Carbon and Nutrient Fluxes in a Mangrove Ecosystem

GONG Wooi Khoon

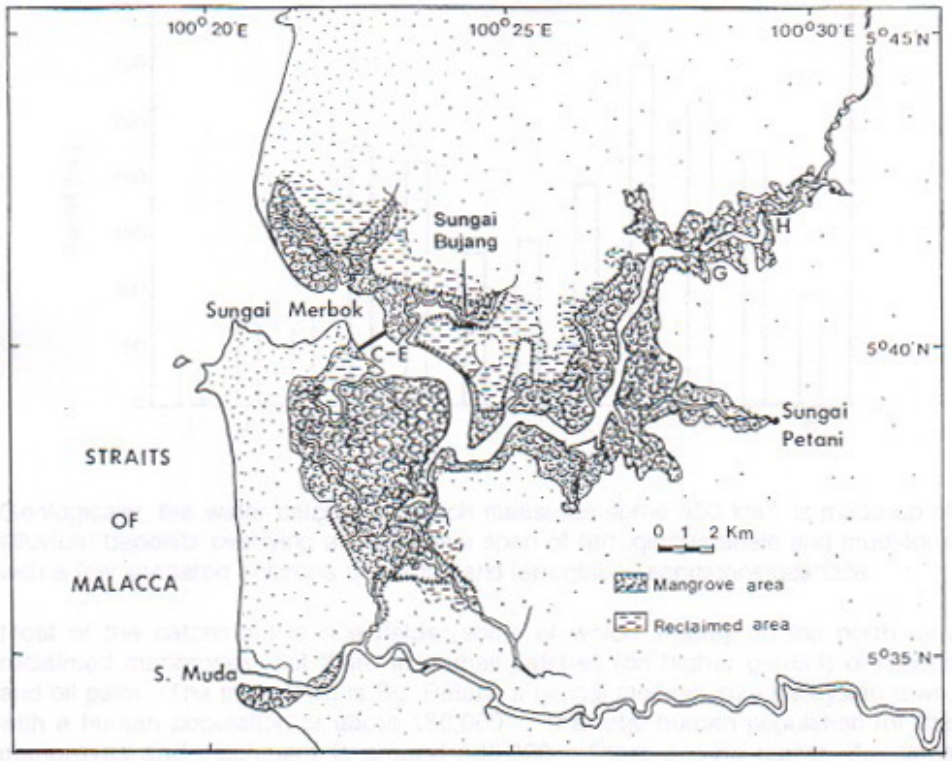
Contents

HORIZONTAL FLUXES

- **Land to mangrove waterways**
- **Mangroves to waterways**
- **Mangrove waterways to ocean**

HORIZONTAL FLUXES
Estuarine Cross-Section

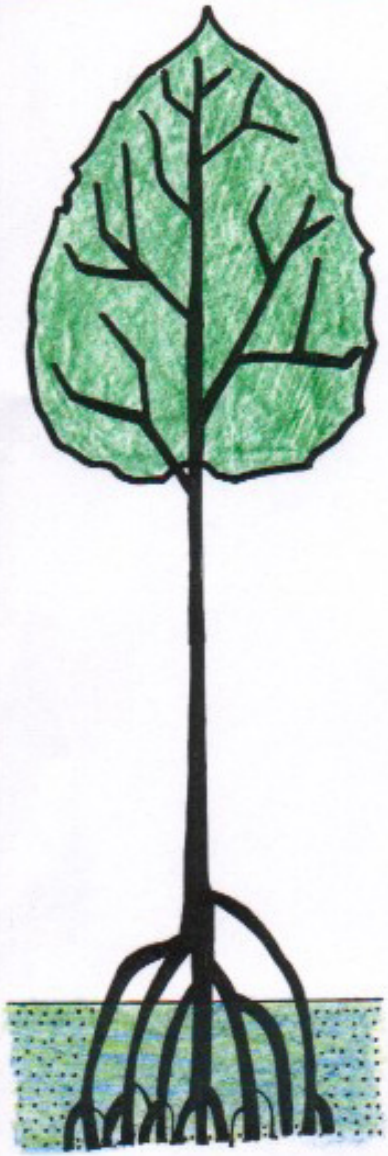
Map 1. The Sg. Merbok Mangroves and its water catchment.



VERTICAL FLUXES

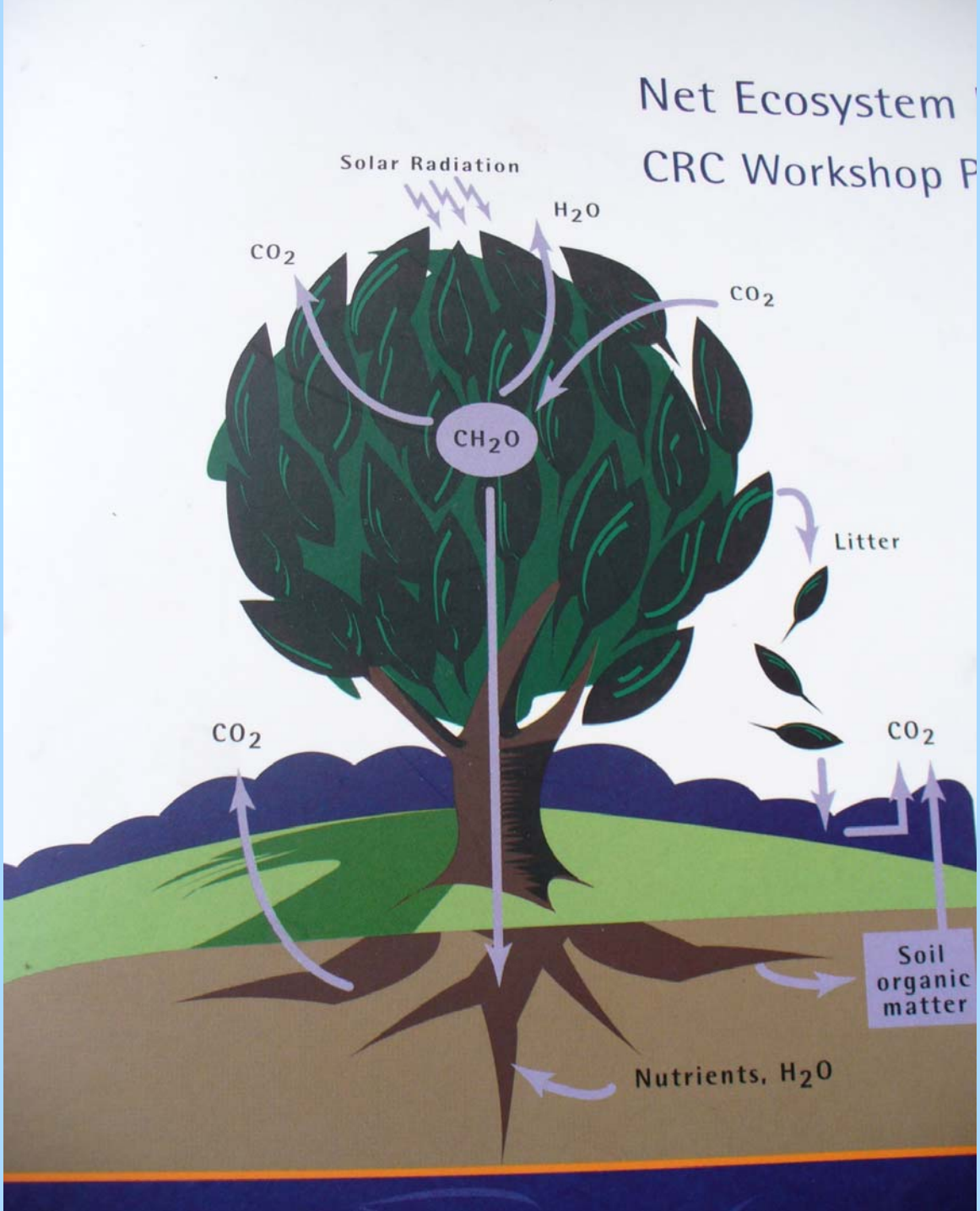
- **Atmosphere / Forest**
  - **Biomass**
  - **Gas Exchange**
- **Atmosphere / Soil**
- **Atmosphere / Water**
- **Water / Sediment**

Atmosphere/forest, Atmosphere/soil, Atmosphere/water, Water/sediment



	% BIOMASS	PRODUCTIVITY ($tC\ ha^{-1}\ year^{-1}$)
LEAVES	2.6	0.08 ± 4.0
CANOPY		
BRANCHES	8.0	0.44 ± 1.1
TRUNK	74.0	5.56 ± -
STILT ROOTS	10.0	0.64 ± -
ROOTS	5.1	0.42 ± ?
TOTAL	100.0	7.14 ± 5.1 ± ?

