HYDRODYNAMIC CONNECTIVITY BETWEEN SHALLOW + DEEP ENVIRONMENTS:

A first-order control on phytoplankton blooms in South San Francisco Bay

Lisa Lucas, USGS
Jan Thompson, USGS
Jeff Koseff, Stanford University
Stephen Monismith, Stanford University

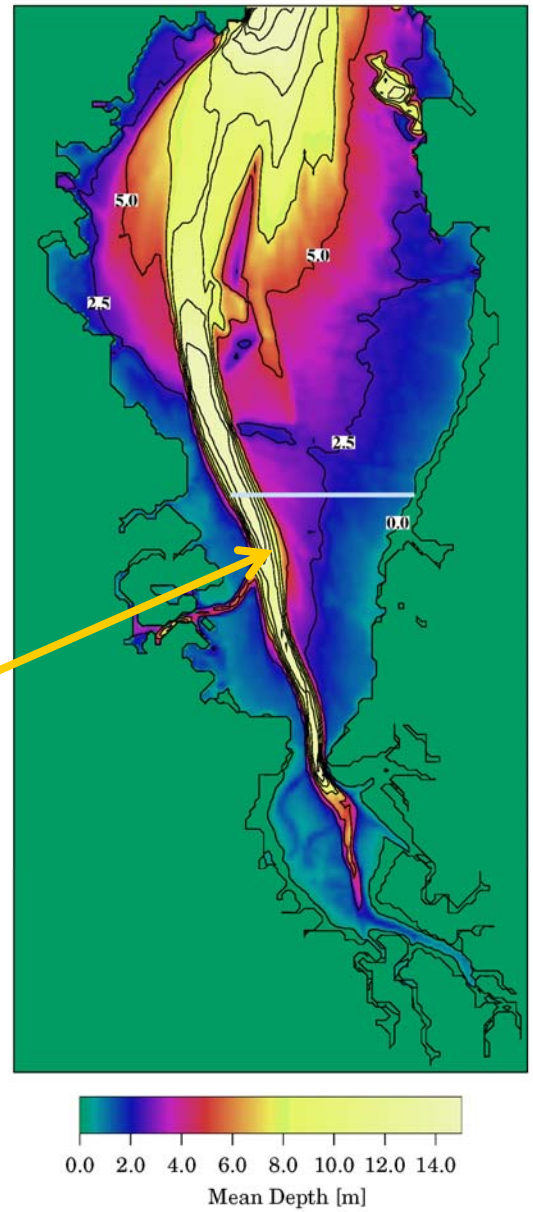
USGS

PRE-RESTORATION SSFB

- 2 primary habitats: shallow shoal & deep channel
- Deep water is location of most historical USGS measurements

