Scale and Location Influence the Role of Bivalves in Mediating Benthic-Pelagic Coupling in Coastal Waters

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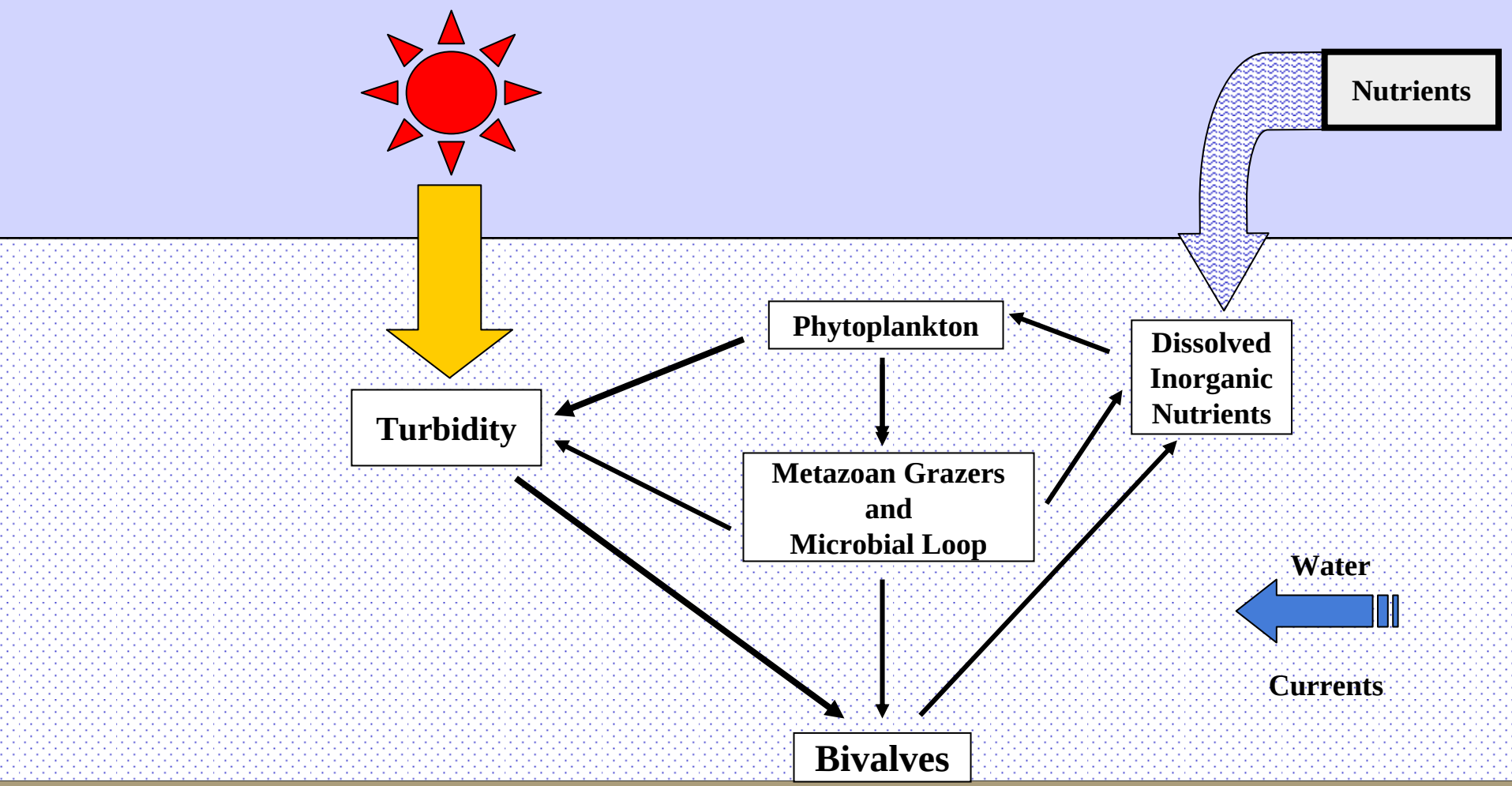
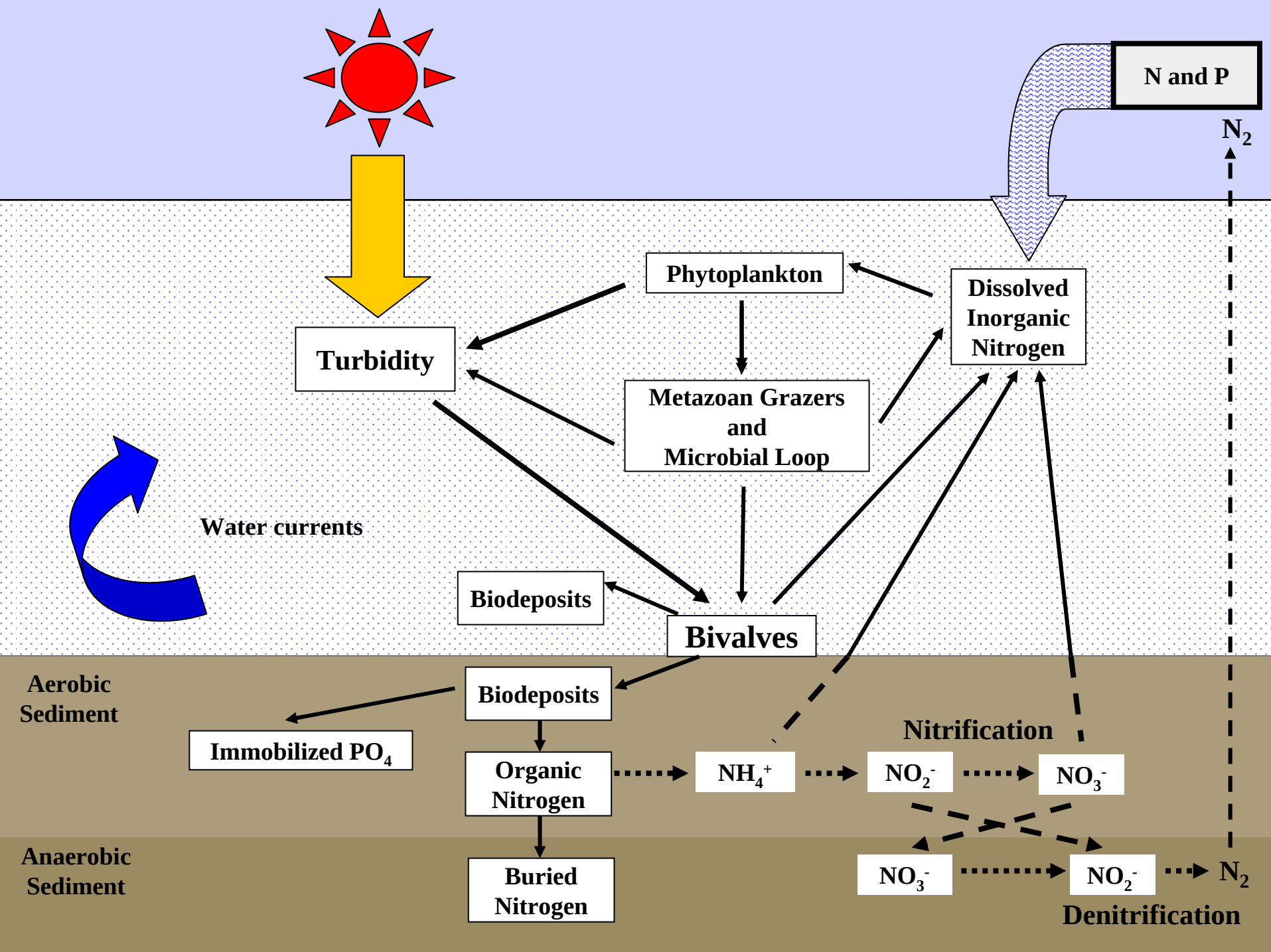