Source : Ong, Gong & Clough (1995)



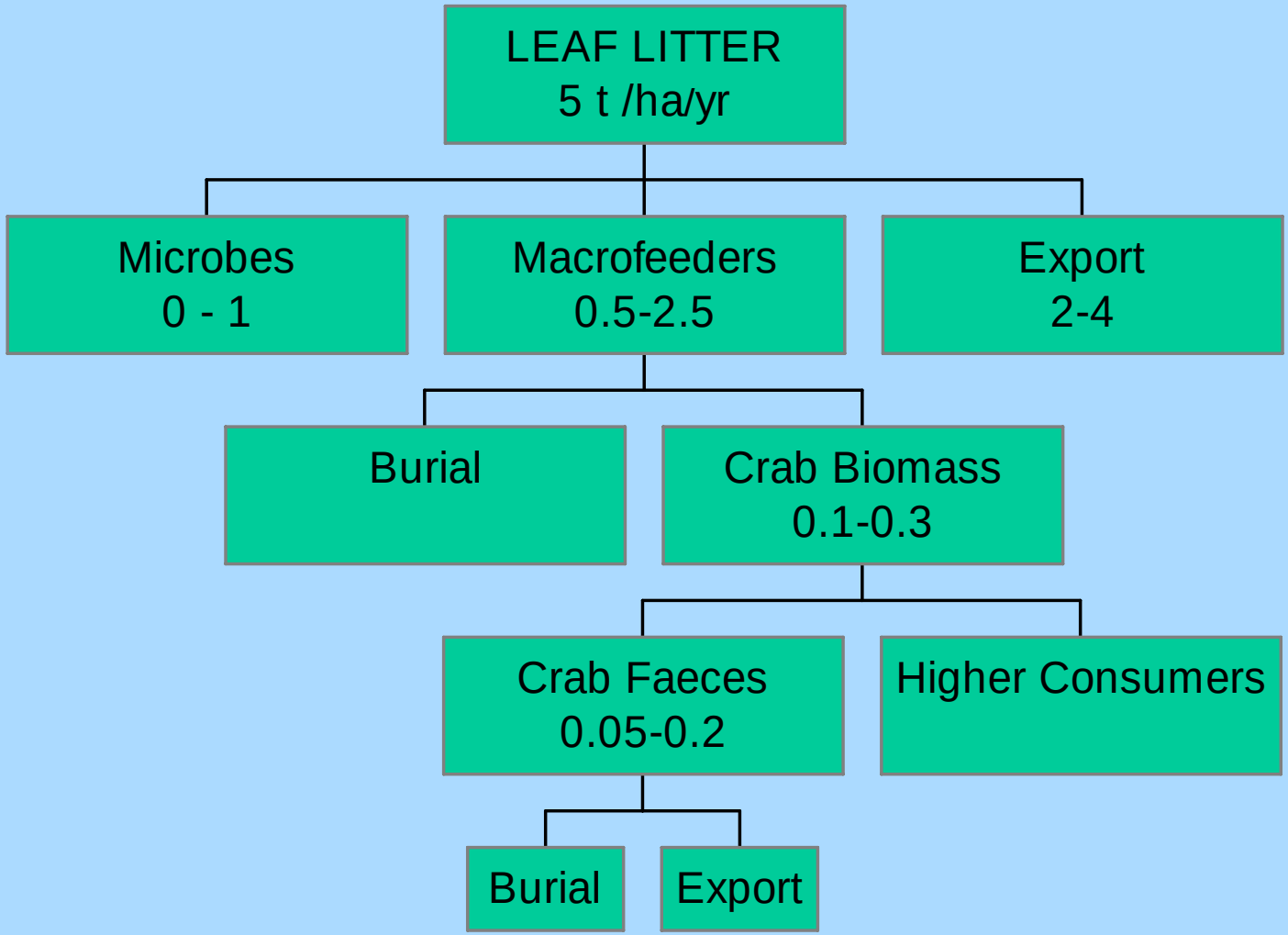
NET ECOSYSTEM EXCHANGE

CRC Greenhouse Accounting, 2001; Australia

ATMOSPHERE / SOIL FLUXES

- **6.44 - 9.22 umol CO_2 m^{-2} s^{-1} (Kumaradevan, S.)**

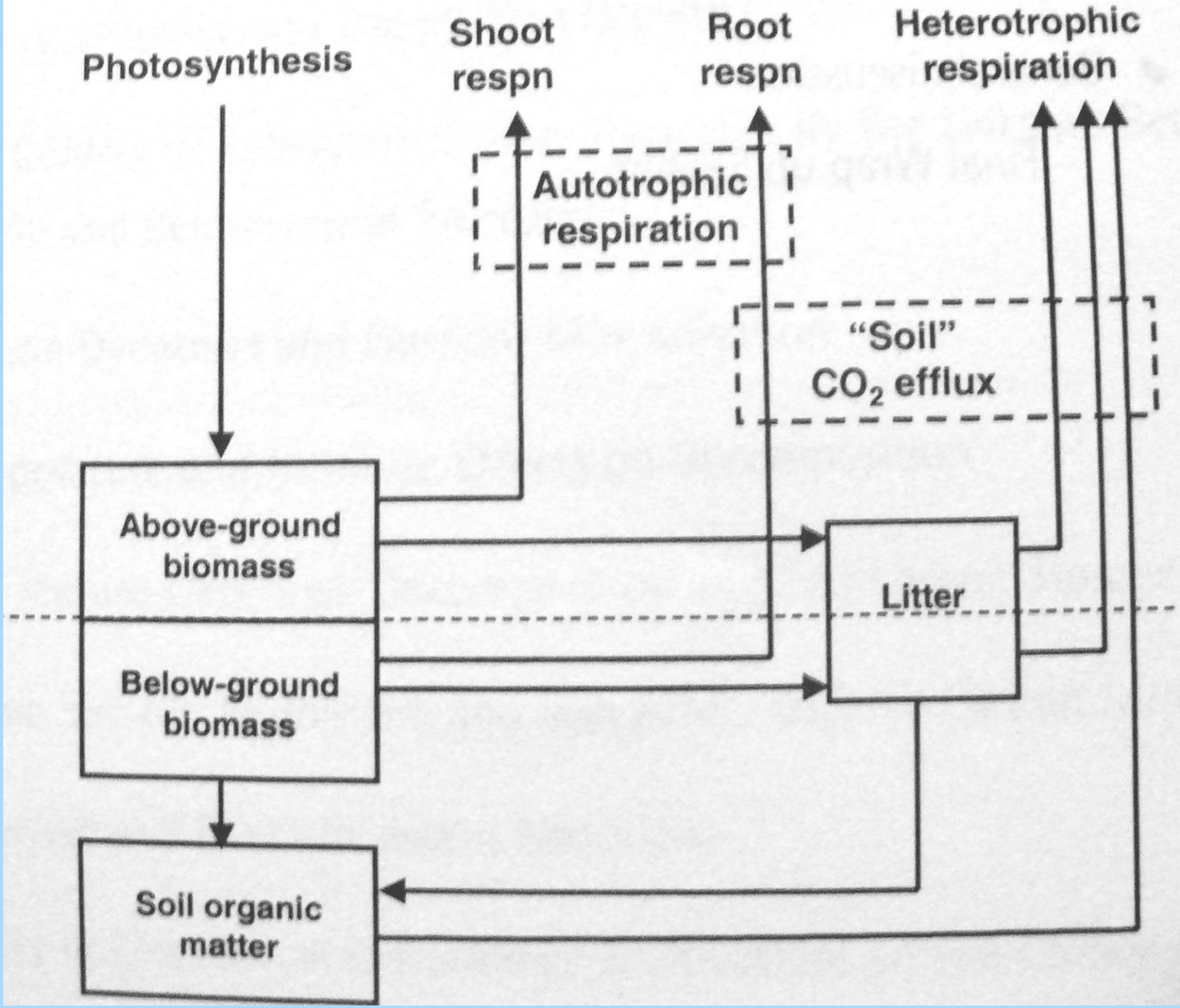
FATE OF PRODUCTION



Mangrove Soil Carbon

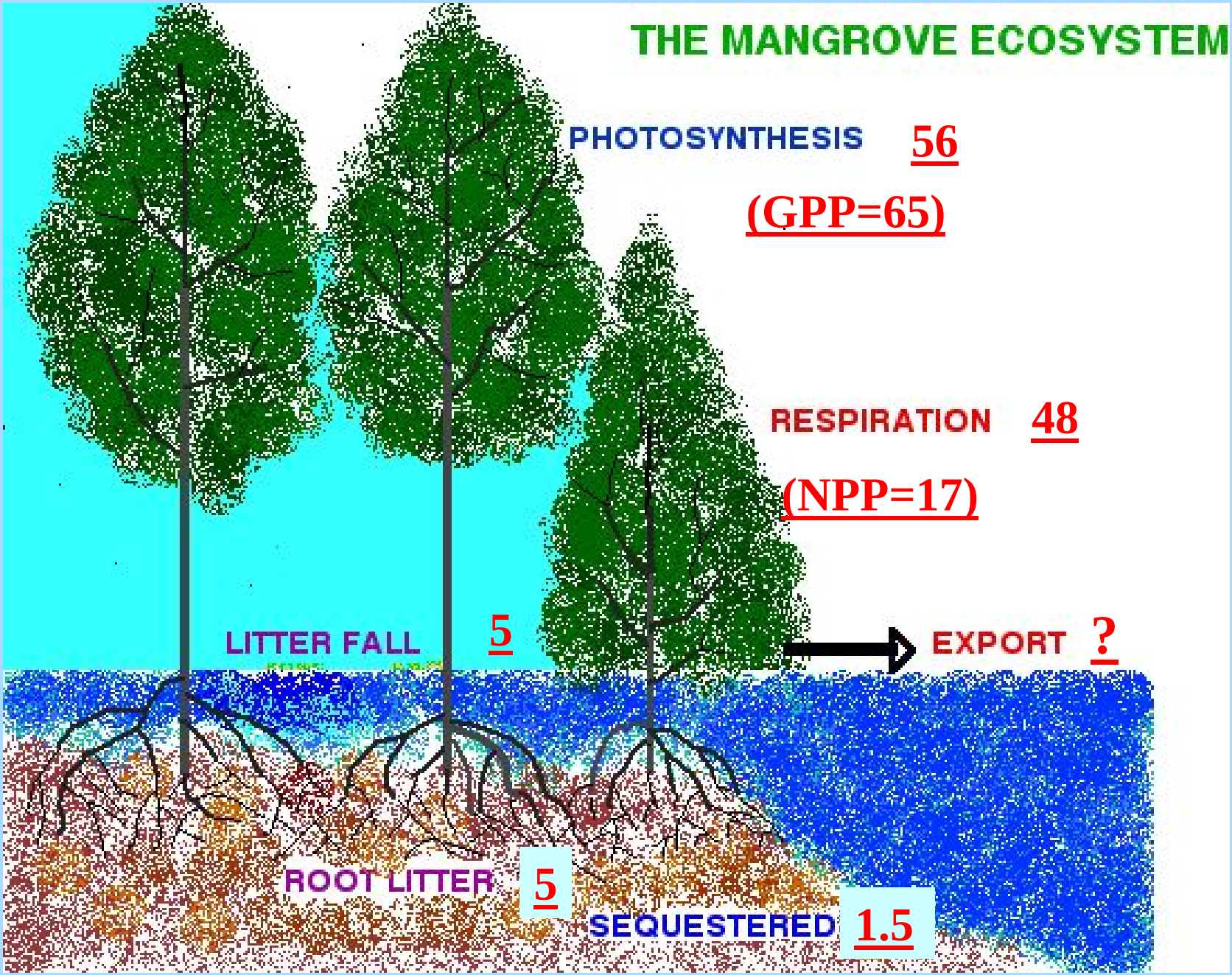
(Ong, 1993)

