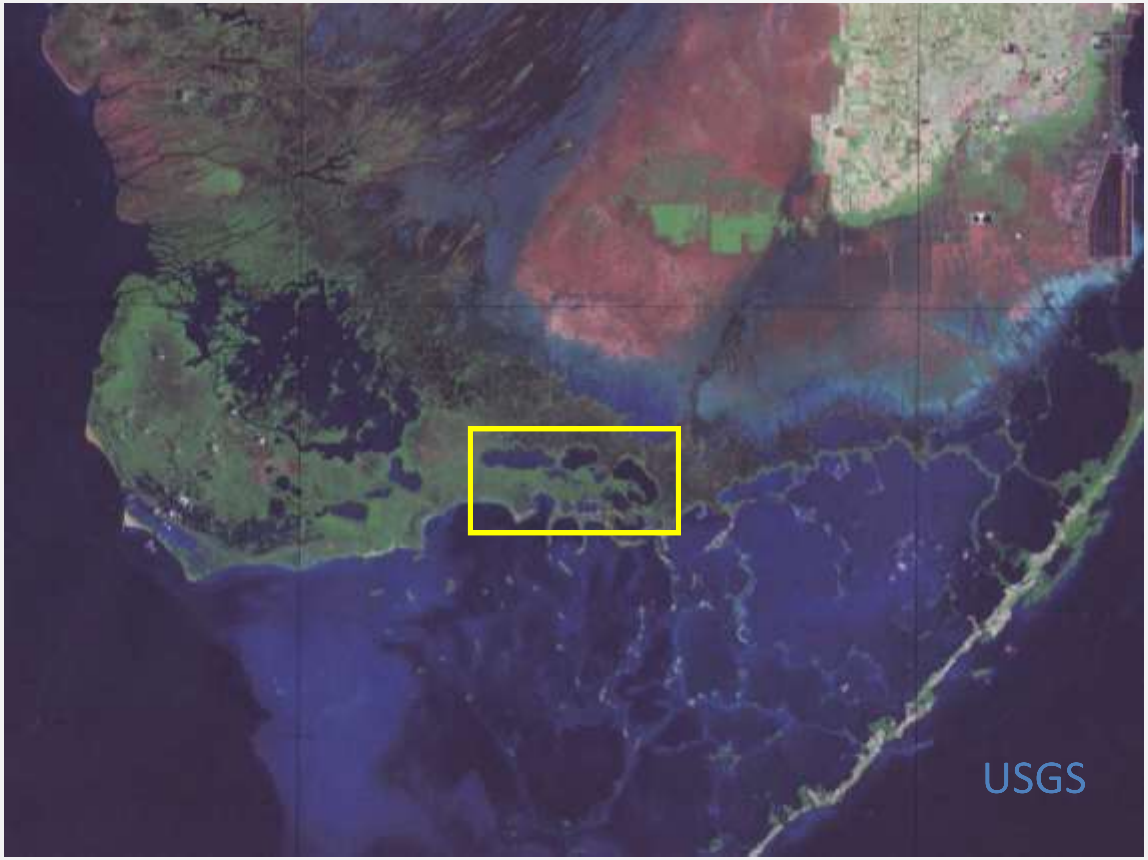
sw = seawater
turb = turbidity
chl = chlorophyll
CDOM = chromophoric dissolved organic matter

$$K_t \text{ (corr)} = K_{sw} + k^*_{turb} \text{ (Turb)} + k^*_{Chl} \text{ (Chl)} + k^*_{CDOM} \text{ (CDOM)}$$

k^* = specific light attenuation coefficients

Where are the Mangrove Lakes?





The Mangrove Lakes are located in the mangrove estuaries between Florida Bay and the Everglades marsh

The Mangrove Lakes are :

Shallow (1.8m max) with extensive SAV beds (historically)