http://sfbay.wr.usgs.gov/access/wqdata/

Mean depth (m), South SF Bay

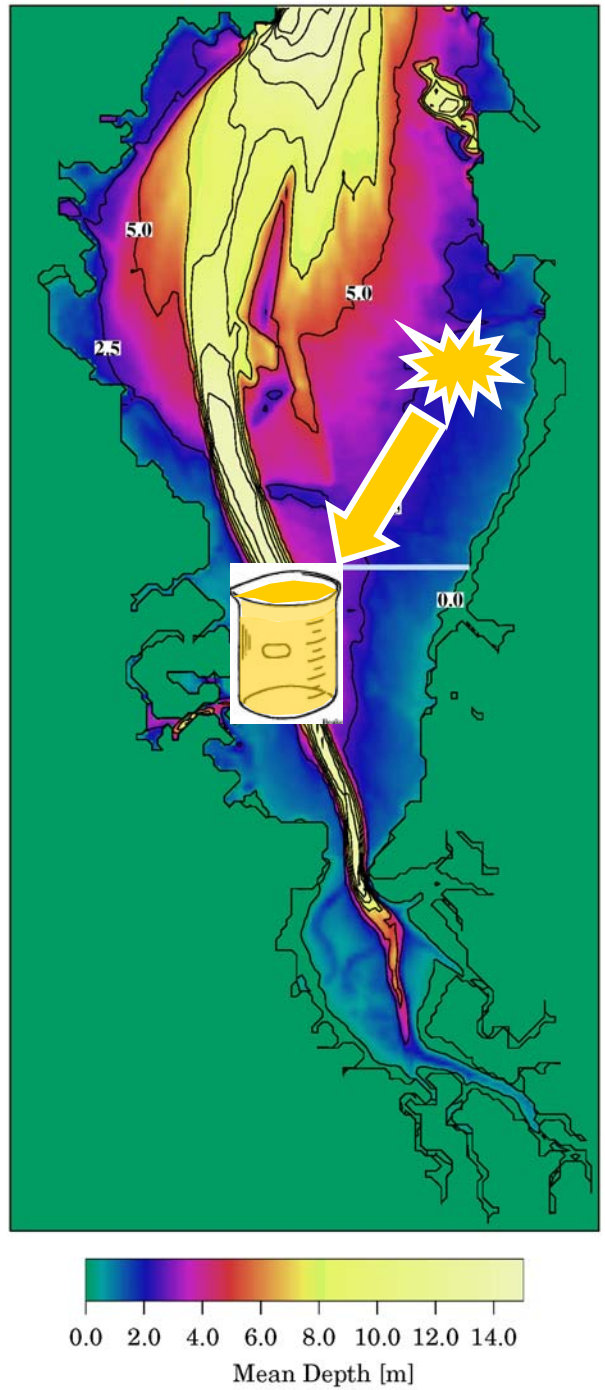


2 LESSONS

1. Remote processes can control locally measured quantities.

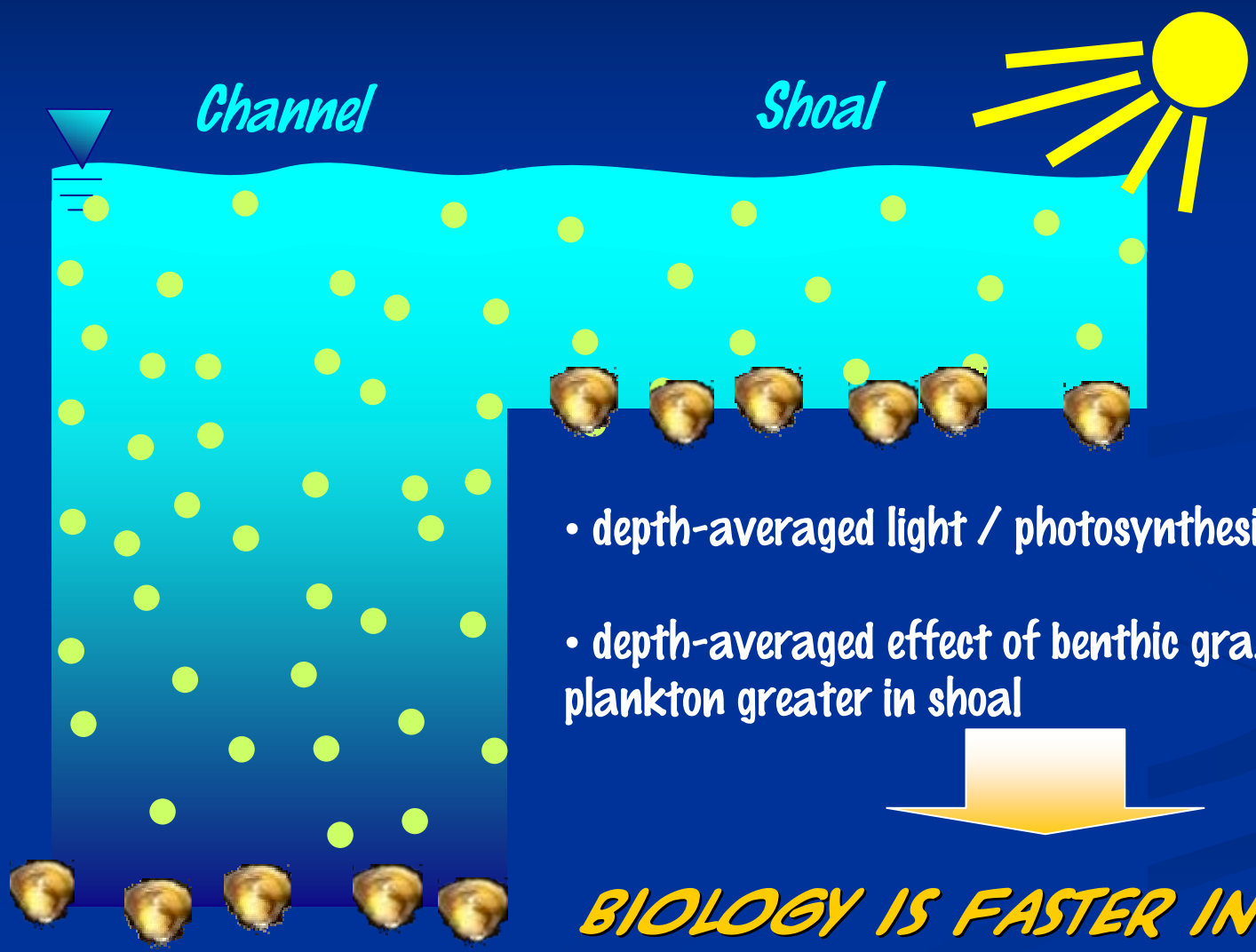
2. A.) Shallow water processes drive system-level phytoplankton blooms in SSFB.

   B.) Deep water processes modulate system-level blooms.



Why would one bathymetric regime have a greater influence?

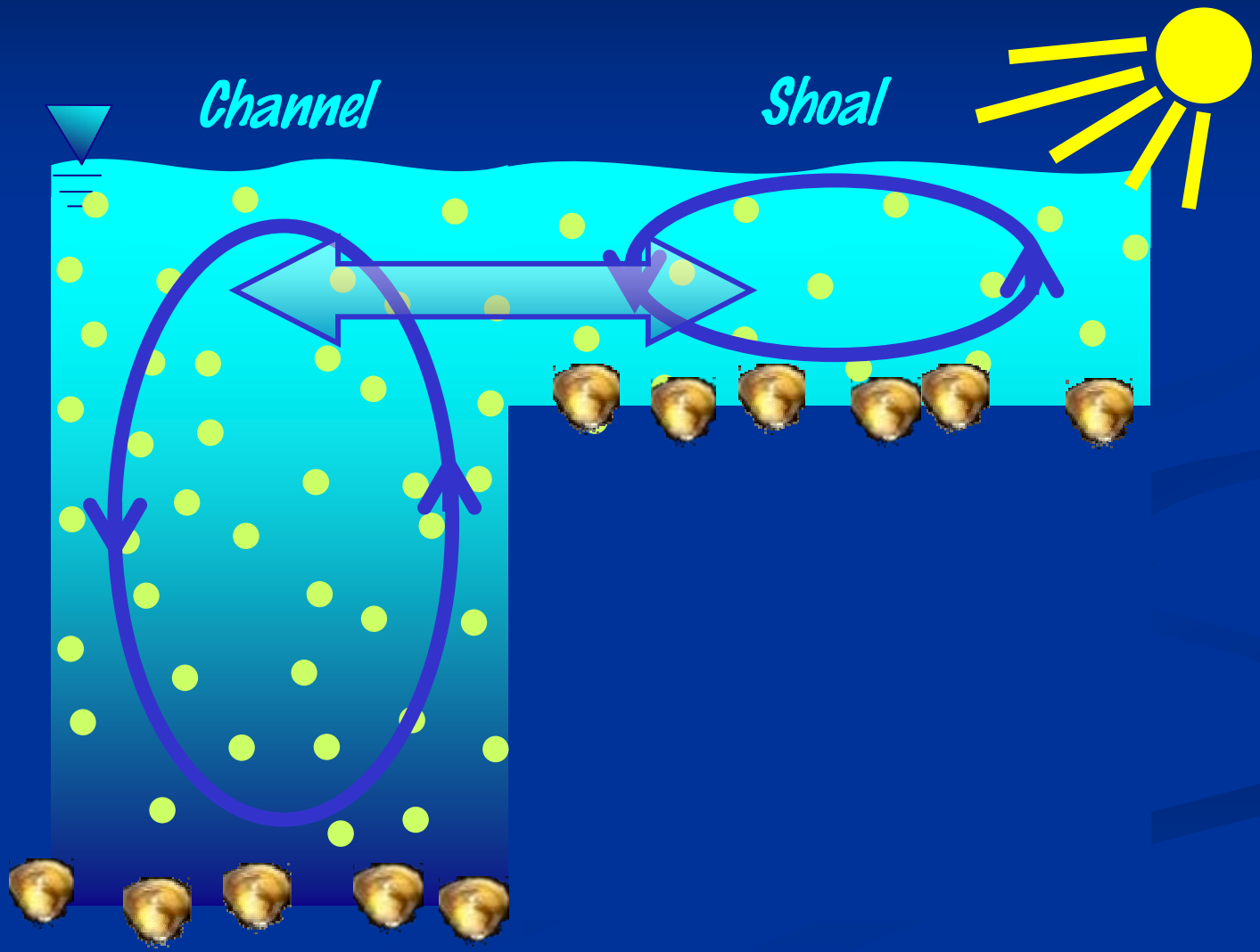
BIOLOGICAL RATES ARE DIFFERENT !!