Nutrients
Phytoplankton
Dissolved Inorganic Nutrients
Turbidity
Metazoan Grazers and Microbial Loop
Water
Currents
Bivalves
Aerobic Sediment
Anaerobic


N and P
N_2
Phytoplankton
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Turbidity
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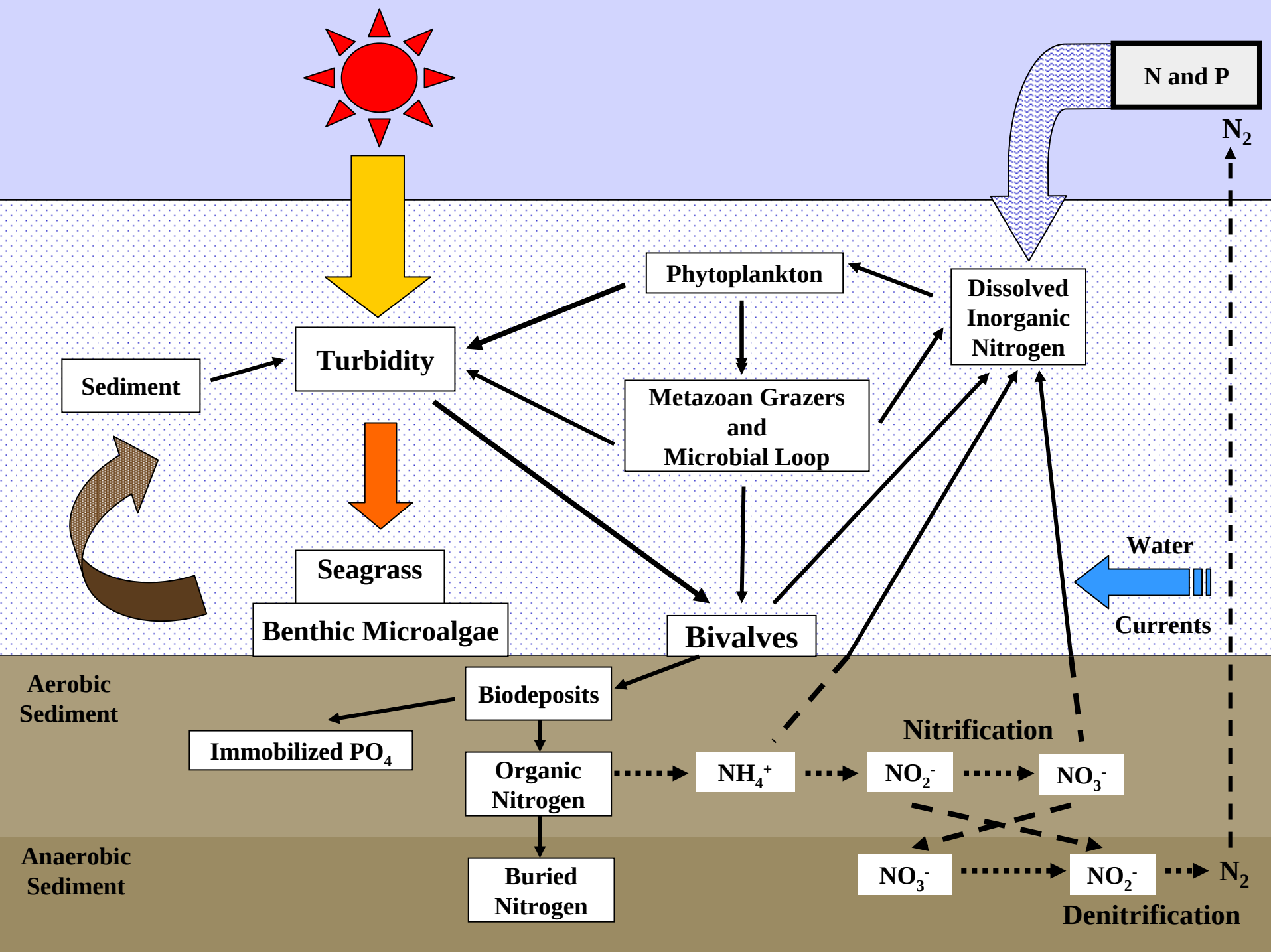
Biodeposits
Immobilized PO_4
Organic Nitrogen
NH_4^+
Nitrification
NO_2^-
NO_3^-