- **Soil carbon: 15 %**
- **Soil density: 0.7**
- **Depth: about 10 metres**
- **Total Carbon: 10,500 t ha^{-1}**
- **Age: 7000 years**
- **Sequestration: 1.5 t ha^{-1} yr^{-1}**



Carbon Fluxes in Ecosystems

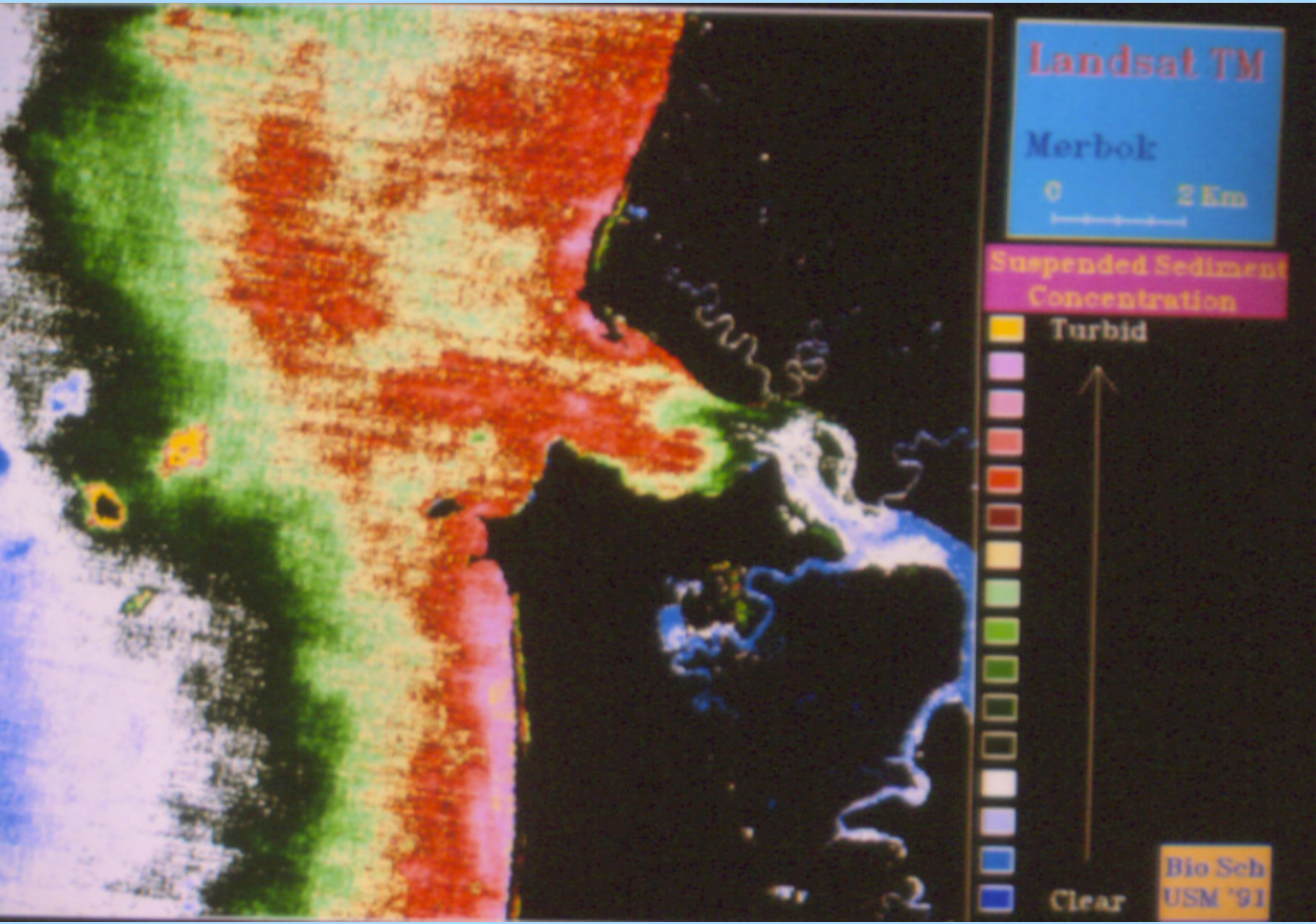
(CRC Greenhouse Accounting, Australia 2001)



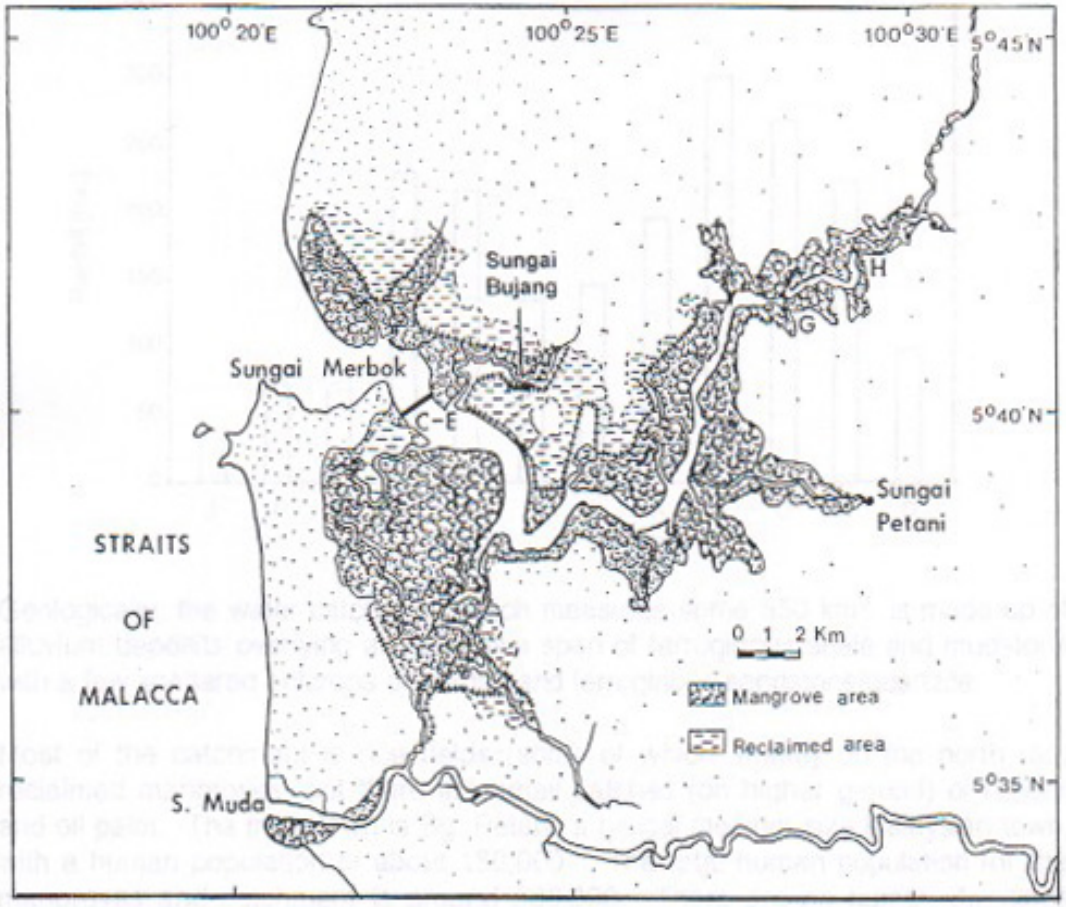
Unit: t C ha $^{-1}$ y^{-1}

HORIZONTAL FLUXES

- **Land to mangrove waterways**
- **Mangroves to waterways**
- **Mangrove waterways to ocean**


Landsat TM
Merbok
0
2 Km
Suspended Sediment Concentration
Turbid
Clear
Bio Sch
USM '91

Map 1. The Sg. Merbok Mangroves and its water catchment.