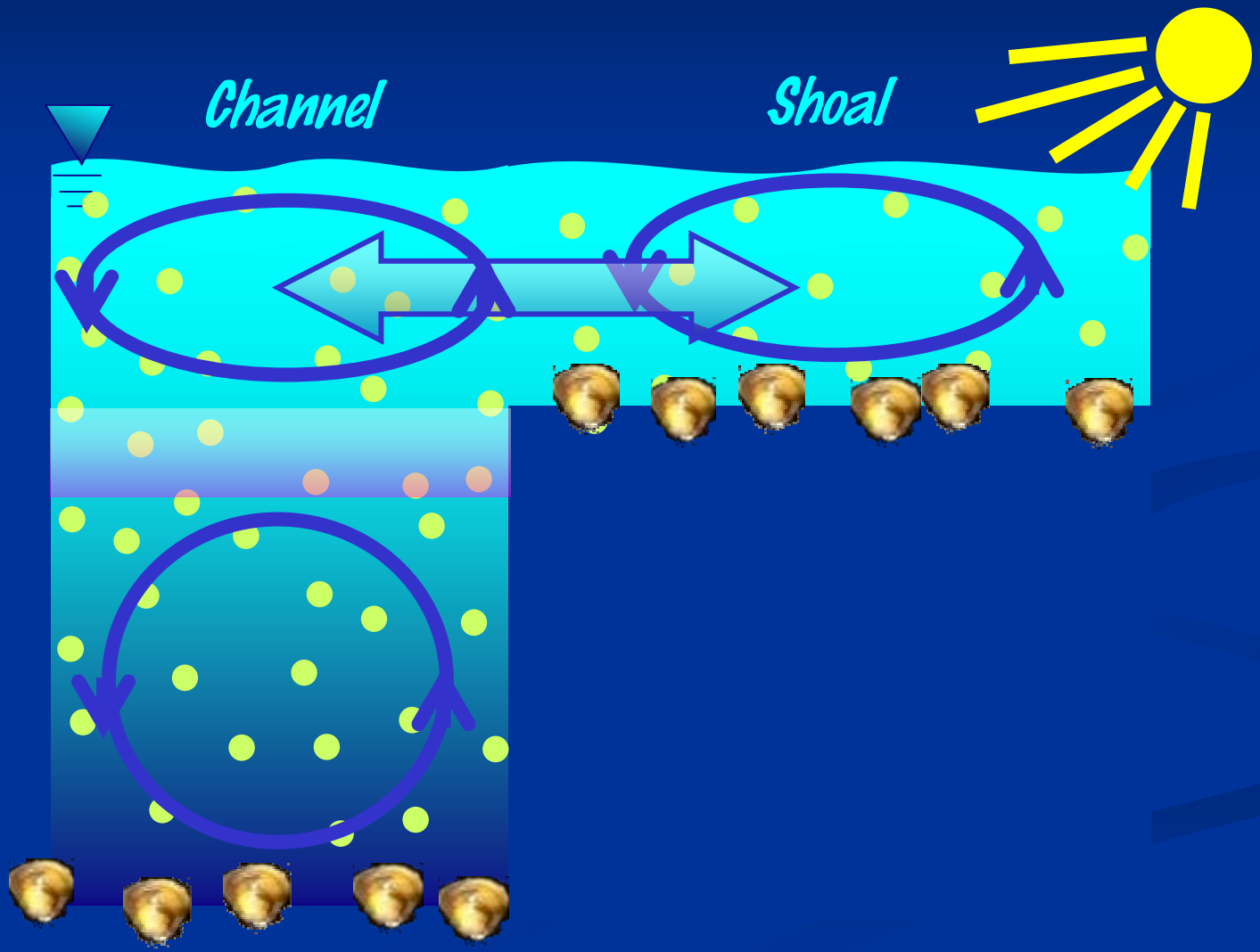
- depth-averaged light / photosynthesis higher in shoal
- depth-averaged effect of benthic grazers on overlying plankton greater in shoal

BIOLOGY IS FASTER IN SHALLOWS

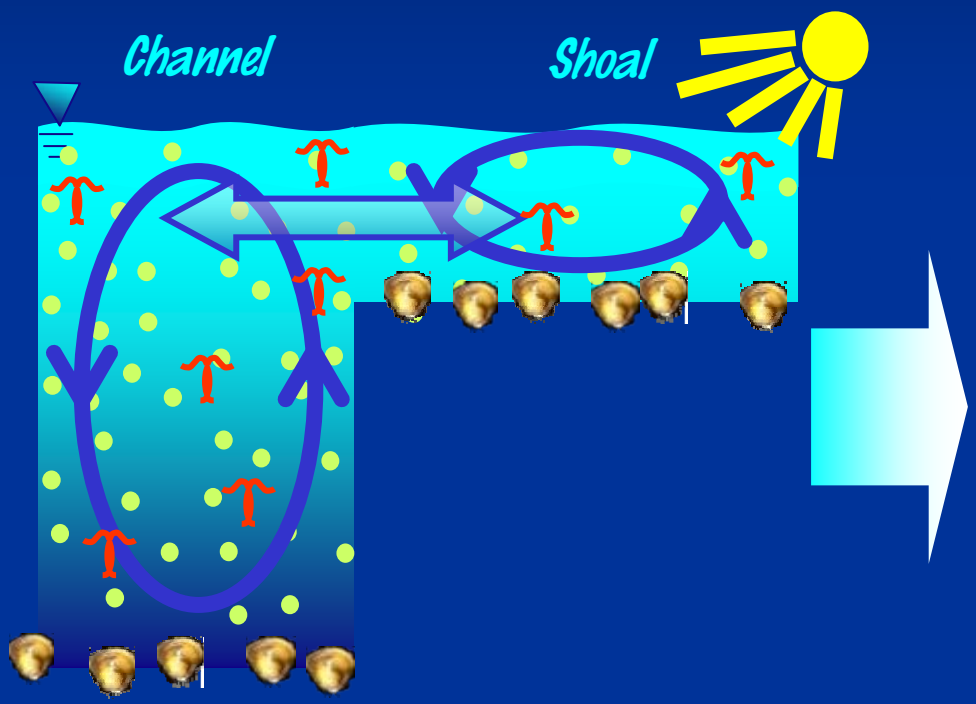
Hydrodynamics regulates rate of phytoplankton transport between different light/grazing zones.

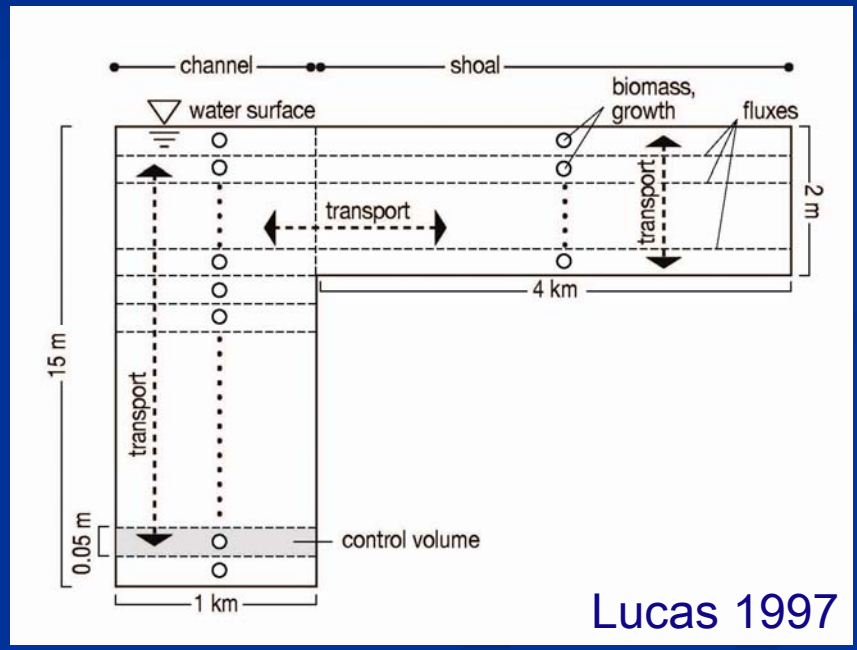


Channel stratification allows prolonged near-surface photosynthesis without benthic grazing threat.