Ruppia maritima and American coots

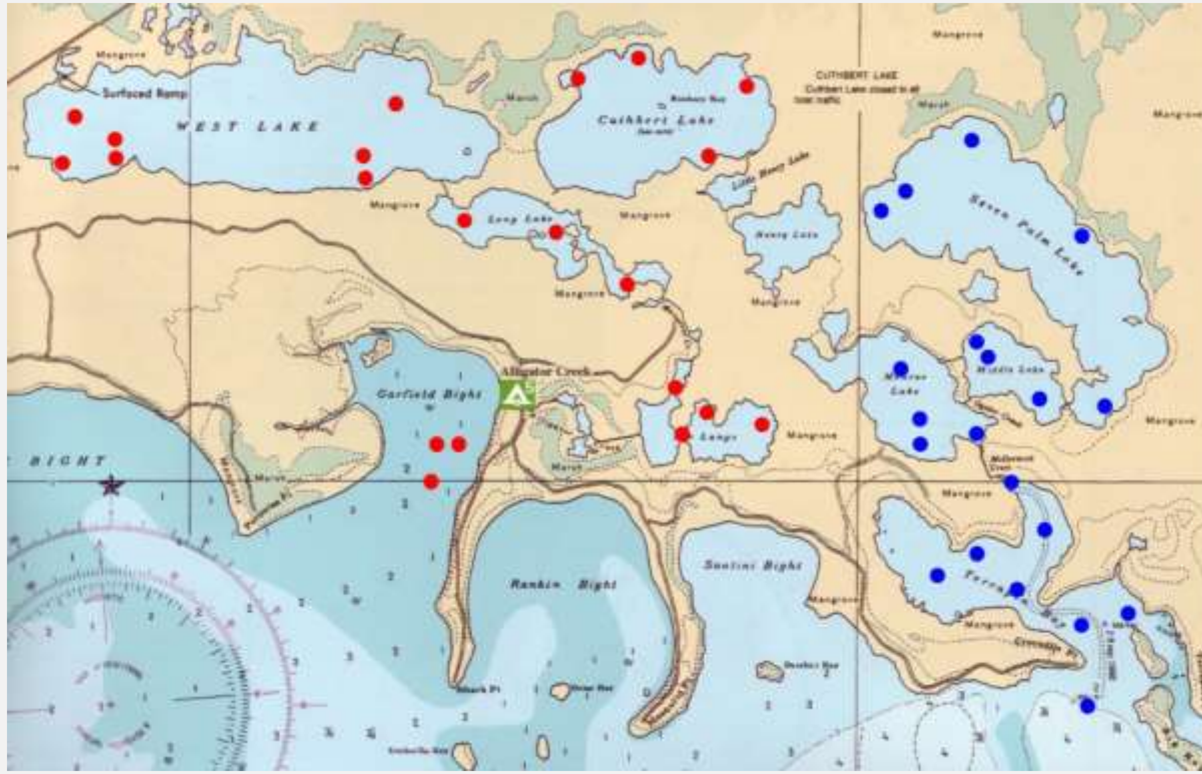
Wintering ducks

Ecosystems affected by reduced freshwater inflows exhibiting:

- estimated 20-30 psu mean salinity increase (McIvor et al. 1994)
- persistent phytoplankton blooms (up to 130 μg Chl a L^{-1})
- reduced SAV cover

The Mangrove Lakes are critical habitats once characterized by extensive SAV beds

Methods



Alligator Creek sub-estuary McCormick Creek sub-estuary

417 simultaneous measurements of Kt, CDOM, turbidity, and chlorophyll *a* (2012 – 2015)

Kt was corrected for sun angle effects using equations of McPherson and Miller 1994 and Miller and McPherson 1995

