Optical effects of suspended sediment, and optical methods for its monitoring and management

(SedNet2015 spec. session on ecological effects)

Rob Davies-Colley* Mark Gall and Sandy Elliott
NIWA (New Zealand)

NIWA
Taihoro Nukurangi

Talk structure

Two parts

1. **Optical effects of fine sed.**
   - Visual clarity
   - Light penetration

2. **Optical monitoring and management**
   - Turbidity (cts proxy)
   - Management of SS

PART 1. Optical effects of SS

Effects of Fine Sediment –

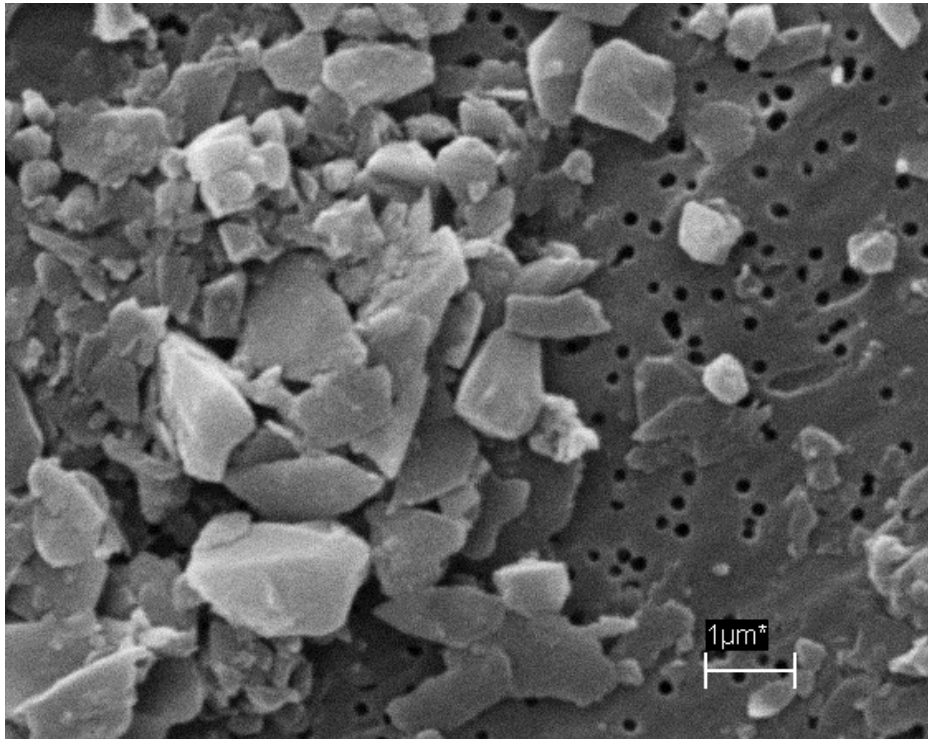
while still suspended

- Damage to biological structures
- Reduced food quality (filter-feeders)
- Transport of (other) pollutants
- **Light attenuation** –
  - Reduced *visibility*
  - Reduced *light penetration*