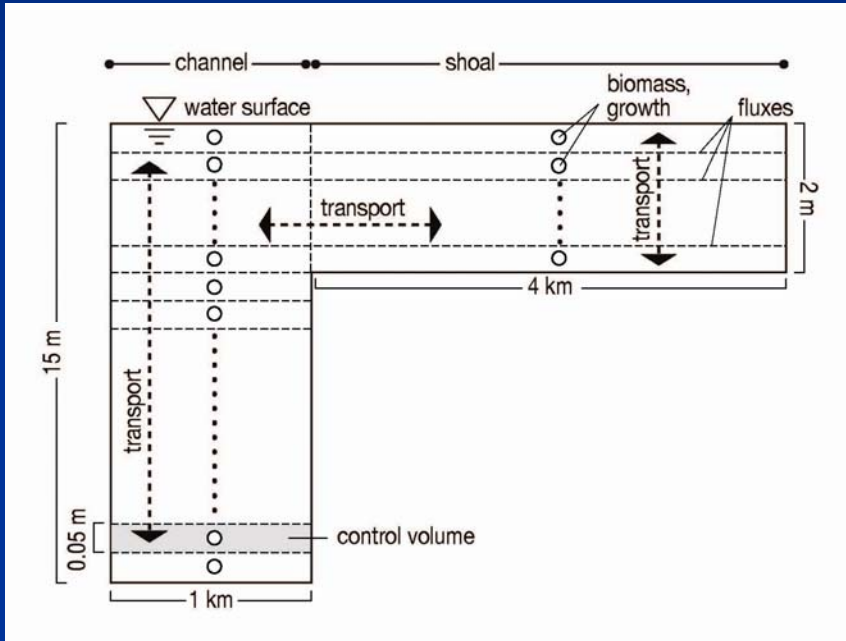
CONCEPTUAL MODEL → NUMERICAL MODEL





"Pseudo-2D model"

MODEL + MEASUREMENTS TAUGHT US 2 LESSONS



1. Remote processes can control locally measured quantities.
2. A.) Shallow water processes drive system-level phytoplankton blooms in SSFB

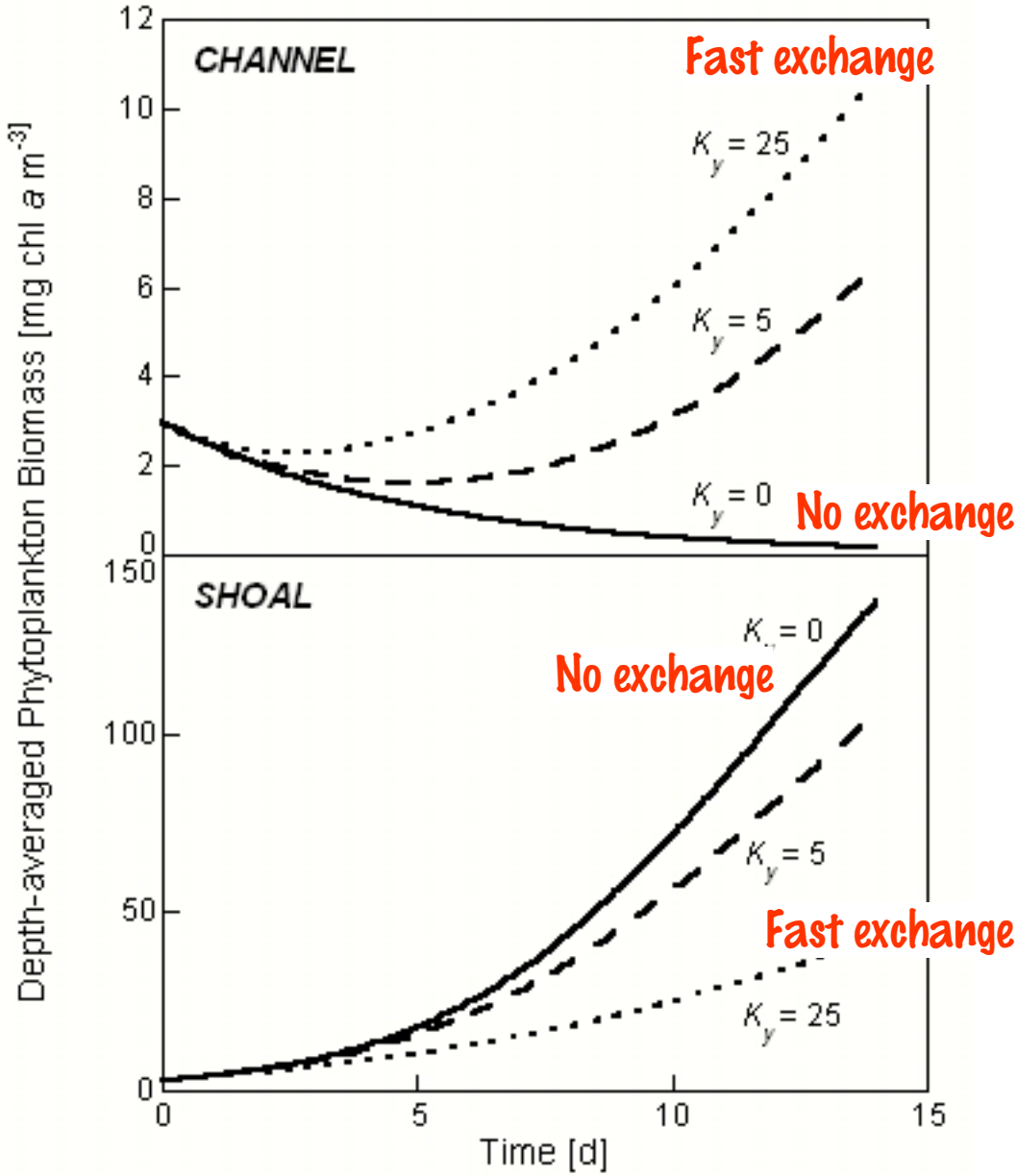
   B.) Deep water processes modulate system-level blooms.

LESSON 1

Remote processes can control locally measured quantities.