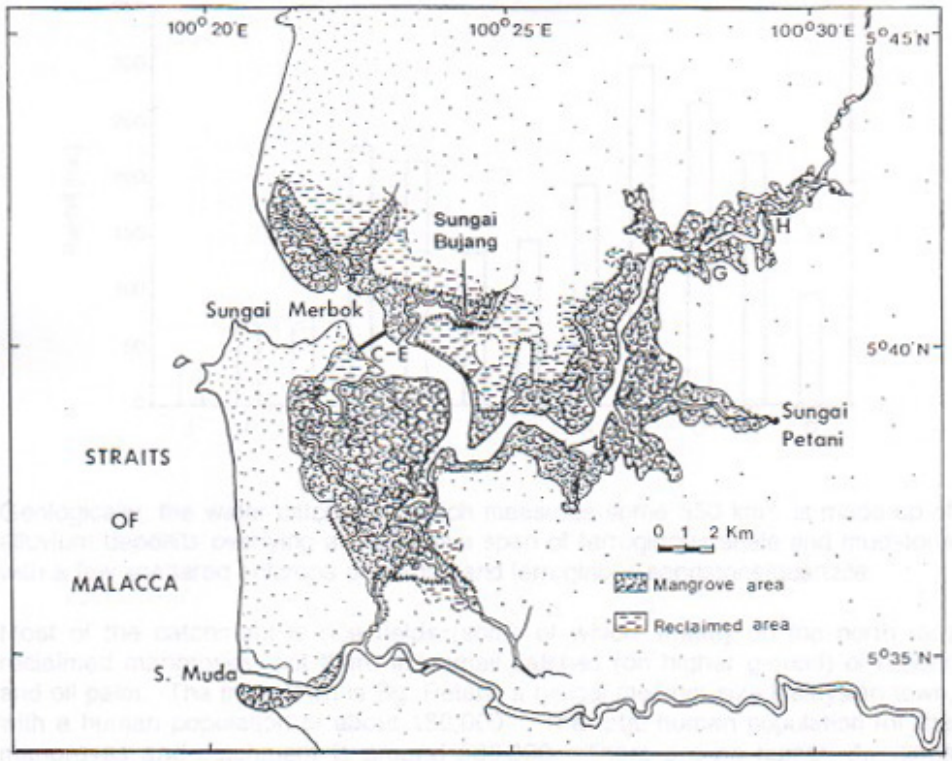
Merbok Mangroves, Peninsular Malaysia

Methods for measuring Fluxes

1. **Estuarine Cross-Section**
2. **Mixing Diagrams**
3. **C-N-P Budgets & Stoichiometry (LOICZ)**

HORIZONTAL FLUXES
Estuarine Cross-Section