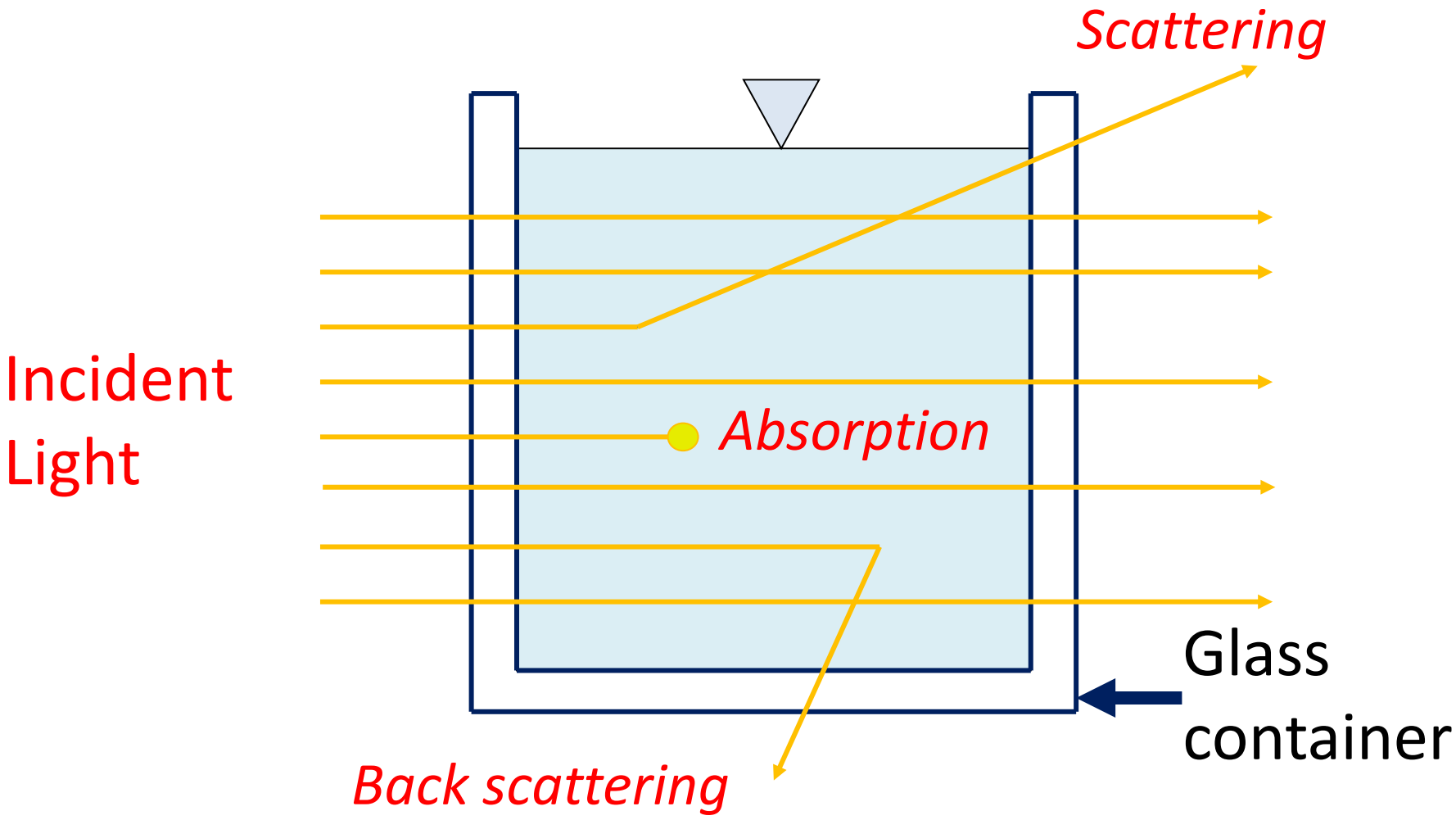
These (suspended) effects* of FS depend on –

- Particle size & shape
- Composition
- Surface chemistry

Mass a poor predictor of effects?