K_y = lateral exchange coefficient, m^2/s

MODEL

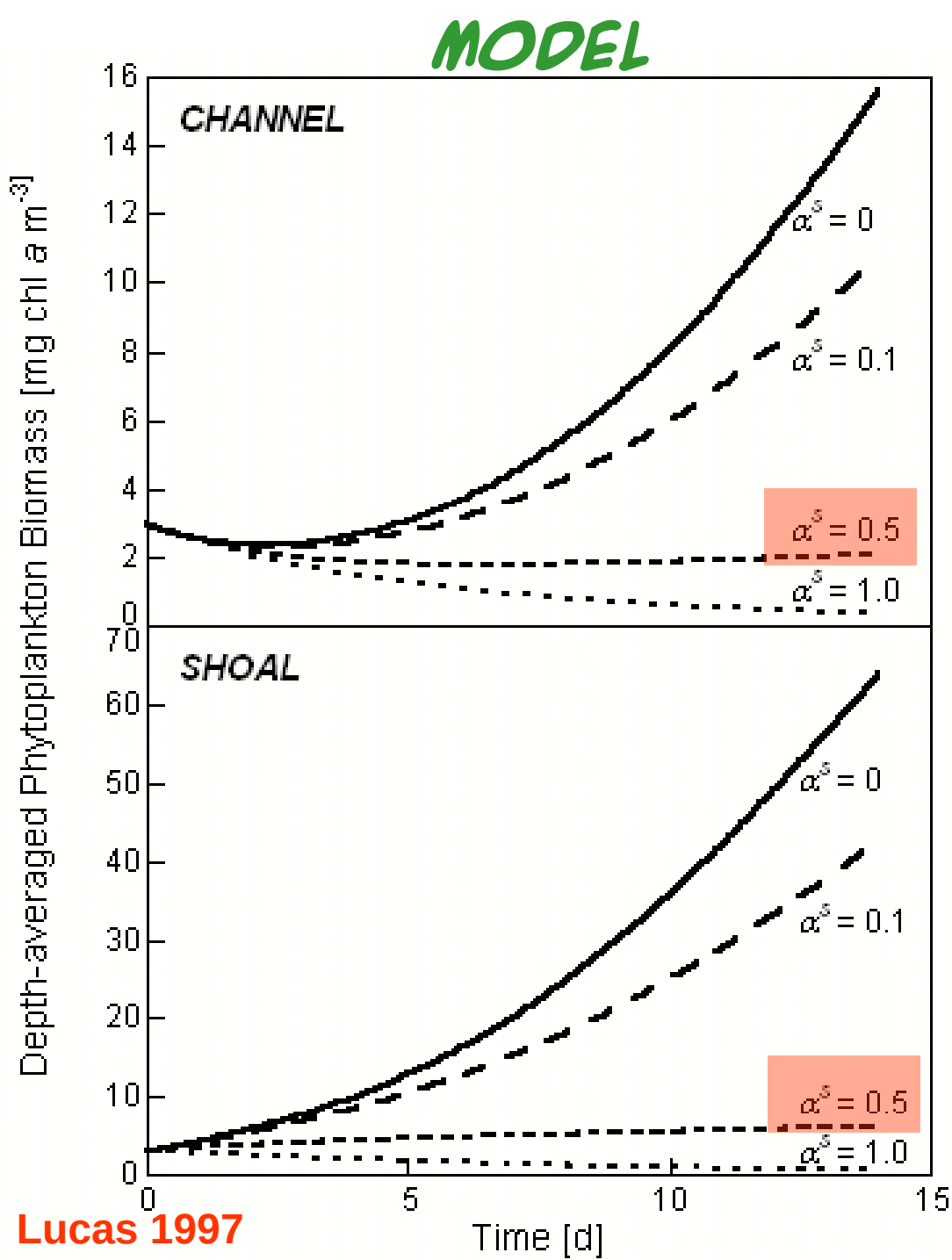


Lucas 1997

LESSON 2A

Shallow water processes (e.g. BENTHIC GRAZING) drive system-level phytoplankton blooms.

α^s = benthic grazing rate in shoal, m/d



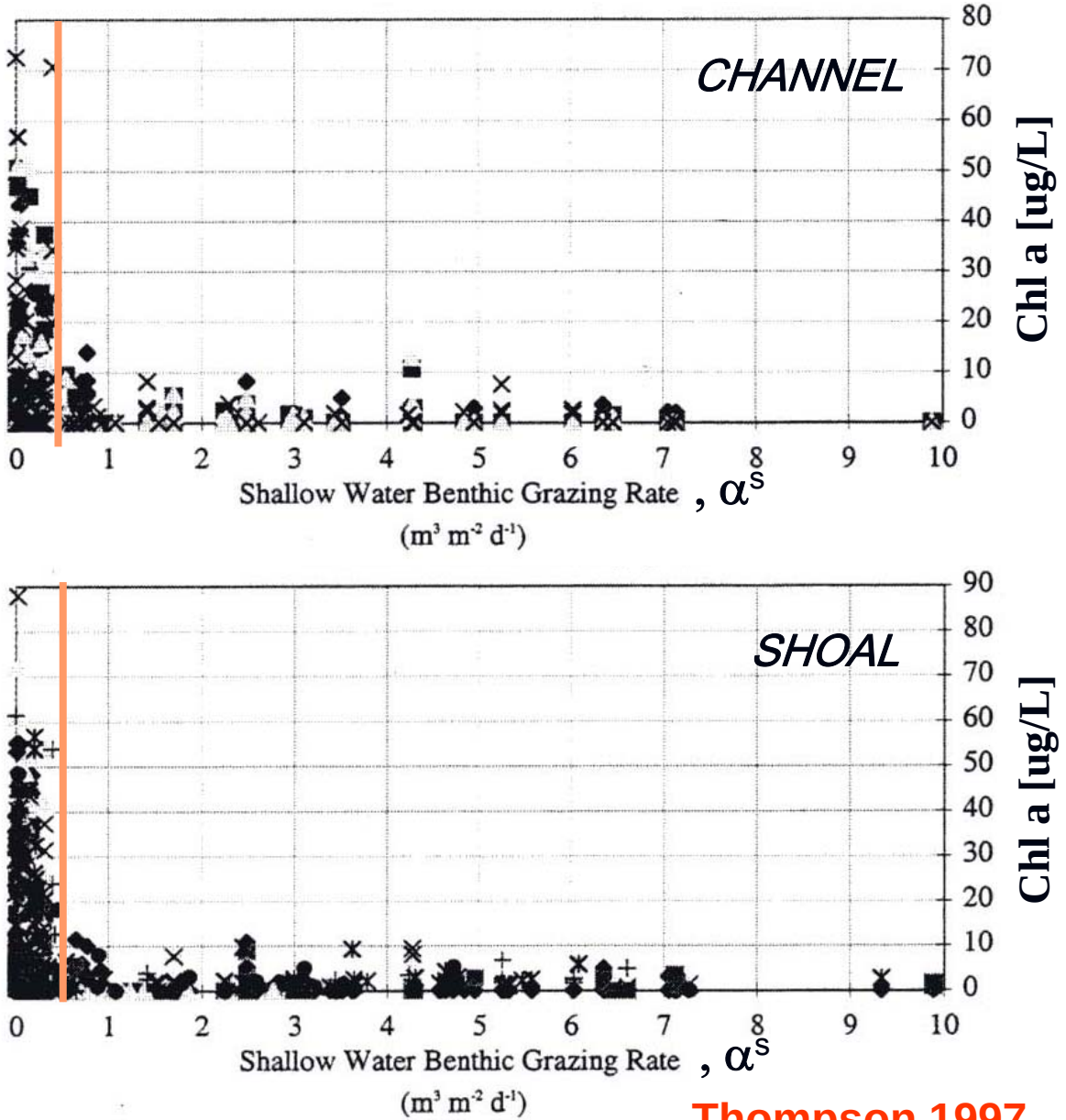
Lucas 1997

LESSON 2A

Shallow water processes (e.g. BENTHIC GRAZING) drive system-level phytoplankton blooms.