Map 1. The Sg. Merbok Mangroves and its water catchment.



Deploying Current Meters

Fouling – Barnacles after 2 weeks!

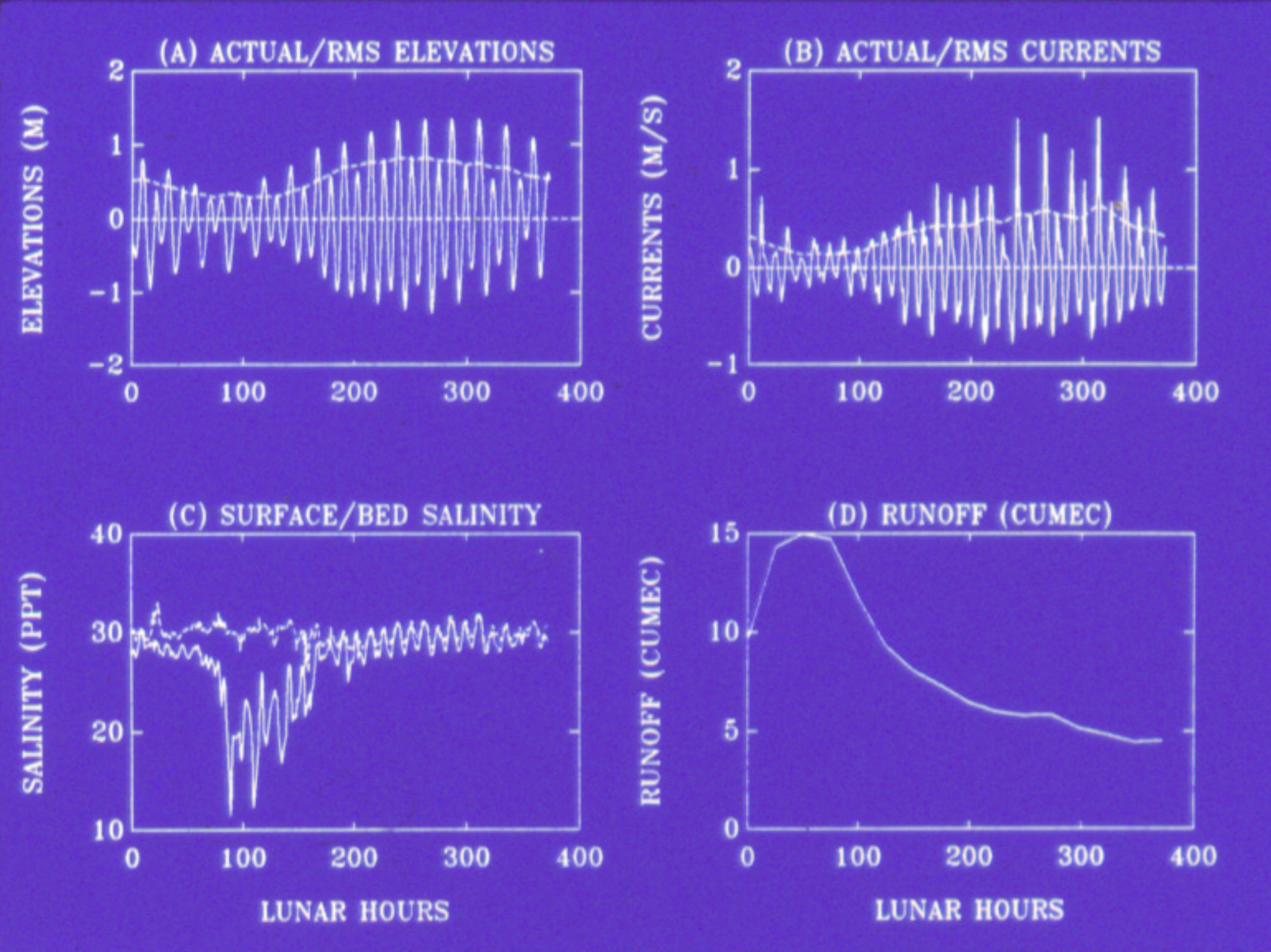
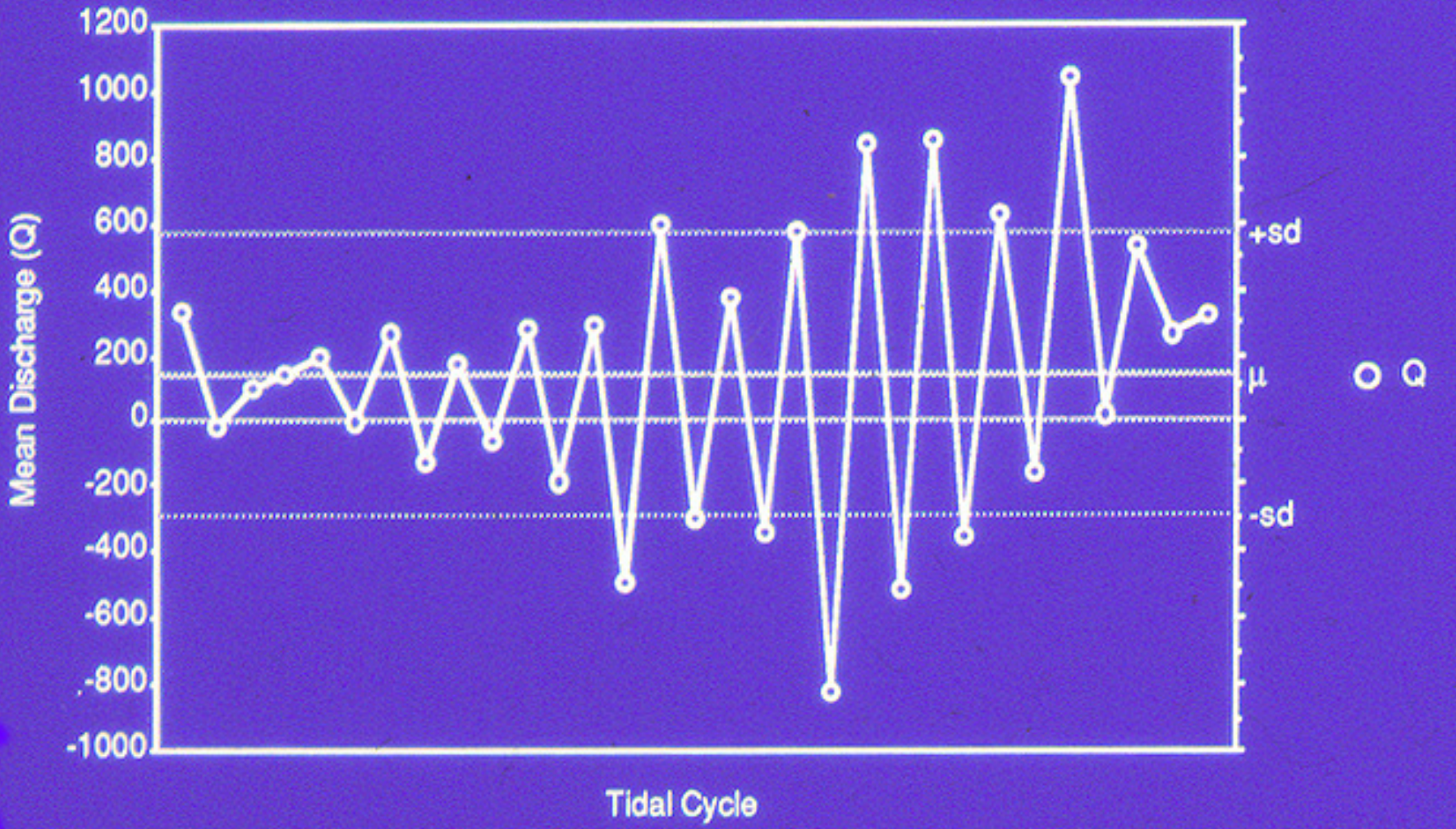
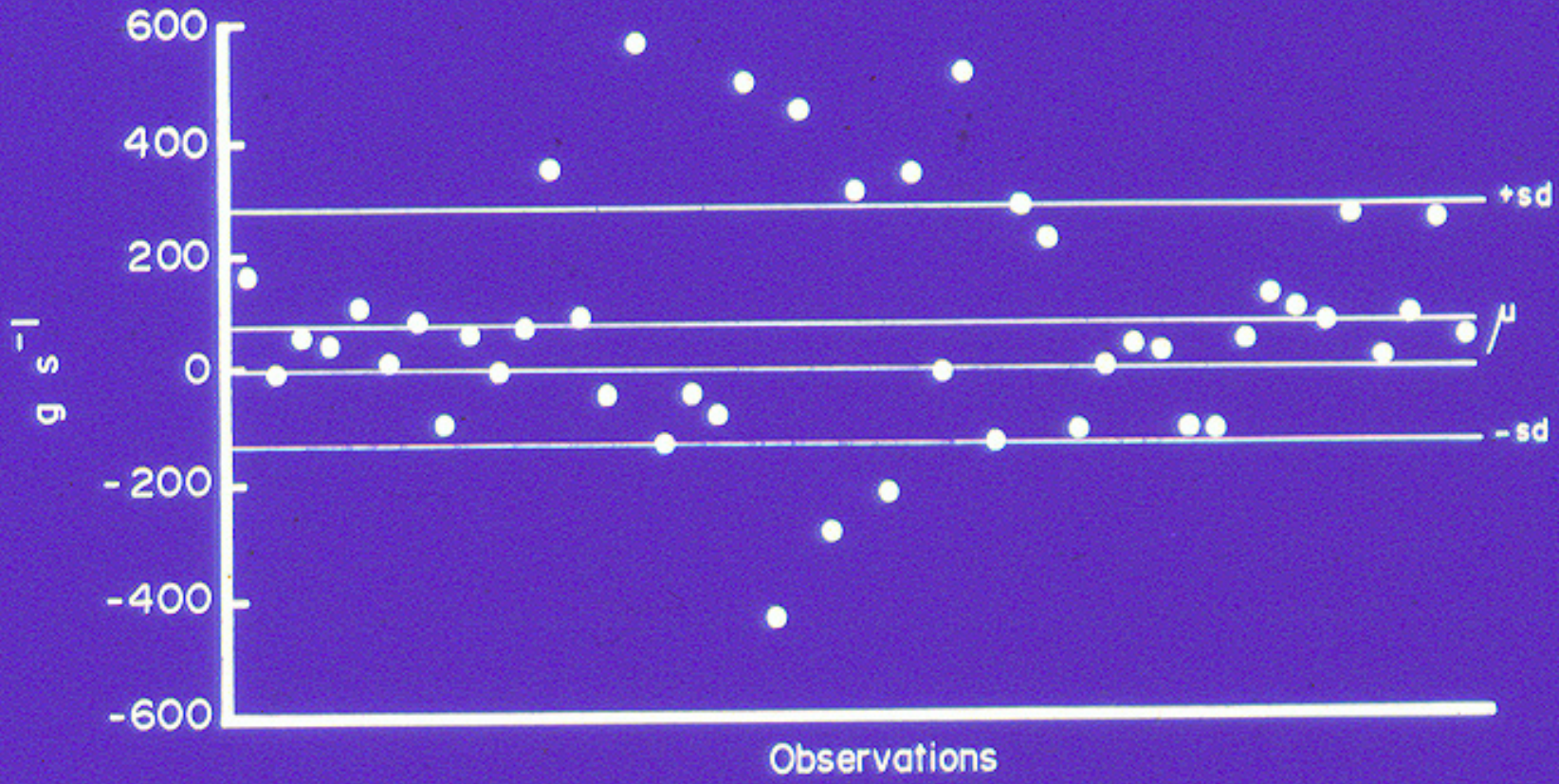
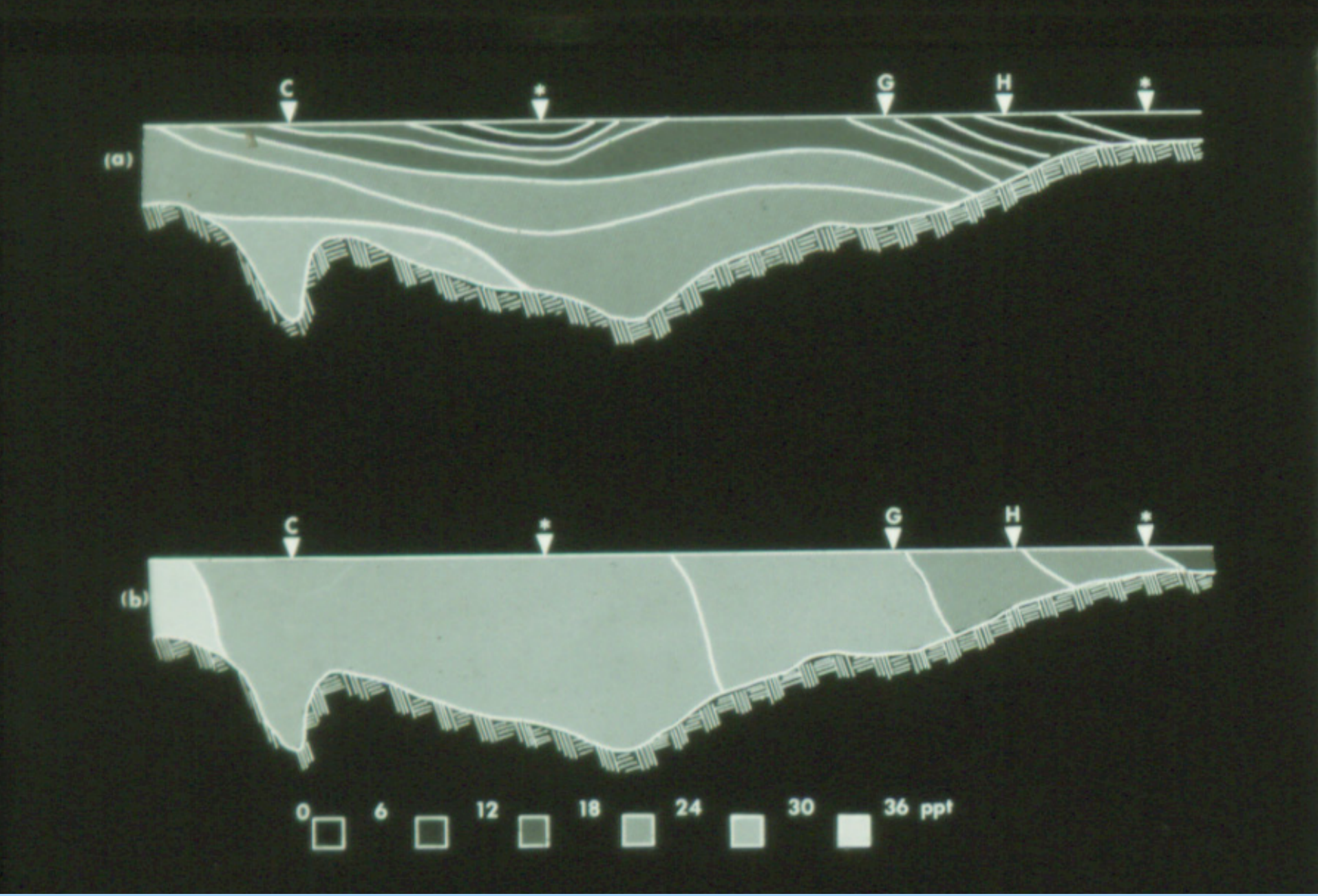