Anaerobic Sediment
Buried Nitrogen
NO_3^-
NO_2^-
N_2
Denitrification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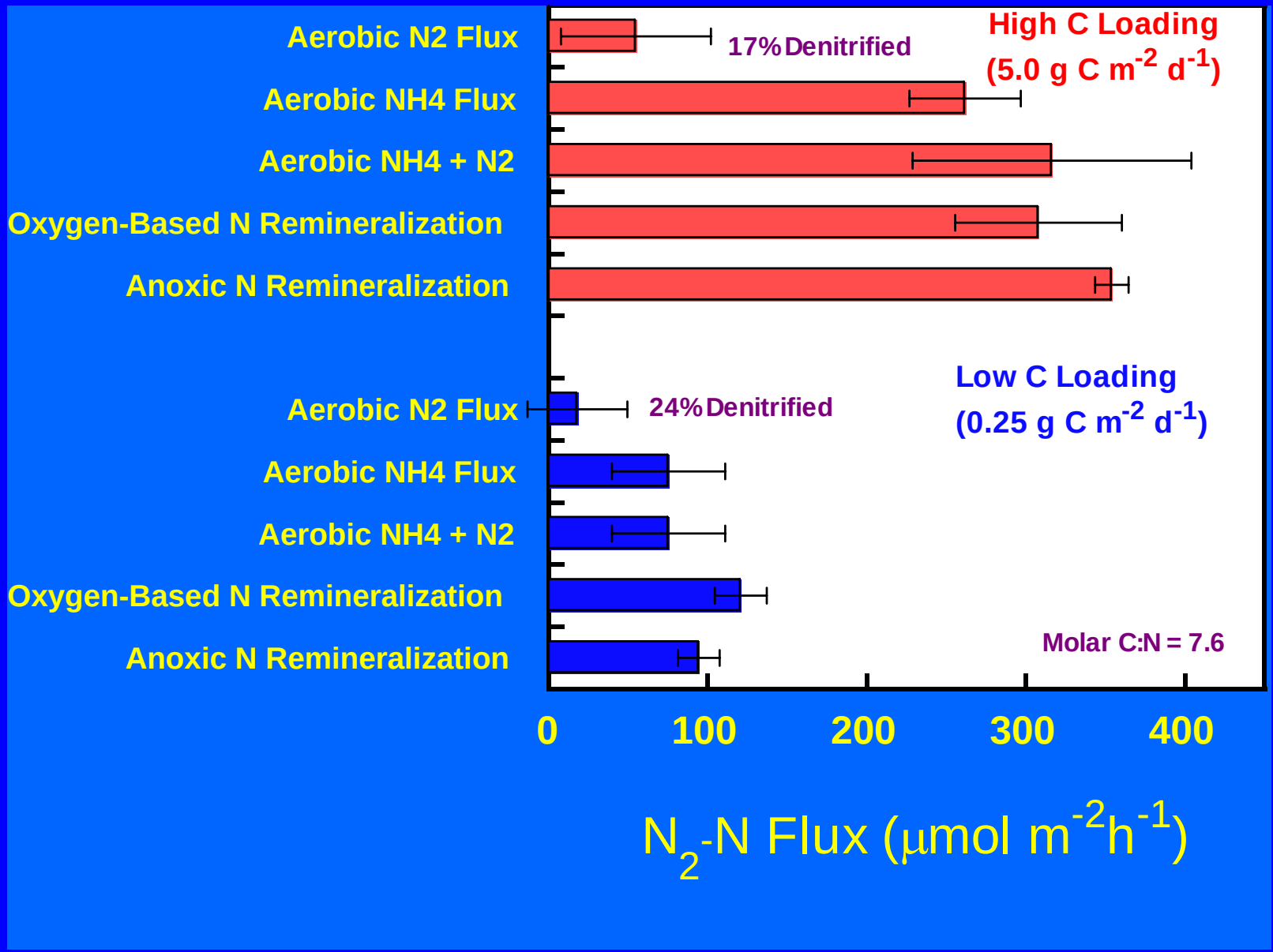
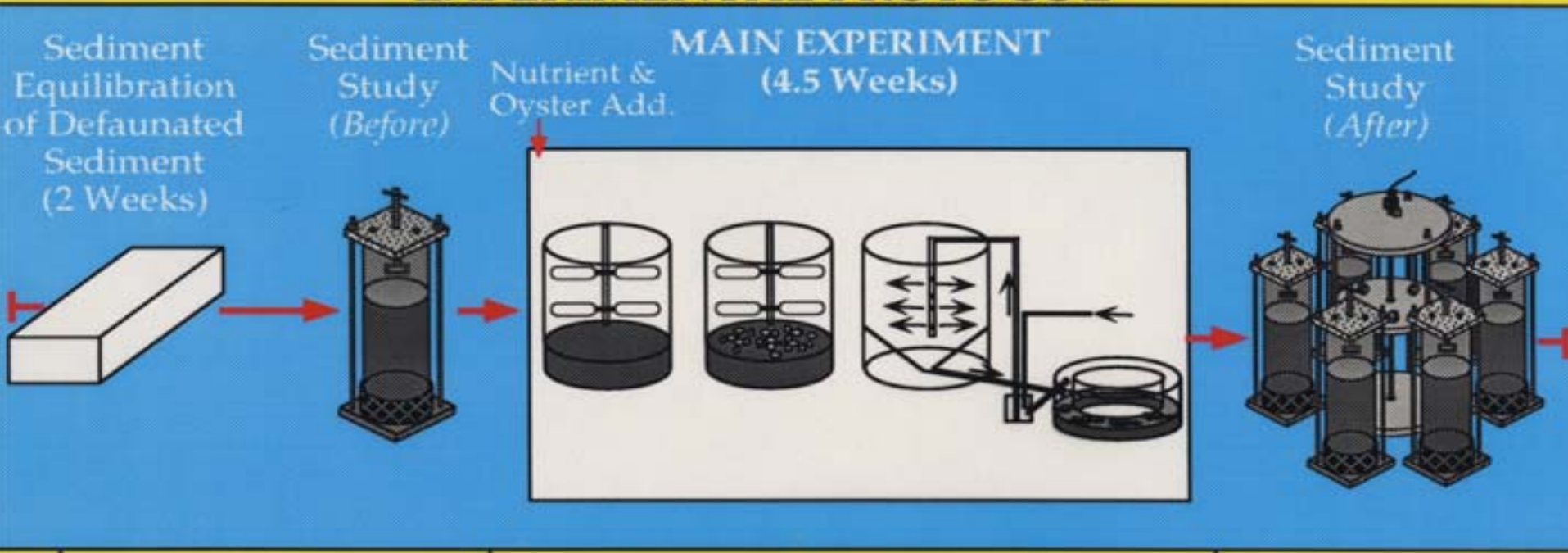
Newell, R.I.E, J.C.Cornwell and M.S.Owens. 2002. Influence of simulated bivalve biodeposition and microphytobenthos on sediment nitrogen dynamics: a laboratory study. Limnology and Oceanography 47: 1367-1379