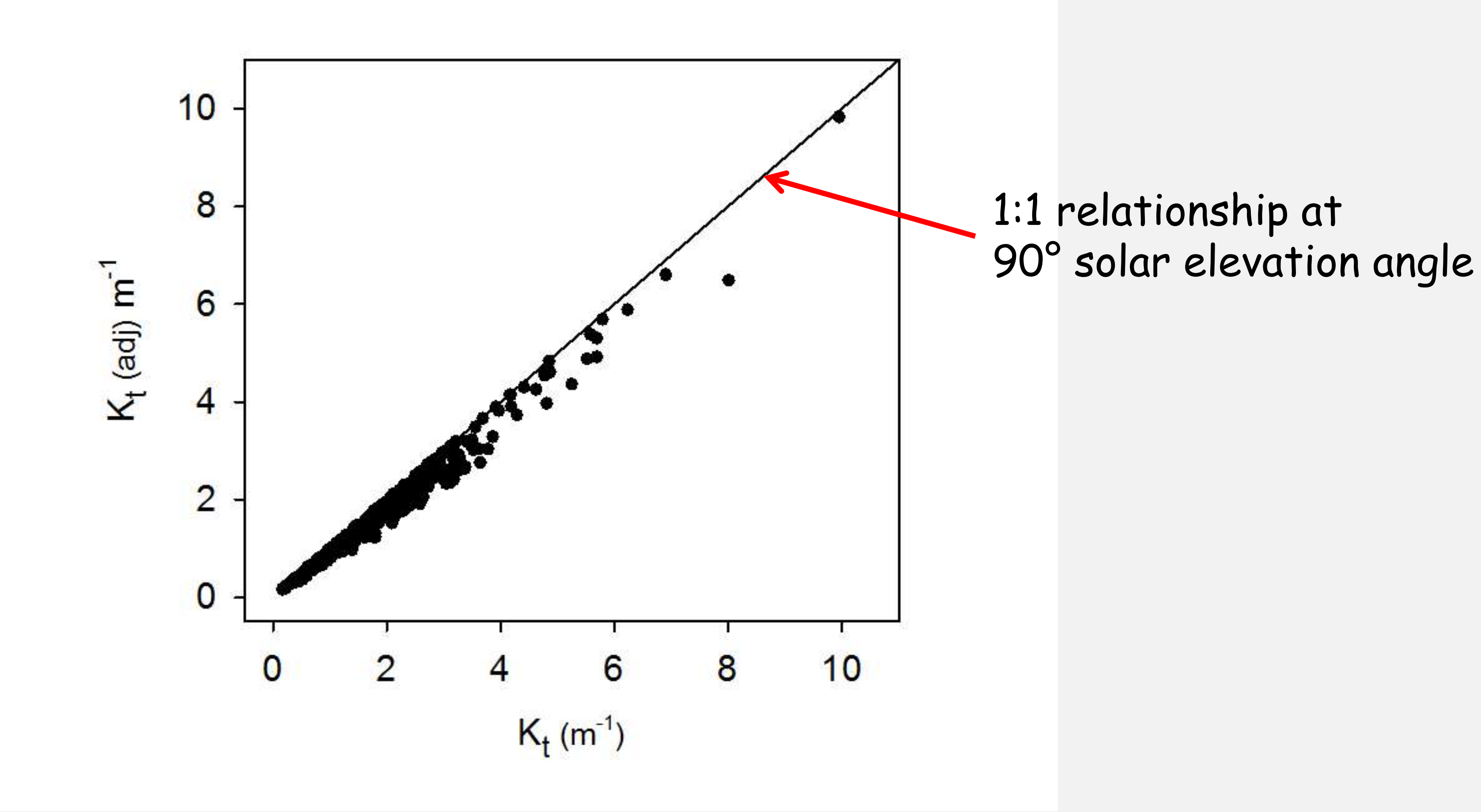
Methods cont.

Multiple regression to estimate specific light attenuation coefficients

Kt versus turbidity, chlorophyll a, CDOM

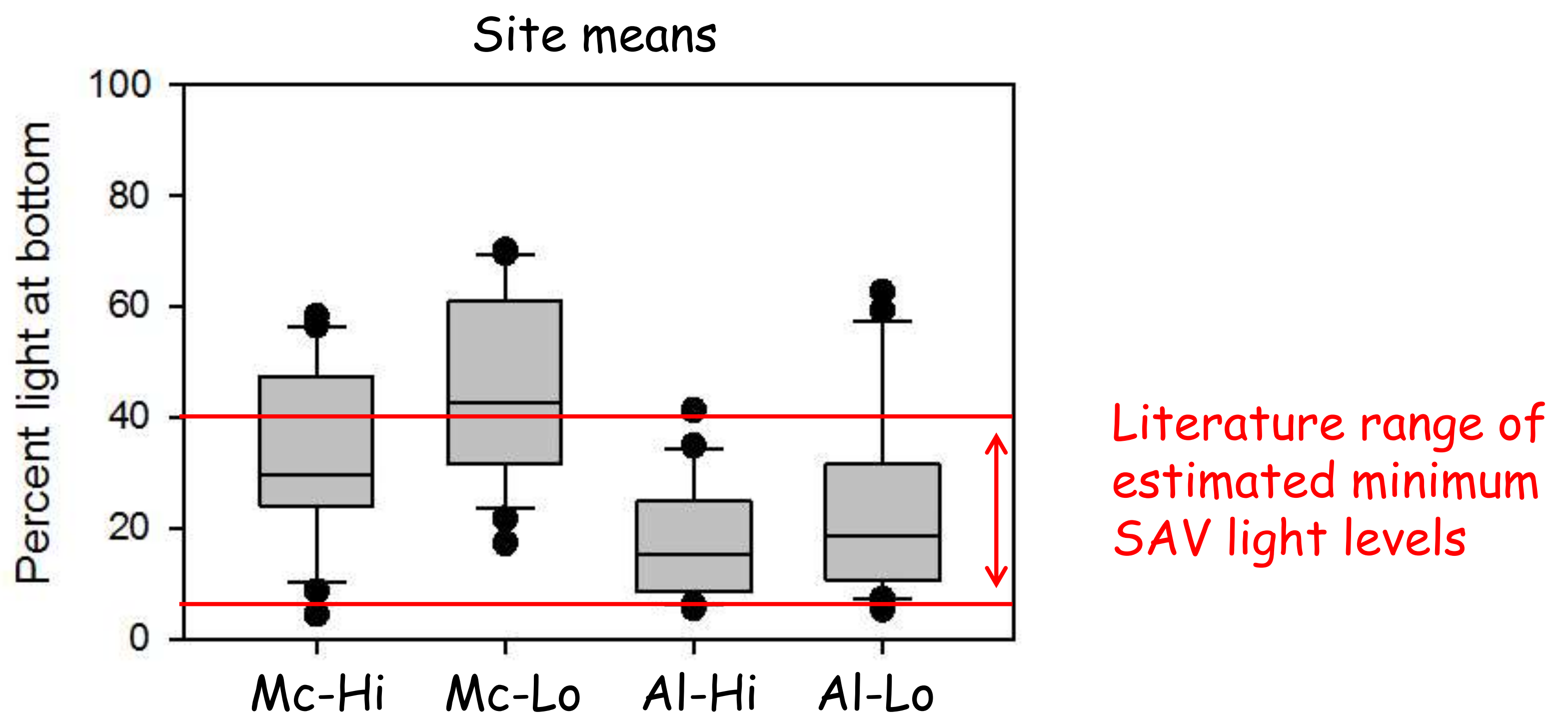
Component contributions to light attenuation determined from estimated specific light attenuation coefficients and component concentrations using expanded partitioning model