(A) ACTUAL/RMS ELEVATIONS
ELEVATIONS (M)
2
1
0
-1
-2
0
100
200
300
400
(B) ACTUAL/RMS CURRENTS
CURRENTS (M/S)
2
1
0
-1
0
100
200
300
400
(C) SURFACE/BED SALINITY
SALINITY (PPT)
40
30
20
10
0
100
200
300
400
LUNAR HOURS
(D) RUNOFF (CUMEC)
RUNOFF (CUMEC)
15
10
5
0
0
100
200
300
400
LUNAR HOURS

Figure 2. Mean water discharge of the Sungai Merbok over 31 continuous tidal cycle.



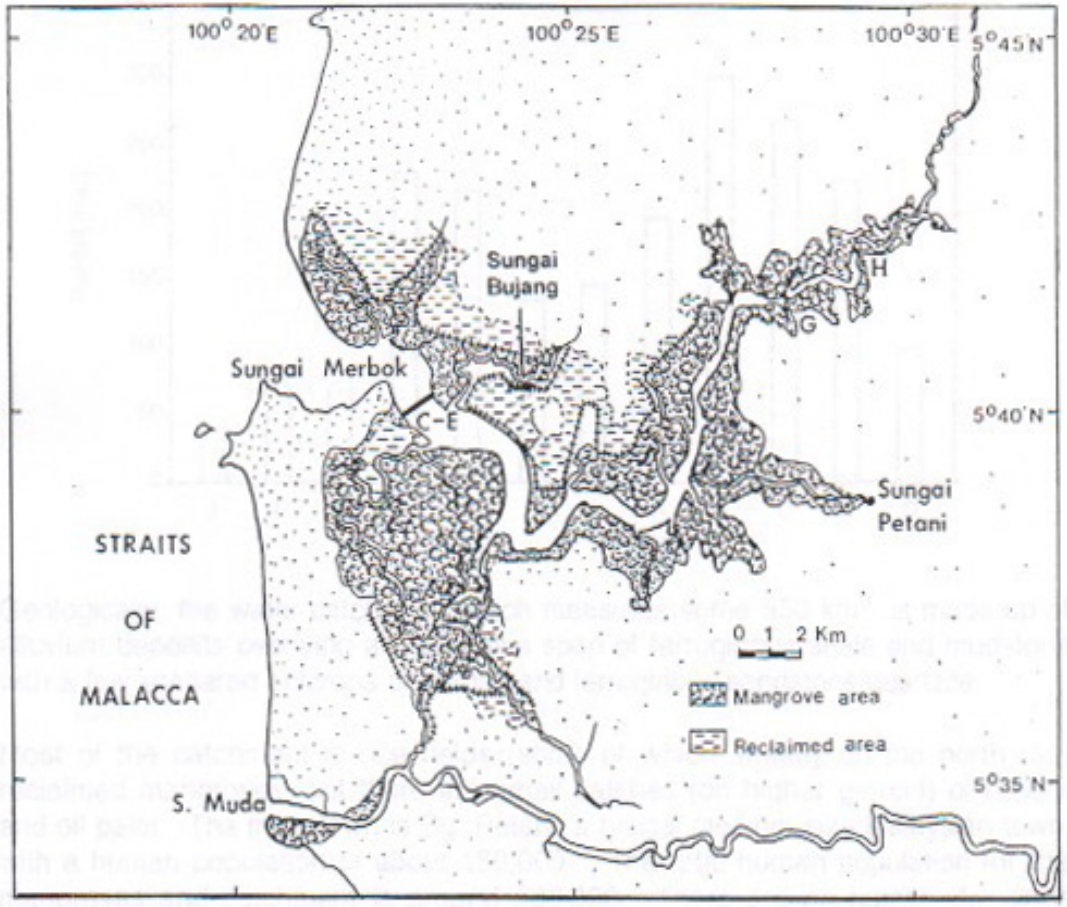


Nitrogen flux ($g\ s^{-1}$) for 45 tidal cycles for the Sungai Merbok estuary



Salinity: Neap – stratified; Spring - mixed

Map 1. The Sg. Merbok Mangroves and its water catchment.



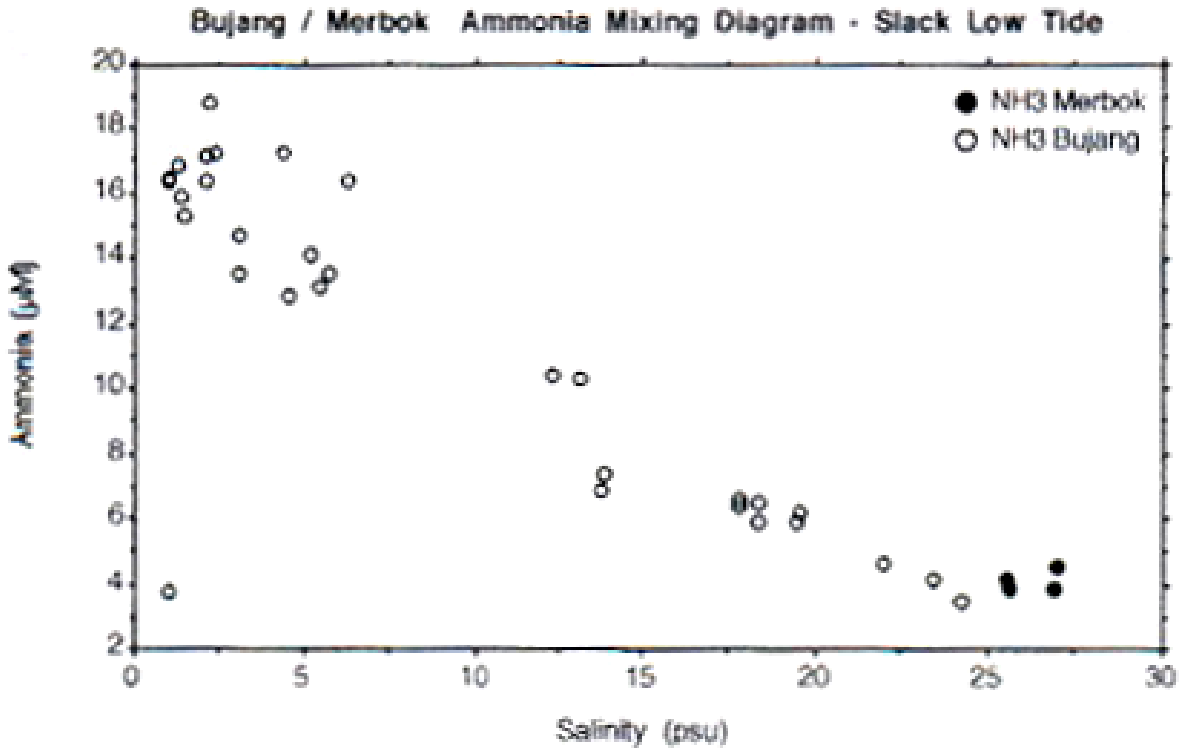
Merbok Mangroves, Peninsular Malaysia

Methods for measuring Fluxes

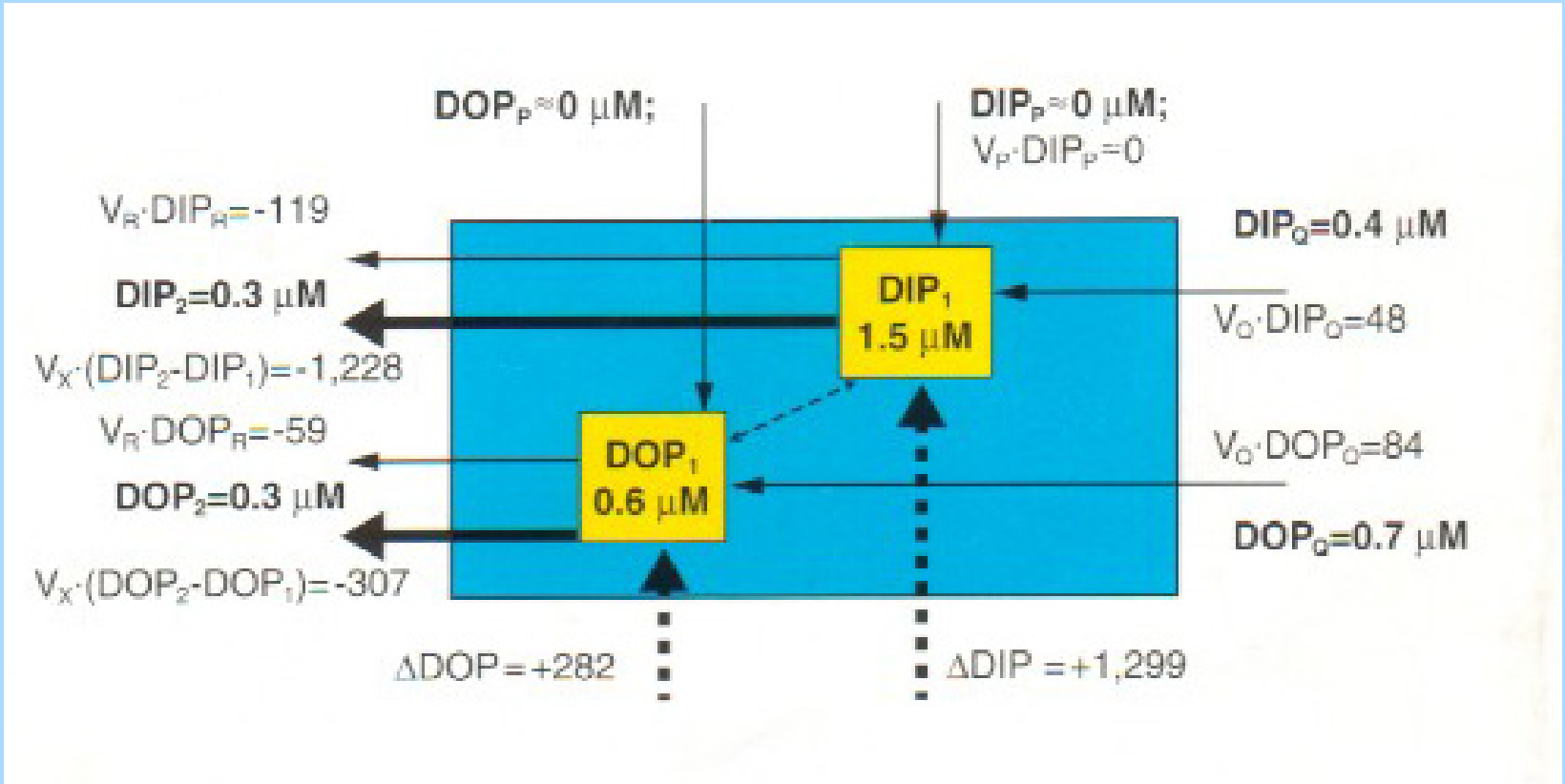
1. **Estuarine Cross-Section**
2. **Mixing Diagrams**
3. **C-N-P Budgets & Stoichiometry (LOICZ)**

HORIZONTAL FLUXES
Mixing Diagrams

Figure 7. Distribution of ammonia with salinity along the Sg. Bujang on the spring tide of 22 September, 1998.