Light attenuation – thought experiment



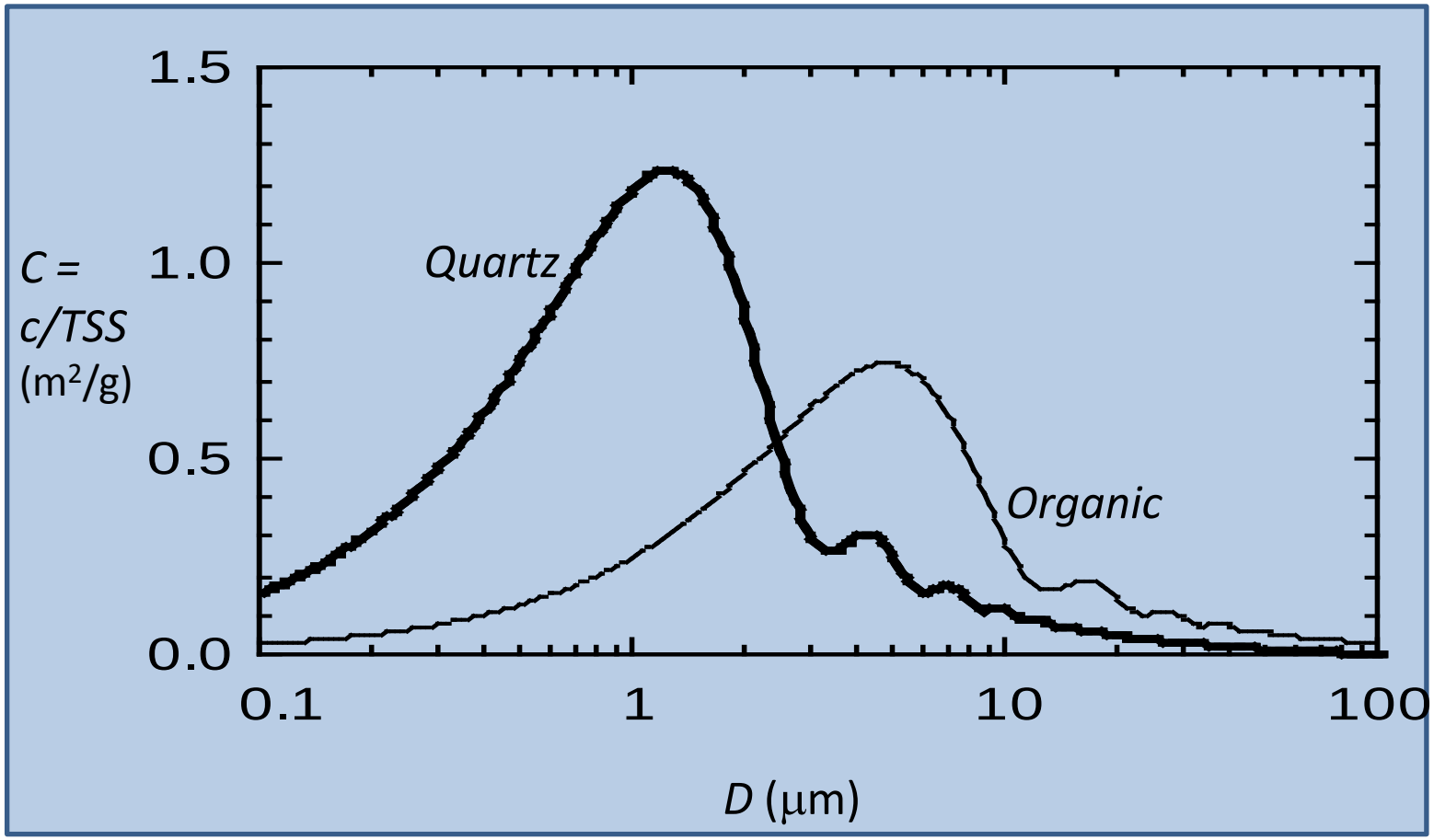
Total light (beam) attenuation = absorption + scattering:

$$c = a + b$$

Light attenuation by fine sediment –

Strong function of particle size

Light attenuation per unit mass concentration



Visual clarity

- Controls sighting range – for humans and fish

- Robust index –

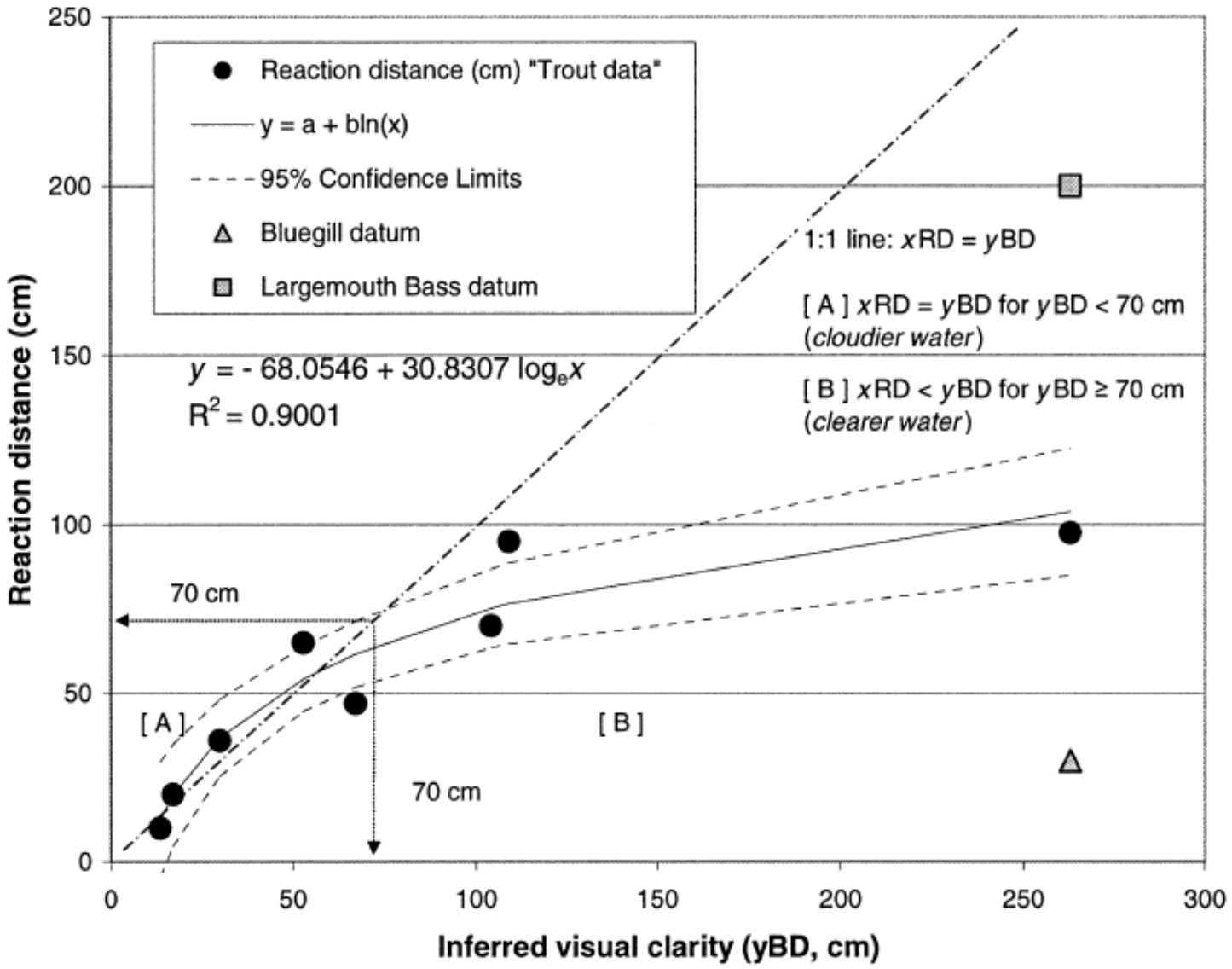
black disc sighting range

- Black disc visibility:

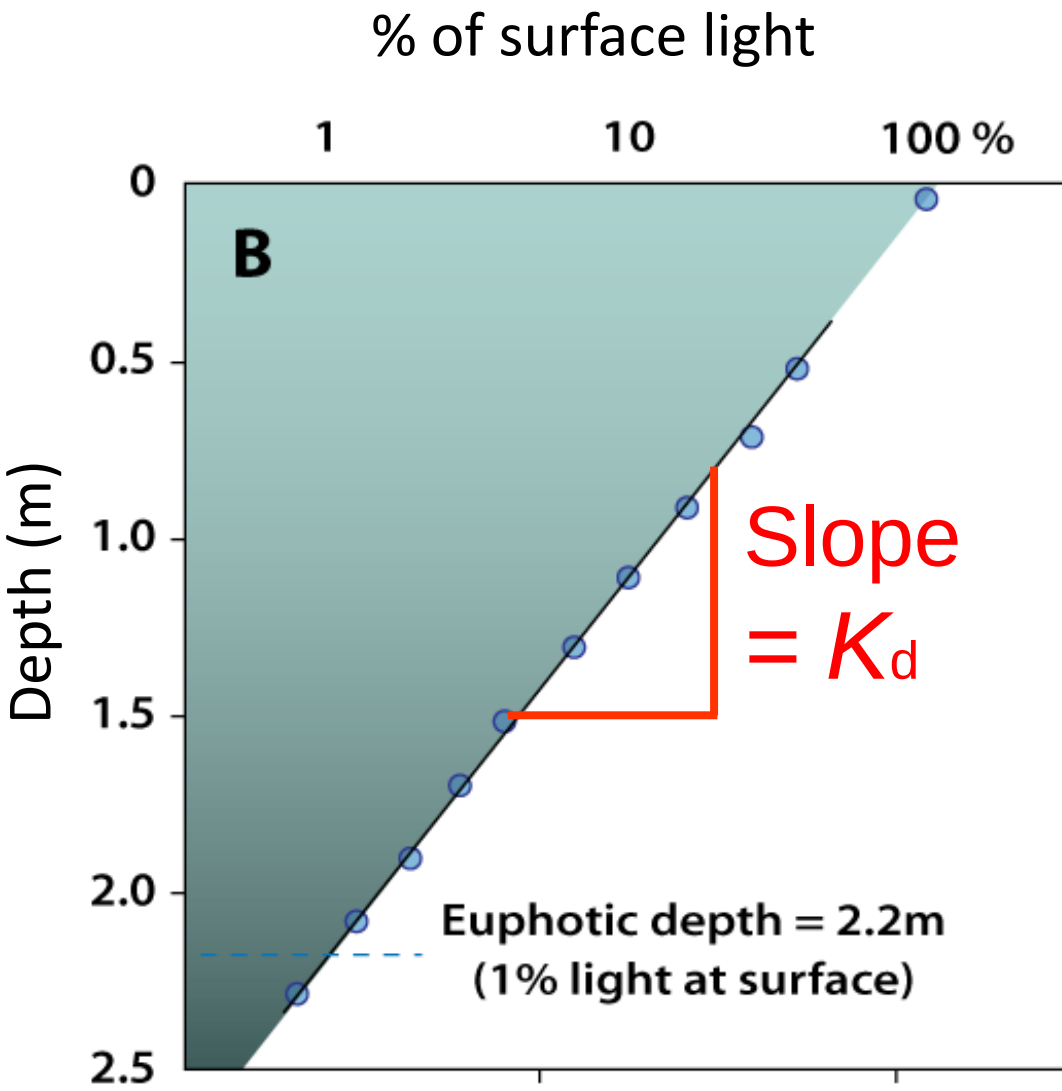
$$y_{BD} = 4.8/c$$

Black disc target

Reactive distance of fish

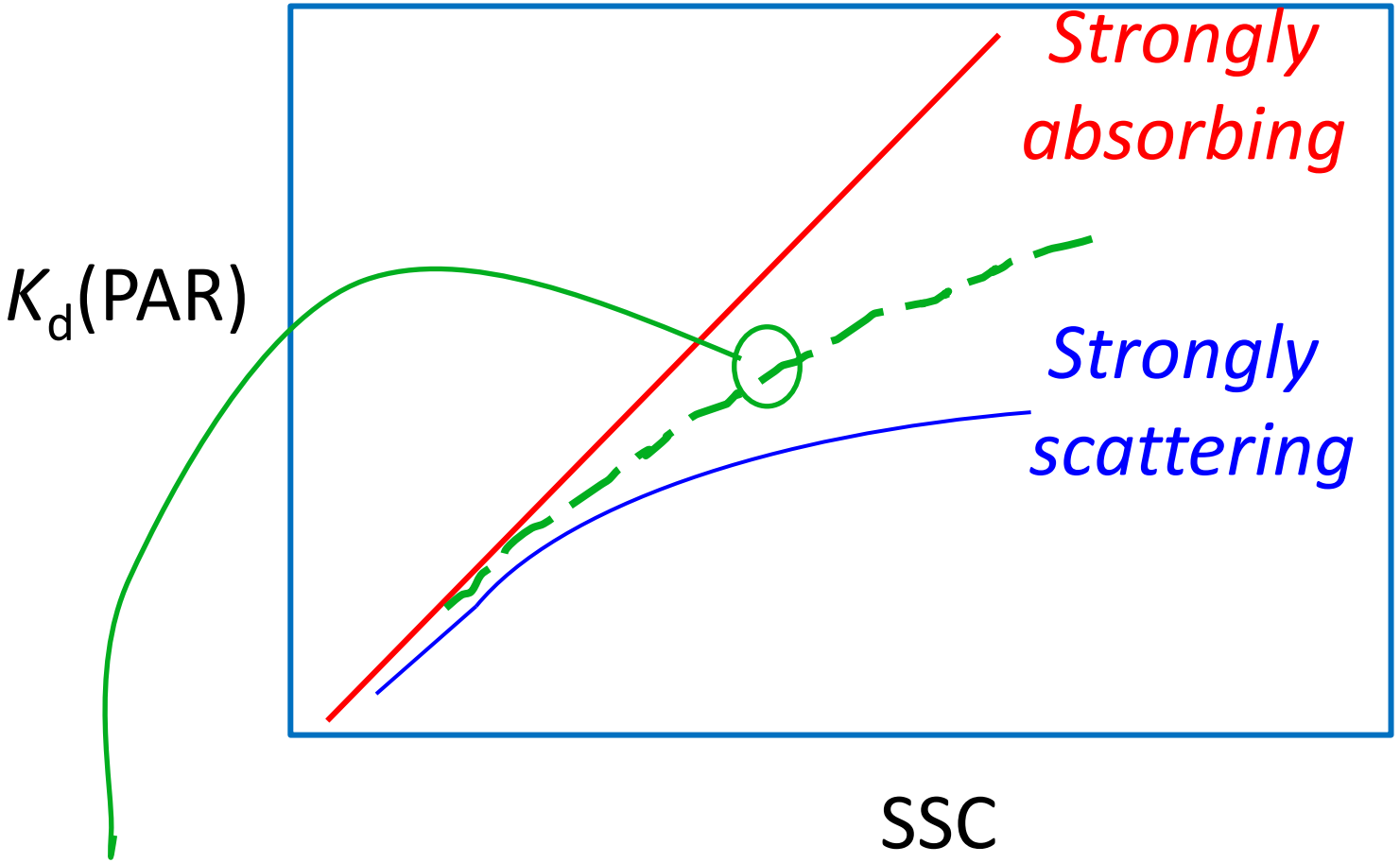


Light penetration



Light penetration – relation to SSC

- Depends on absorption to scattering ratio of fine sediment particles