α^s = benthic grazing rate in shoal, m/d

FIELD MEASUREMENTS



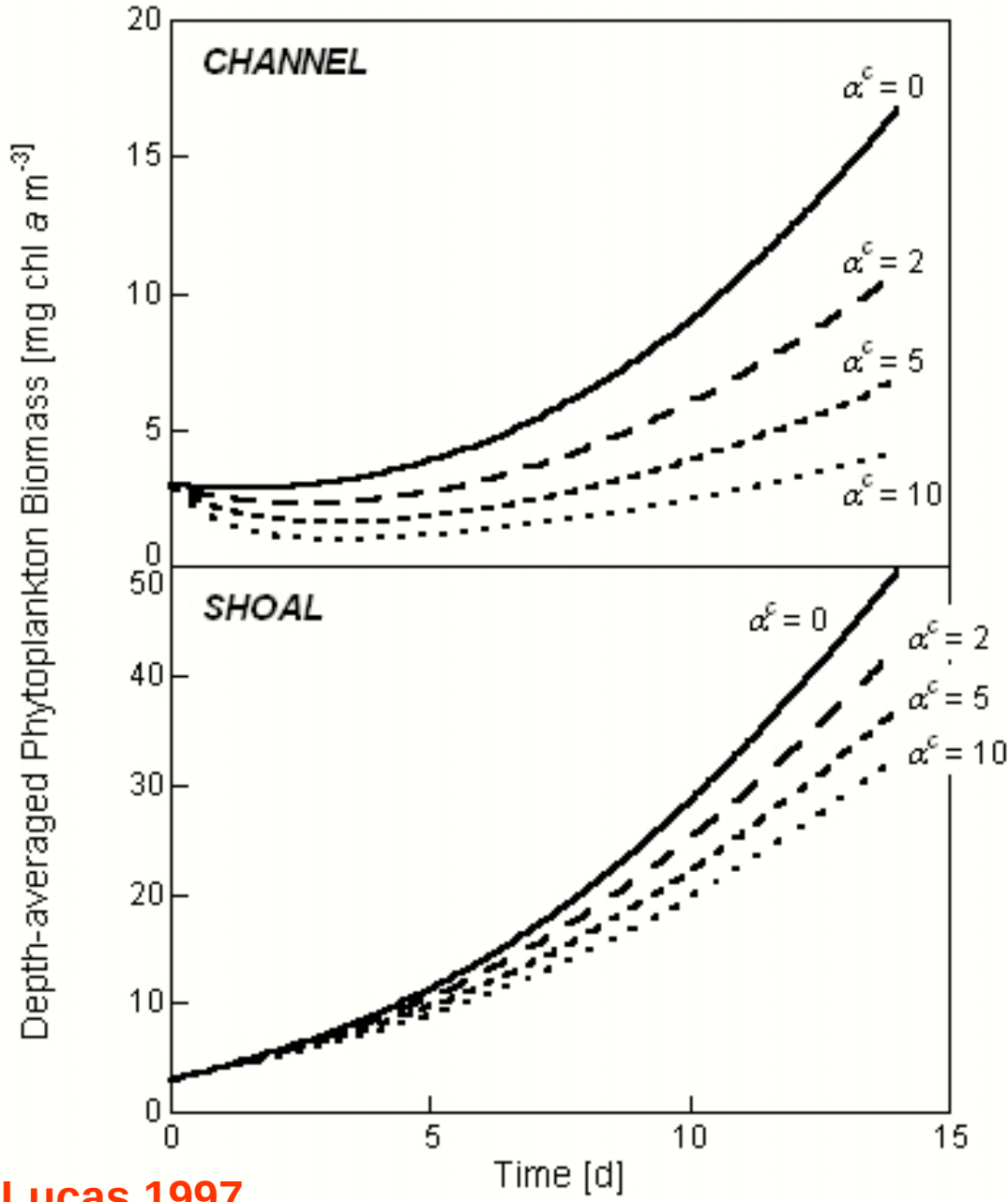
Thompson 1997

LESSON 2B

Deep water processes (e.g. BENTHIC GRAZING) modulate system-level blooms.

α^c = benthic grazing rate in channel, m/d

MODEL



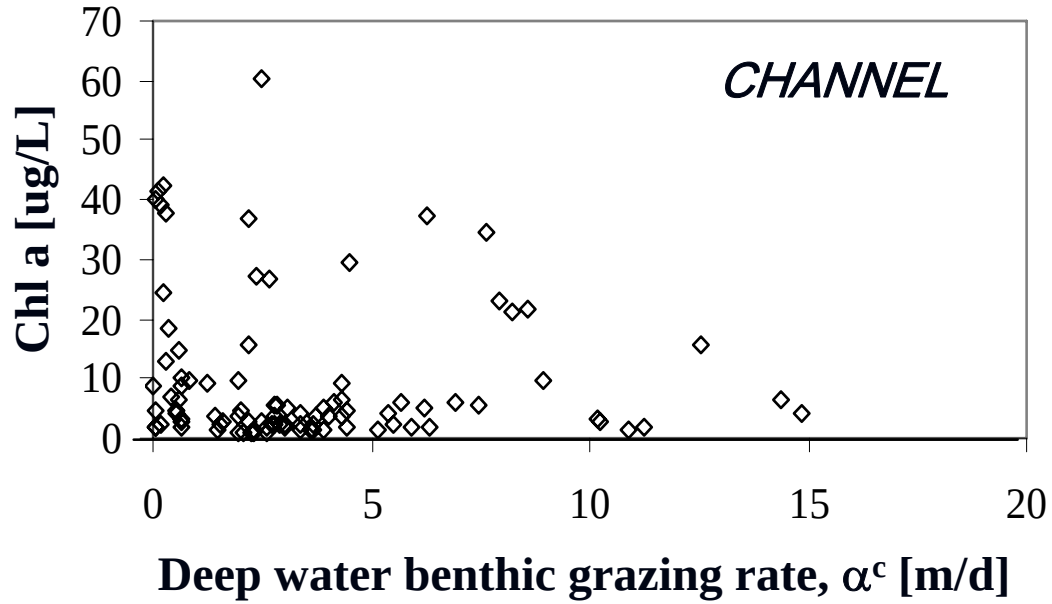
Lucas 1997

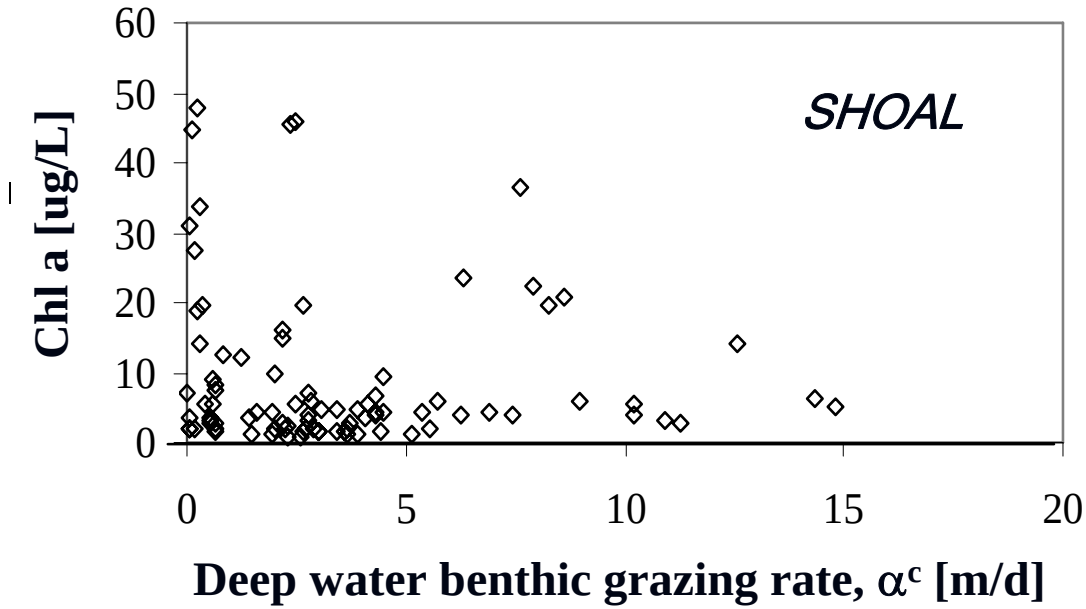
LESSON 2B

Deep water processes (e.g. BENTHIC GRAZING) modulate system-level blooms.