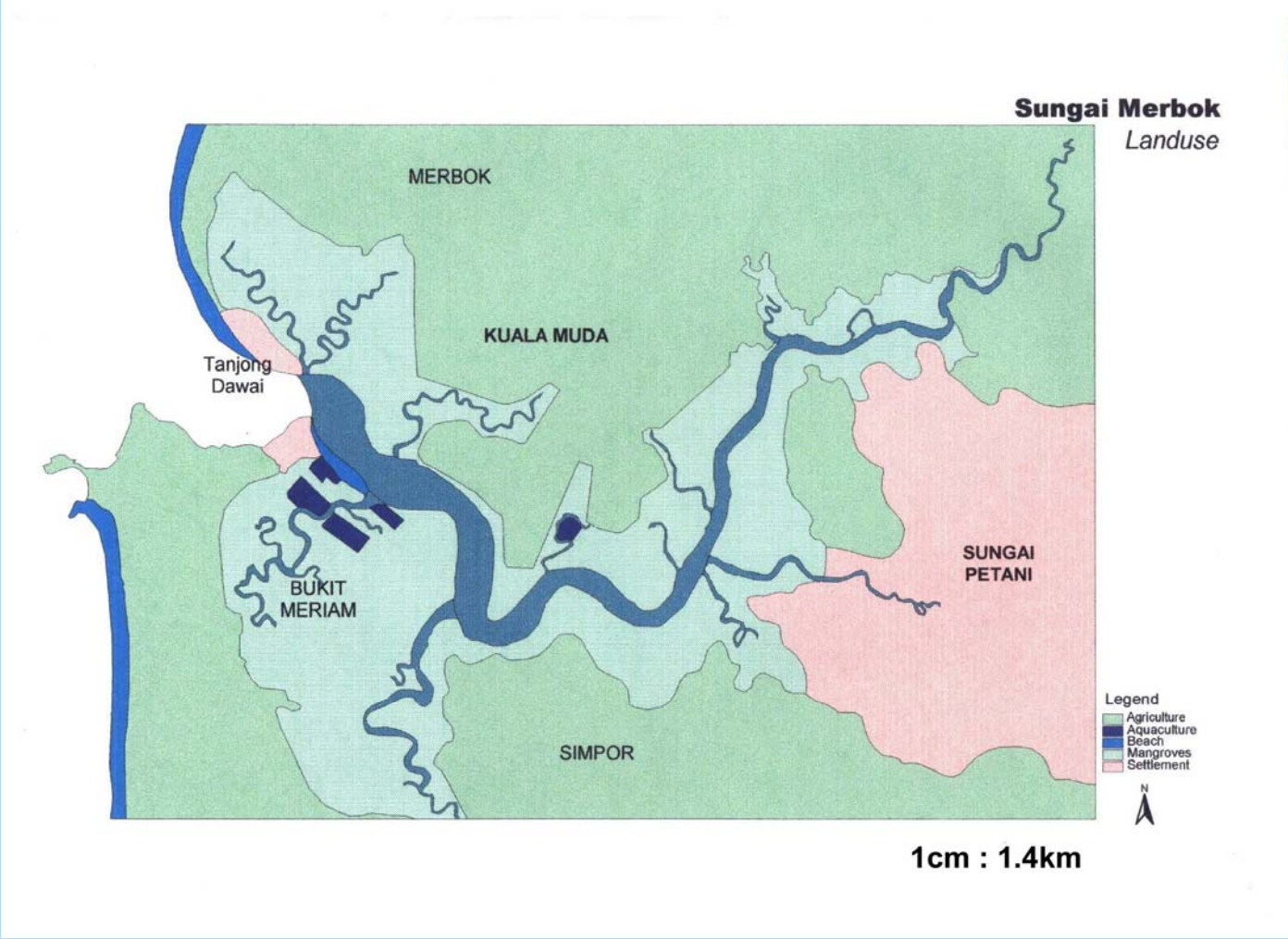


HORIZONTAL FLUXES
Stoichiometry



Gordon *et. al.*, (1996)

- **Respiration: 1.38 t C ha^{-1} yr^{-1}**



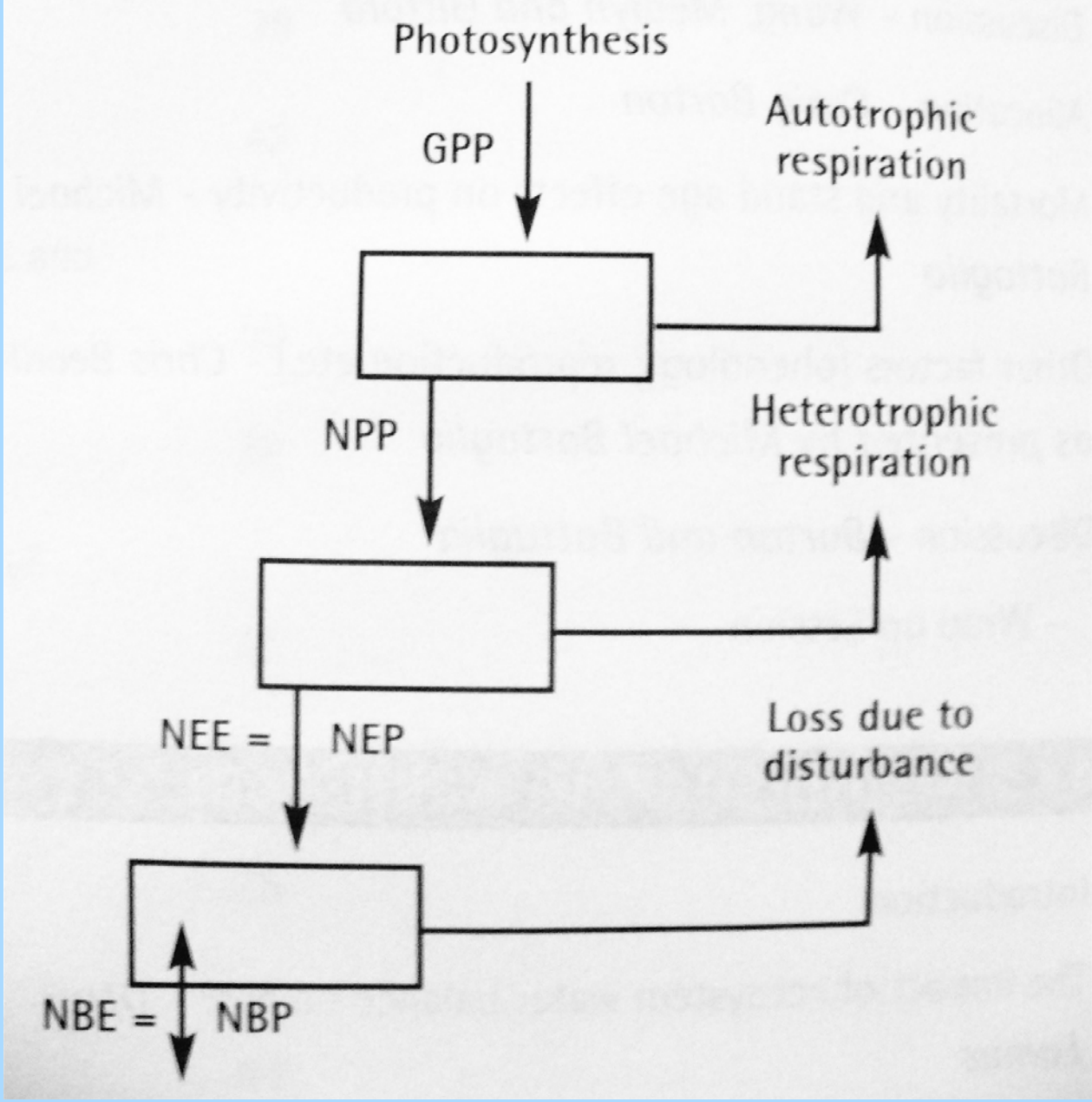
Merbok Mangroves, Peninsular Malaysia C,N,P Fluxes

1. Bujang - Agriculture
2. Dedap - Aquaculture
3. Petani – Human settlement

Human Impact on N Fluxes

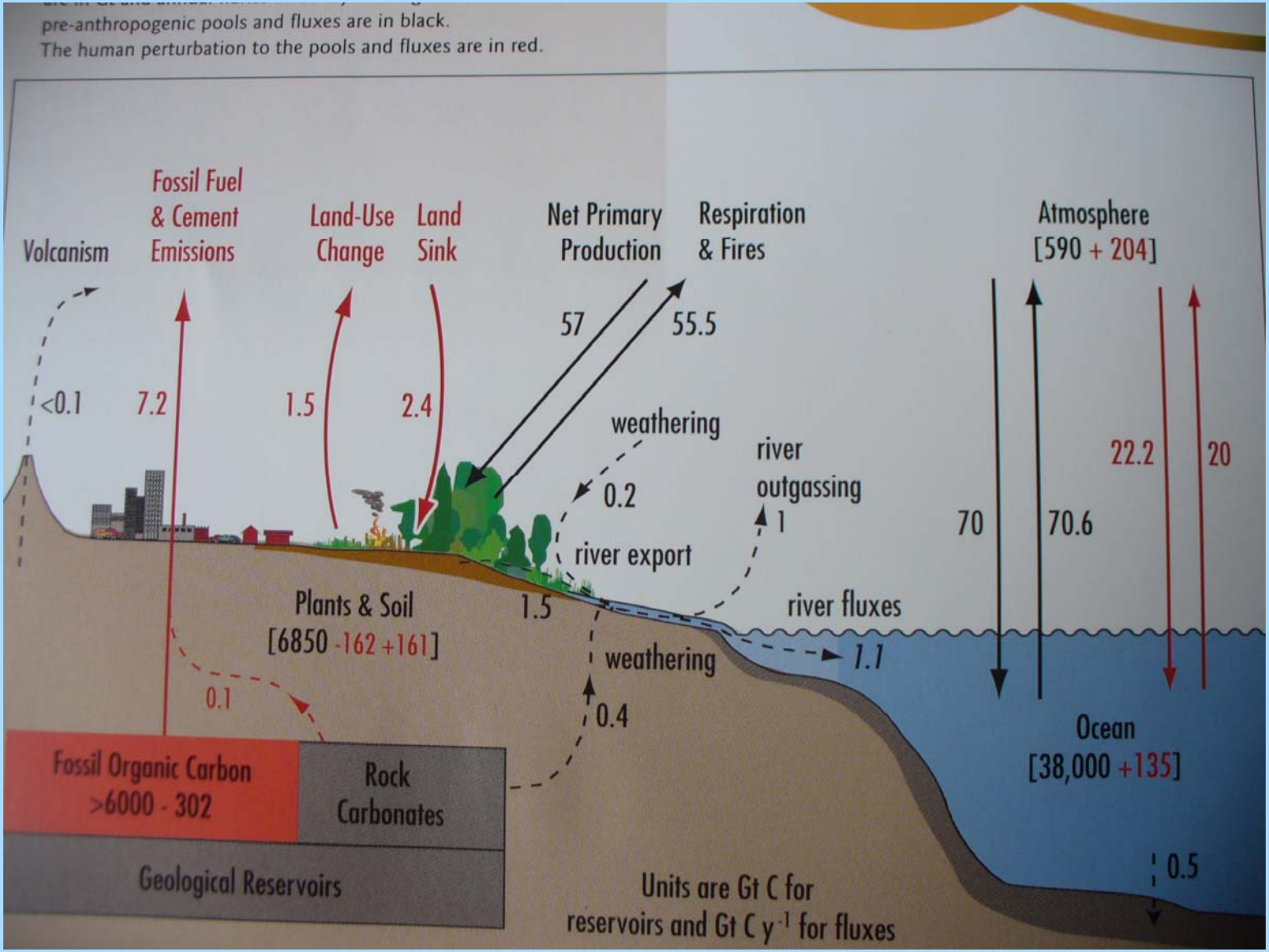
	Petani	Dedap	Bujang
DIN (uM)			
Fresh	15.1	4.1	20.1
System	7.6	4.8	6.2
Sea	4.4	3.9	6.4
DON (uM)			
Fresh	111.5	31.6	30.5
System	44.4	28.0	23.9
Sea	57.9	16.4	18.6