Results



Light attenuation coefficients uncorrected for sun angle are, on average, 13% higher than adjusted estimates

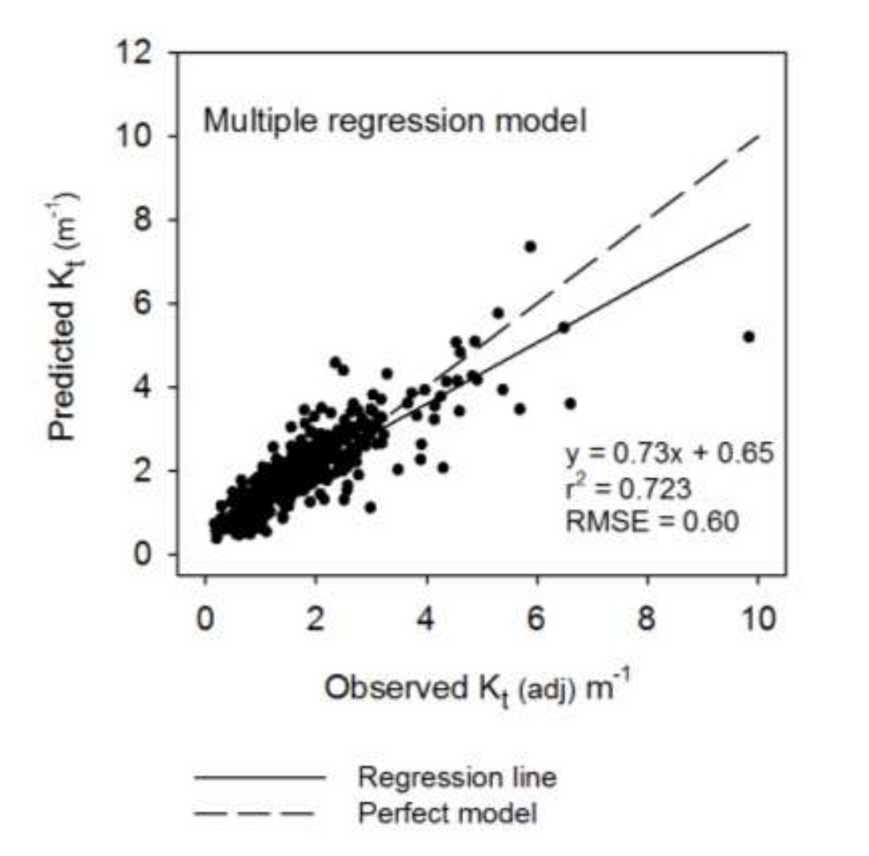
Results



Underwater light environment often unsuitable for SAV

Results

$$K_t\,(pred) = K_{sw} + k^*_{turb}\,(Turb) + k^*_{Chl}\,(Chl) + k^*_{CDOM}\,(CDOM)$$