α^c = benthic grazing rate in channel, m/d

FIELD MEASUREMENTS



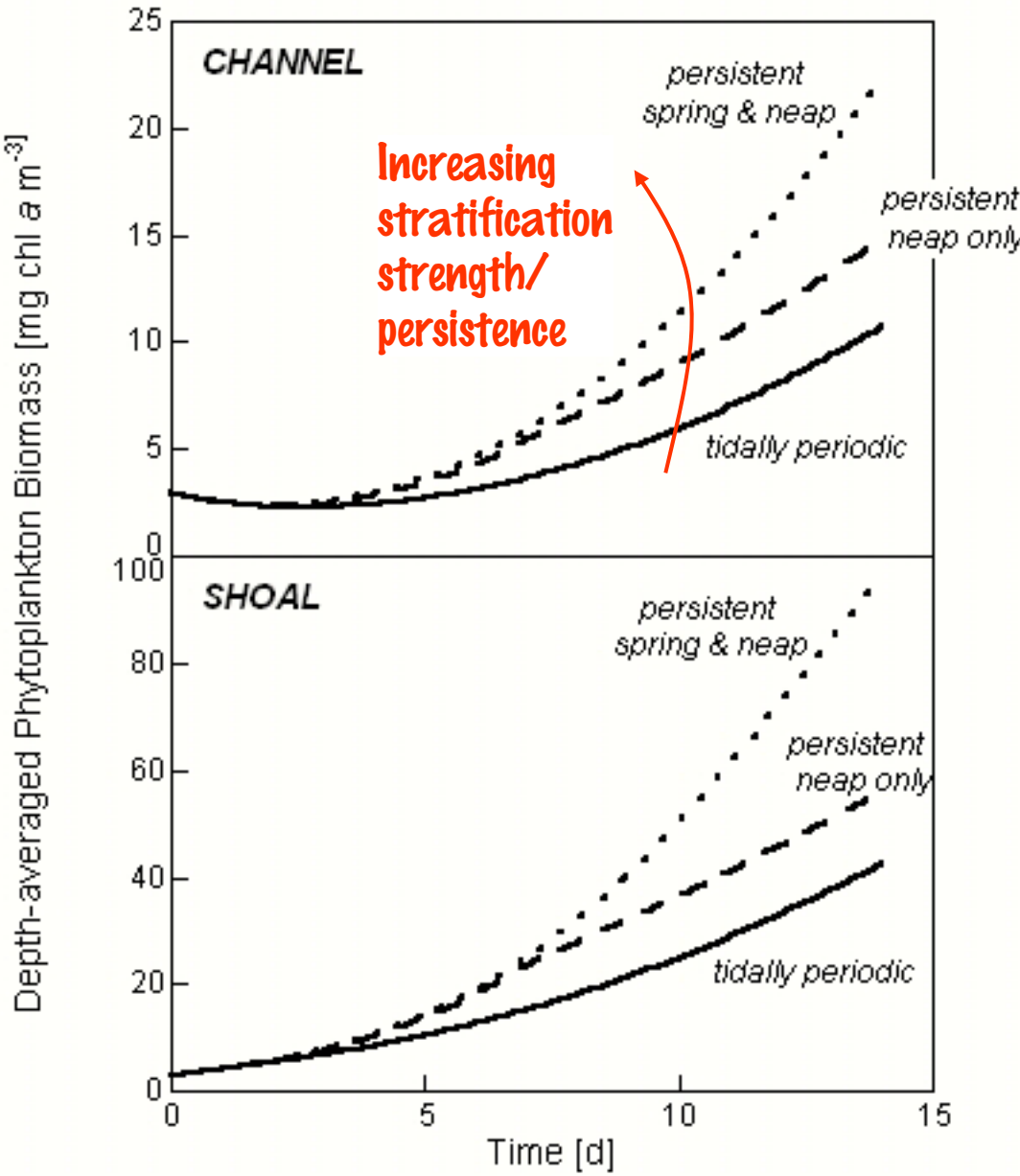


Thompson 1997

LESSON 2B

Deep water processes (e.g. STRATIFICATION) modulate system-level blooms.