(Gong & Ong, 2002)



System Carbon Balance (CRC, Canberra 2001)

Current (2000-2005) Global Carbon Cycle



Black: background;

Red: Human perturbations

(Sabine et all. 2004 SCOPE 62

MANGROVE CARBON BUDGET : MANAGEMENT IMPLICATIONS

Charcoal Production (Matang)

Woodchips

Oil Palm

Rice

Aquaculture (Merbok)

Housing Estates

MANAGEMENT IMPLICATIONS
Charcoal

Matang Mangroves, Peninsular Malaysia

Management started 1902

30 year rotation – clear-felling
2 thinnings - 15 years.
20 years

Sustained Yield Management

Thinning – 15 years (1.2 m stick), 20 years (1.8m stick)

Poles from thinnings

Matang - carbon sequestered
(a) Dead Matter

Small litter	**5.1 t ha^{-1} yr^{-1}**
Root turnover	**5.1 t ha^{-1} yr^{-1}**
Dead trees	**6.4 t ha^{-1} yr^{-1}**
Slash	**0.7 t ha^{-1} yr^{-1}**
Total (1 yr)	**17.3 t ha^{-1} yr^{-1}**
Total (30 yrs)	**519 t ha^{-1}**

Matang - Carbon Sequestration (b) Harvest

- Poles
- (1st thinning) 39 t ha^{-1}

- Poles
- (2nd thinning) 42 t ha^{-1}
- Charcoal
- (final felling) 117 t ha^{-1}

Matang - Carbon Sequestration (c) Total Sequestered

Total C (30 yrs)	**519 t ha^{-1} dead matter; 81t ha^{-1} poles**
Total C per year	**17.3 t ha^{-1} yr^{-1} dead matter; 2.7 t ha^{-1} yr^{-1} poles**

Wood-chips

OIL PALM

Net photosynthesis: 15.5 umol m^{-2} s^{-1}

Leaf Area Index: 2 - 7

(Muhamad Awang, 1991)

NPP : 5.5 - 17.5 t C ha^{-1} yr^{-1}

(Squire, G. R. 1986)

Carbon Sequestration - comparison

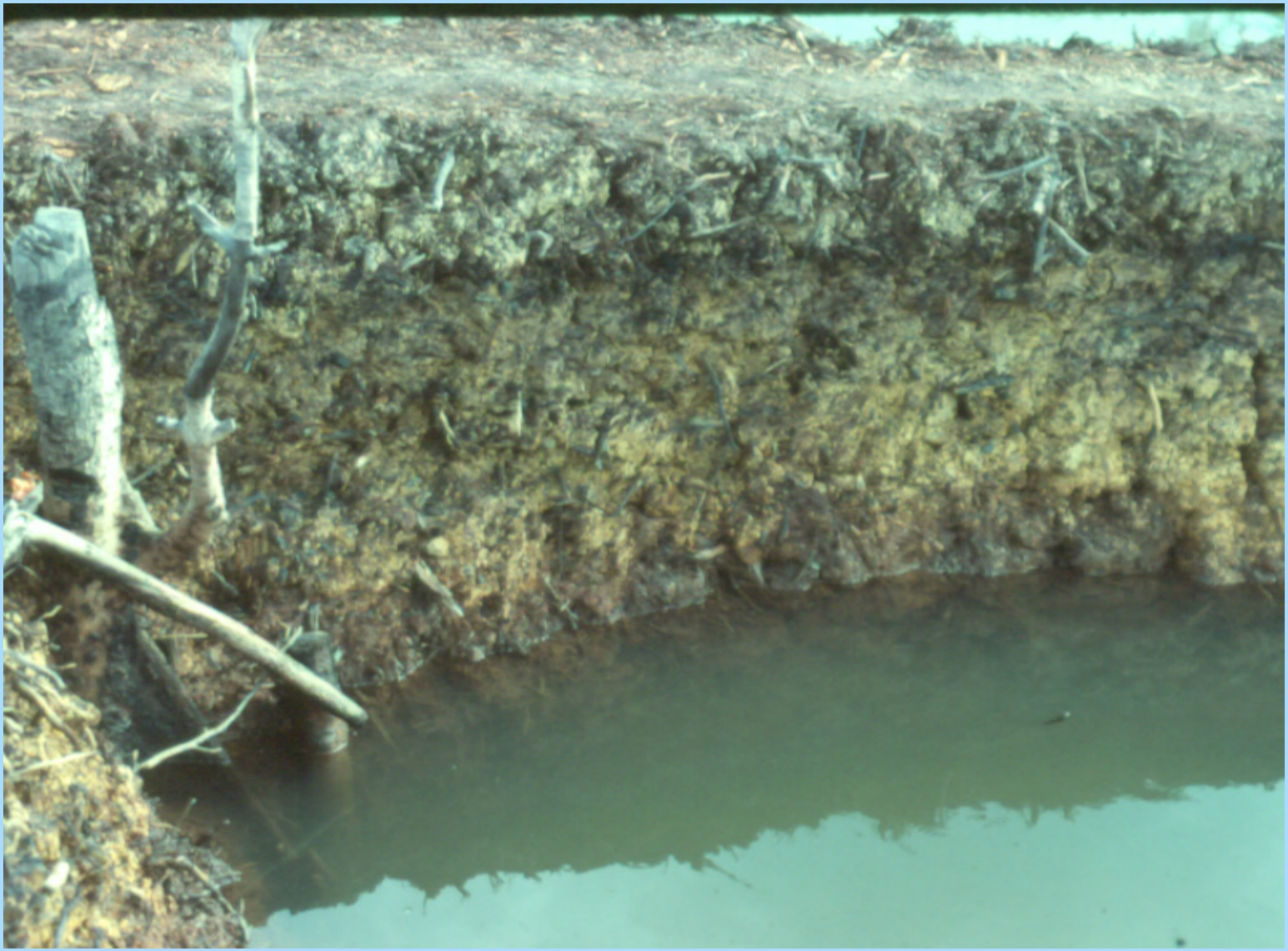
	Mangrove	Oil Palm (20 yrs) **(Chan '02)**	TRForest **(Henson '99)**
Standing Biomass (tC/ha)	114	45	200
Net C fixed (tC/ha/yr)	17	9	12

MANAGEMENT IMPLICATIONS
Rice

Management Implications
Aquaculture Ponds (Merbok)

Management Implications
Aquaculture Ponds (Merbok)

Acid sulphate soils



MANAGEMENT IMPLICATIONS
Aquaculture Ponds

Sequestration: 1.5 tC ha^{-1} yr^{-1}

Sedimentation: 2mm yr^{-1}

2 metres: 1000 years

1500 tC ha^{-1}

Assuming 50% oxidised over 10 years:

Carbon released: 75 t C ha^{-1} yr^{-1}

(Ong, 1993)

MANAGEMENT IMPLICATIONS
Industrial / Housing Estates, Airport

Selected References

Gordon, D.C.,Jr., Boudreau, P.R., Mann, K.H., Ong, J.E., Silvert, W.L., Smith, S.V., Wattayakorn, G., Wulff, F. & Yanagi, T. (1996). LOICZ Biogeochemical Modelling Guidelines. LOICZ Reports & Studies No.5

Kjerfve,B., Stevenson, L.H., Proehl,J.A.,Chrzanowski, T.H. & Kitchens, W.M. (1981). Estimation of material fluxes in an estuarine cross-section: A critical analysis of spatial measurement density and errors. **Limnology and Oceanography 26**: 325-335

Nixon, S.W. (1980). Between coastal marshes and coastal waters - a review of twenty years of speculation and research on the role of salt marshes and estuarine productivity. Pp. 437-520 in: P. Hamilton and K.B. Macdonald (eds) **Estuarine Wetland Processes**. Plenum Publishing Corporation, New York.

Selected References (contd)

Gong, W.K. & Ong, J.E. (1990). Plant biomass and nutrient flux in a managed mangrove forest in Malaysia. **Estuarine, Coastal and Shelf Science 31**: 519-530

Ong, J.E. (1993). Mangroves - a carbon source and sink. **Chemosphere 27**: 1097-1107.

Robertson, A.I. (1986). Leaf-burying crabs: their influence on energy flow and export from mixed mangrove forests (*Rhizophora* spp.) in northeastern Australia. **Journal of Experimental Marine Biology and Ecology 102**: 237-248.

Thank You