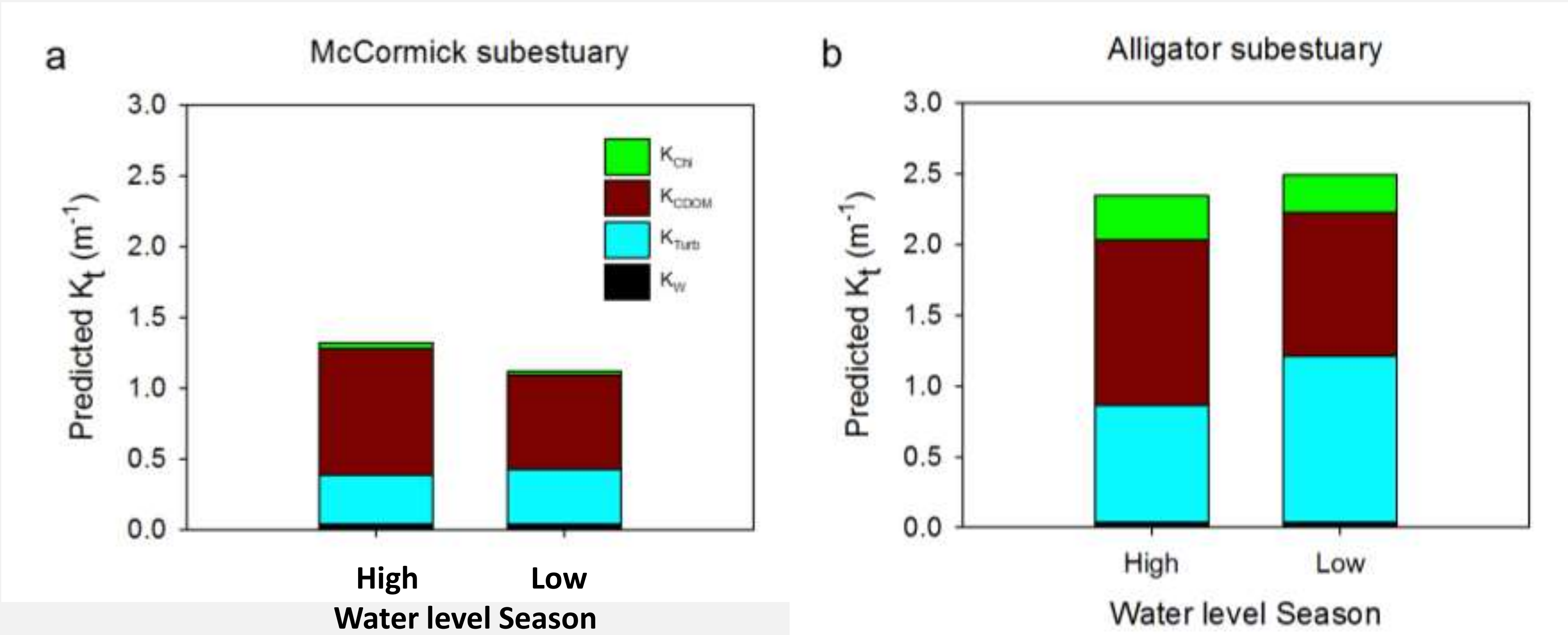
$k^*_{turb} = 0.059 \pm 0.004\ m^{-1}\ NTU^{-1}$

$k^*_{Chl} = 0.024 \pm 0.004\ m^{-1}\ m2\ mg^{-1}$

$k^*_{CDOM} = 0.008 \pm 0.001\ m^{-1}\ QSU^{-1}$

Light attenuation was well predicted by the multiple regression model

Results



Chlorophyll, CDOM, Turbidity, water

CDOM contributes most to light attenuation in mangrove lakes followed by turbidity, and chlorophyll

More about CDOM in the mangrove lakes

To achieve light transmission >40% at 1m depth, $K_t < 0.92\ m^{-1}$

Mean KCDOM (entire study area) = $0.88\ m^{-1}$

CDOM alone reduces light transmission to near light limits

CDOM specific light attenuation coefficient for CDOM in mangrove lakes ($k^*_{CDOM} = 0.008\ m^{-1}$ QSU-1) is 20X greater than that determined for CDOM in downstream Florida Bay ($0.0004\ m^{-1}\ QSU^{-1}$, Kelble et al. 2005).

Fresh mangrove-derived CDOM absorbs much more light than CDOM in downstream Florida Bay.

Conclusions

- Underwater light environment in mangrove lakes often unsuitable for SAV.

- Light attenuation component contributions

  CDOM > Turbidity > Chlorophyll.

- High concentrations of CDOM of high specific light absorption density sufficiently reduces light transmission to limits for SAV growth.

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