MODEL

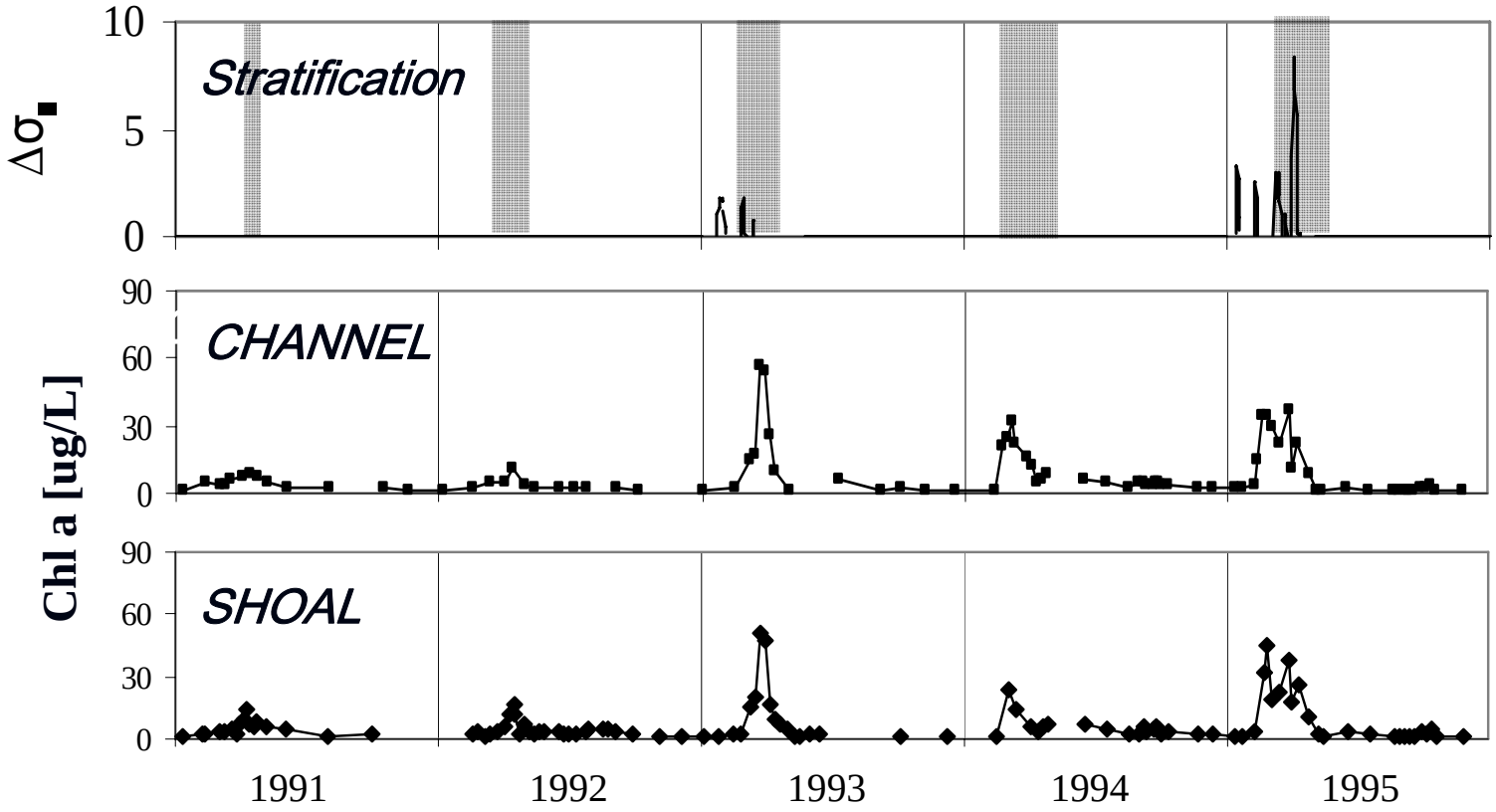


Lucas 1997

LESSON 2B

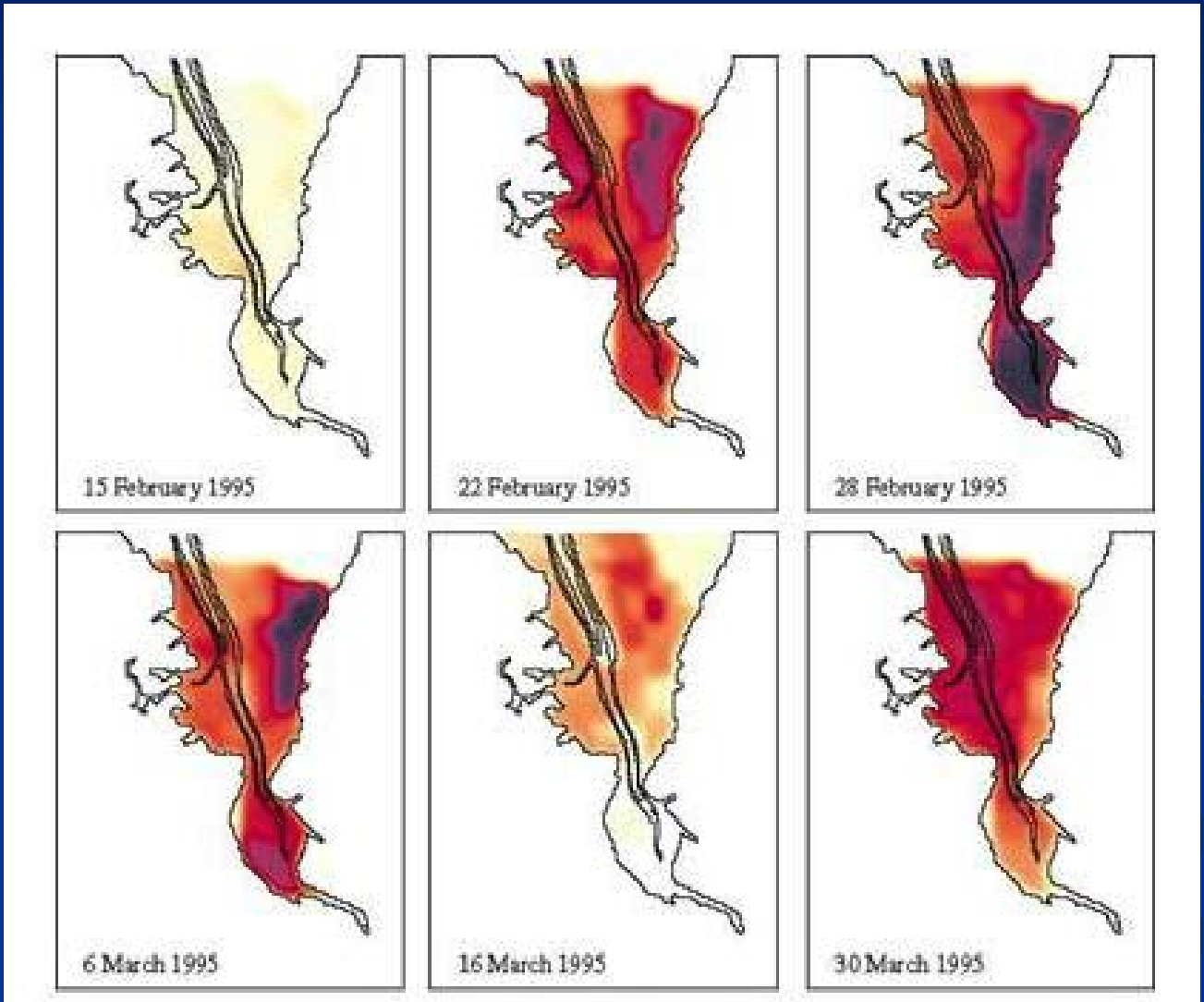
Deep water processes (e.g. STRATIFICATION) modulate system-level blooms.

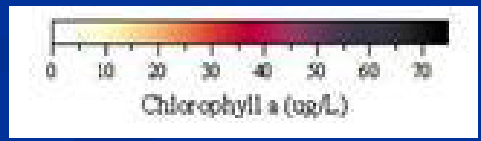
FIELD MEASUREMENTS



Thompson 1997

LEST YOU DOUBT…





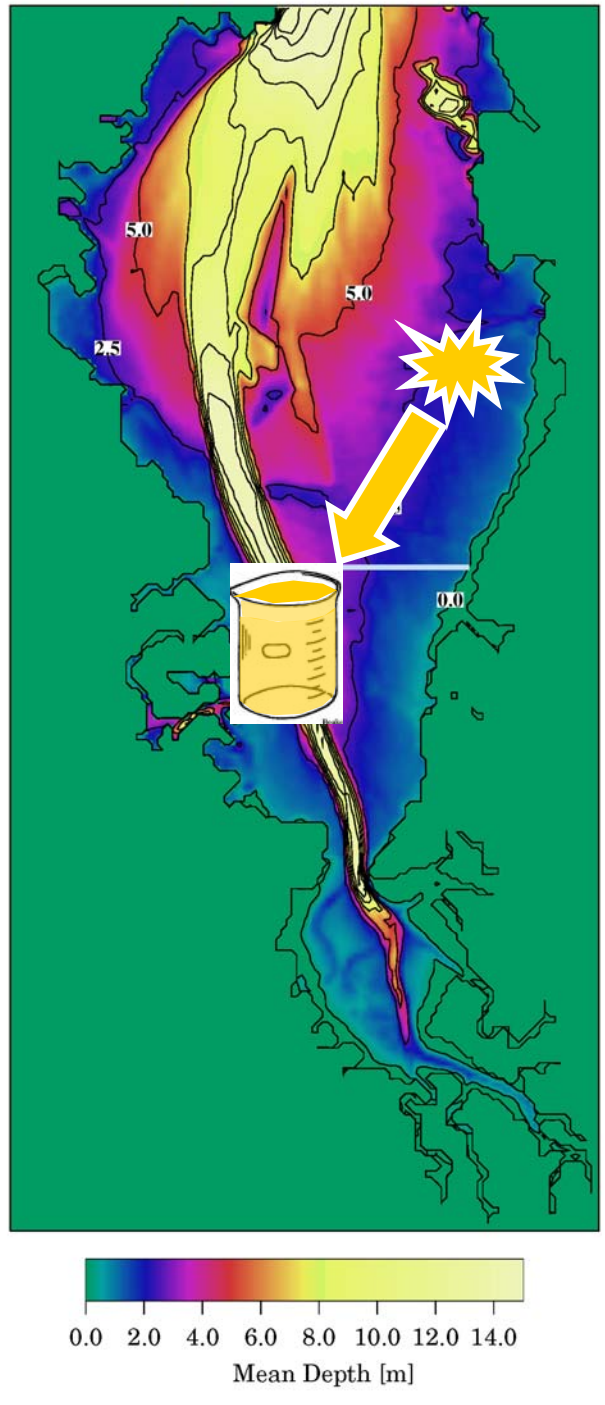
Thompson 1997

2 LESSONS

1. Remote processes can control locally measured quantities.

2. A) Shallow water processes drive system-level phytoplankton blooms in SSFB

   B) Deep water processes modulate system-level blooms.



WHAT DOES THIS MEAN AS SSFB CHANGES?

Any habitats (esp. shallow habitats) that are hydrodynamically connected to other habitats should be seen as potentially strongly influencing those connected habitats, because:

1. **Biology is fast in shallow water**
2. **Hydrodynamic connectivity allows the processes in one location to remotely control that which we measure in another location.**