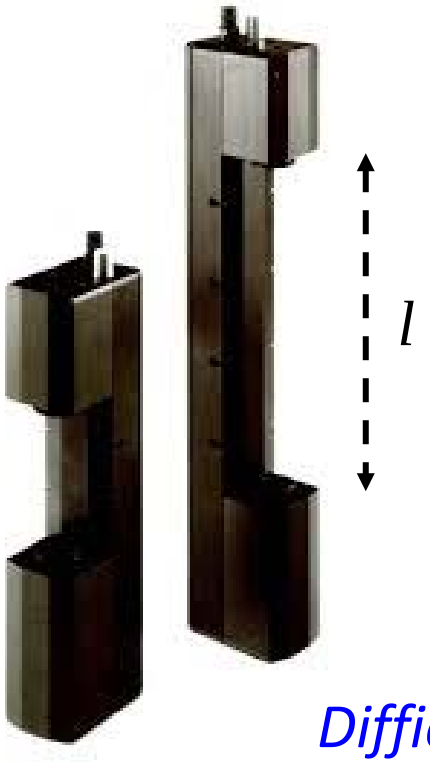
PART 2. Optical monitoring and management

Monitoring optical effects of SS

- Visual clarity

(Beam transmissometer)

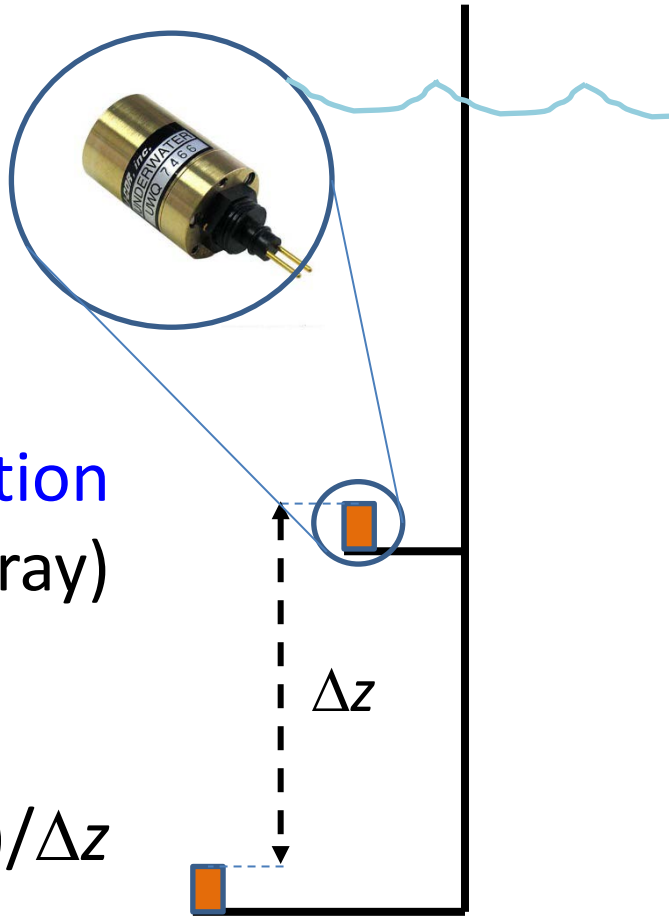
$c = -\ln T(\text{beam})/l$



- Light penetration

(Light sensor array)

$K_d = -\ln T(\text{PAR})/\Delta z$



Difficulties with long-term deployment - fouling

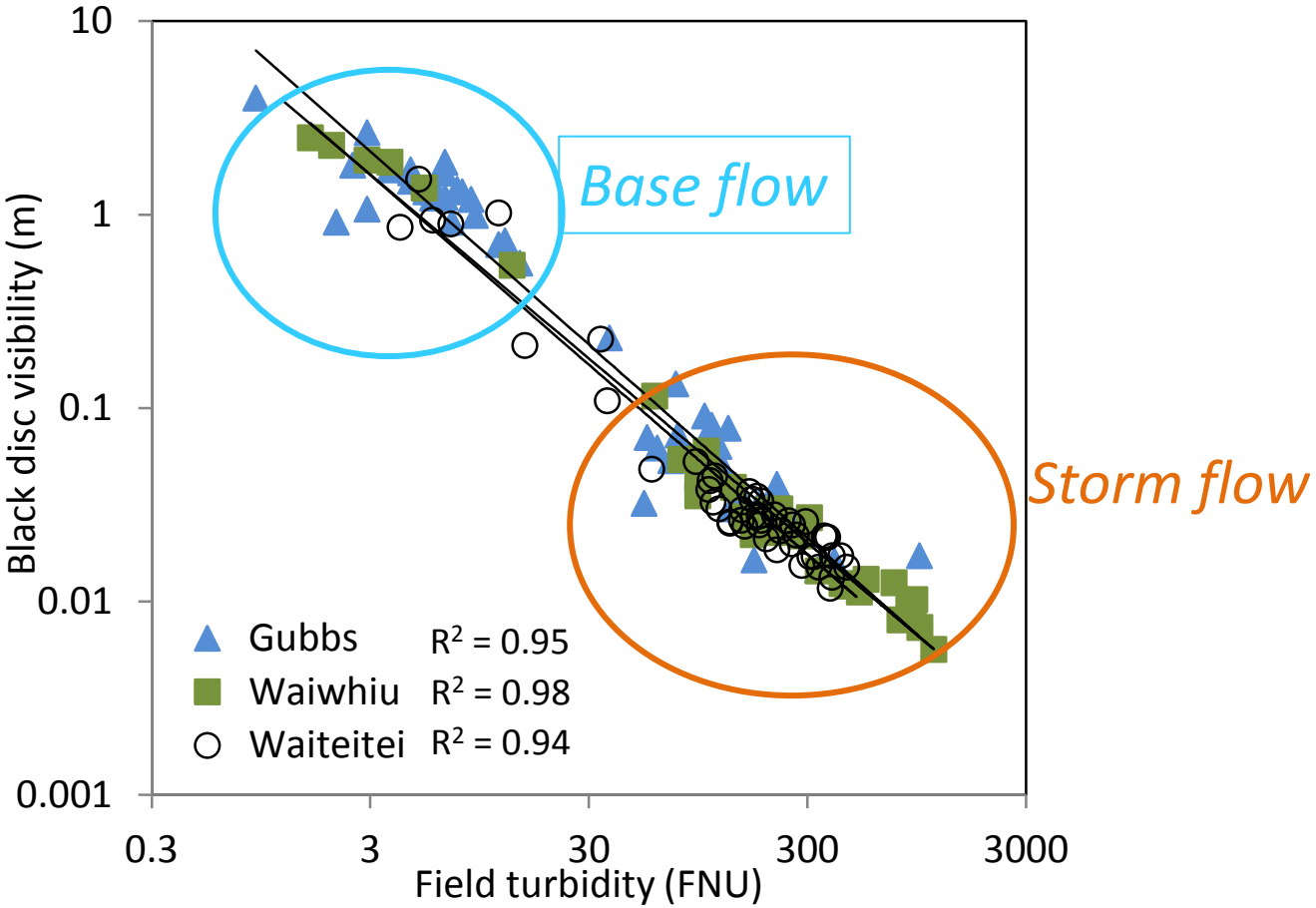
Turbidity monitoring

- Cheaper and greater dynamic range than transmissometers
- BUT, turbidity is unsatisfactory! (arbitrary, non-SI units,…)
- ISO 7027 design standard
- Proxy for visual clarity, SSC
- K_d, TP, *E. coli*?

DTS-12 Turbidity sensor

Visual clarity vs continuous turbidity

Hoteo River (from Hughes et al. (2014) *IAHS publ. 367*: 170-6.)



Visual clarity regime

Load of beam attenuation

Optical management of fine sediment

- Measure –
  - ***visual clarity*** (black disc method)
  - ***light penetration*** in lakes, estuaries

- Monitor ***turbidity*** continuously

- **Calibrate turbidity**
  to *c* or SSC (and K_d?)

- Calculate
  - Optical regime
  - Loads
    (load of *c* – units m^2/yr)

Summary

- The most severe effects of fine suspended sediment – probably optical?

- ***Beam attenuation*** – a key metric

- Two main optical effects:
  - ***visual clarity***, and
  - ***light penetration***

- ***Turbidity*** is a useful continuous proxy (calibrated to vis or SSC; perhaps also K_d…)

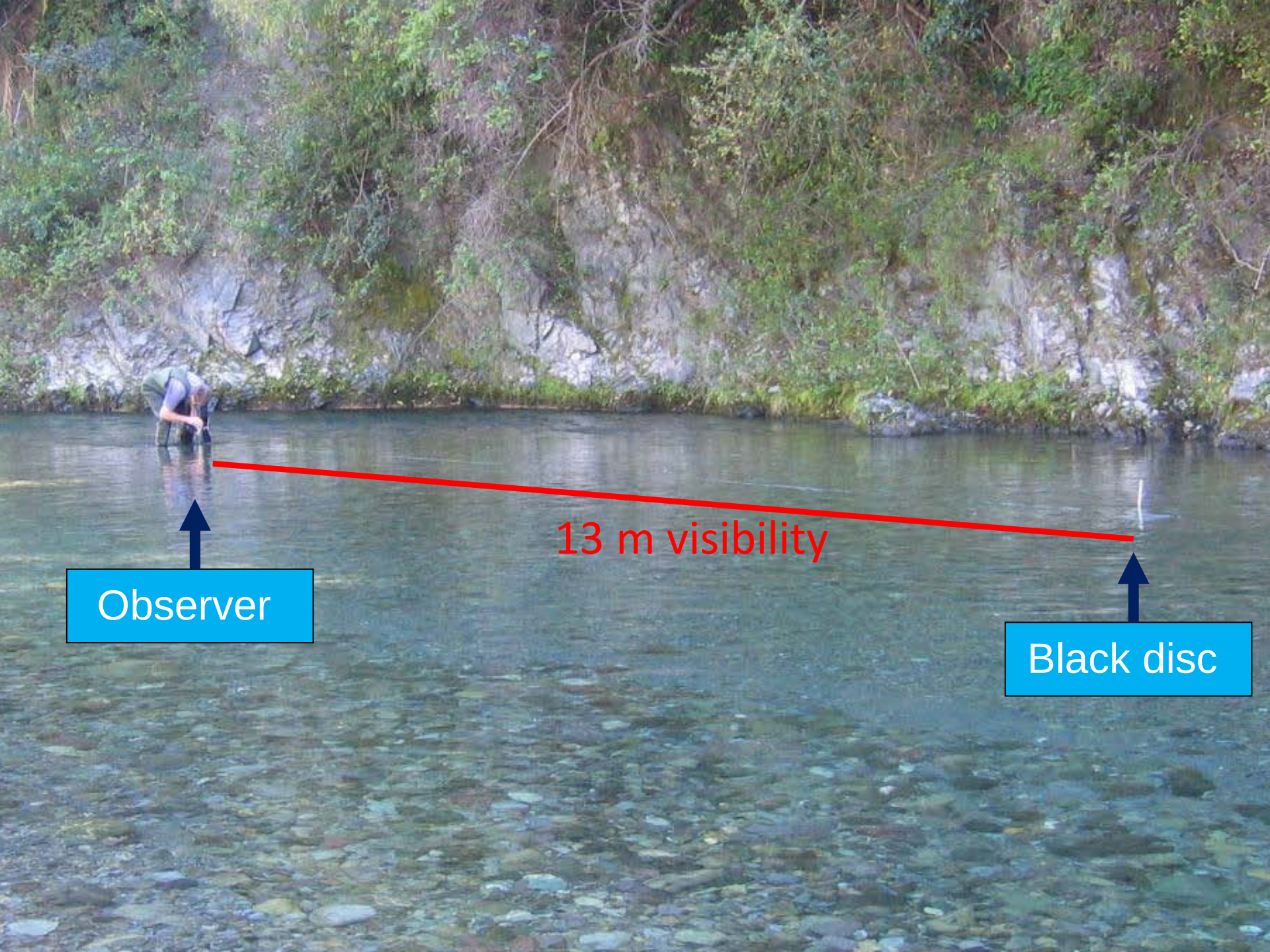
Effects of Fine Sediment –

When deposited

- Shoaling or infilling*
- Clogging of sediment beds
- Reduced benthic food quality
- Smothering of biota

These (depositional) effects ***do*** seem to relate to sediment mass

But what about FS while still suspended?


13 m visibility
Observer
Black disc


Blue Lake –
80 m visibility!