Porter E.T., J.C Cornwell, L.P Sanford, R.I.E. Newell. 2004. Effect of oysters *Crassostrea virginica* and bottom shear velocity on benthic-pelagic coupling and estuarine water quality. Marine Ecology Progress Series. 271:61-75.

EXPERIMENTAL PROTOCOL



MEASUREMENTS

SEDIMENT *Before*:

- **Fluxes of O_2 and NH_4^+, NO_3^-+NO_2^-**
- **N_2 Fluxes**

Others:

- Chl *a*, Sediment C&N
- Porewater Nutrients, H_2S
- Nutrient (PO_4^{---}, Si) Fluxes

WATER COLUMN, Main Expt:

- ***In-situ* Fluorescence, Chl *a* (daily)**

PHYSICAL DATA: -> Light Profiles

Others:

- Nutrients (NH_4^+, NO_3^-+NO_2^-)
- Temp., O_2, Sediment Chl *a*
- Seston Quantity & Quality (POM&PIM)
- Particle Conc., Size, Frequency
- Pigments, Zooplankton, Bacterial Abundance, Bivalve Growth
- Nutrients (PO_4^{---}, Si), CHN, PP

SEDIMENT *After*:

- **Same as Sediment *Before* Main Expt., in Darkness and Light.**

Holyoke, RR., J C.Cornwell, and R.I.E. Newell. Biogeochemical responses of shallow water sediments to small-scale aquaculture of the eastern oyster, *Crassostrea virginica*. Submission to Marine Ecology Progress Series.

Sediment Core Collection and Incubation

Sediment cores were collected beneath Taylor floats and at Reference sites, located 70-300 m downstream. Cores were incubated in the dark and light at ambient temperature (20-32°C).

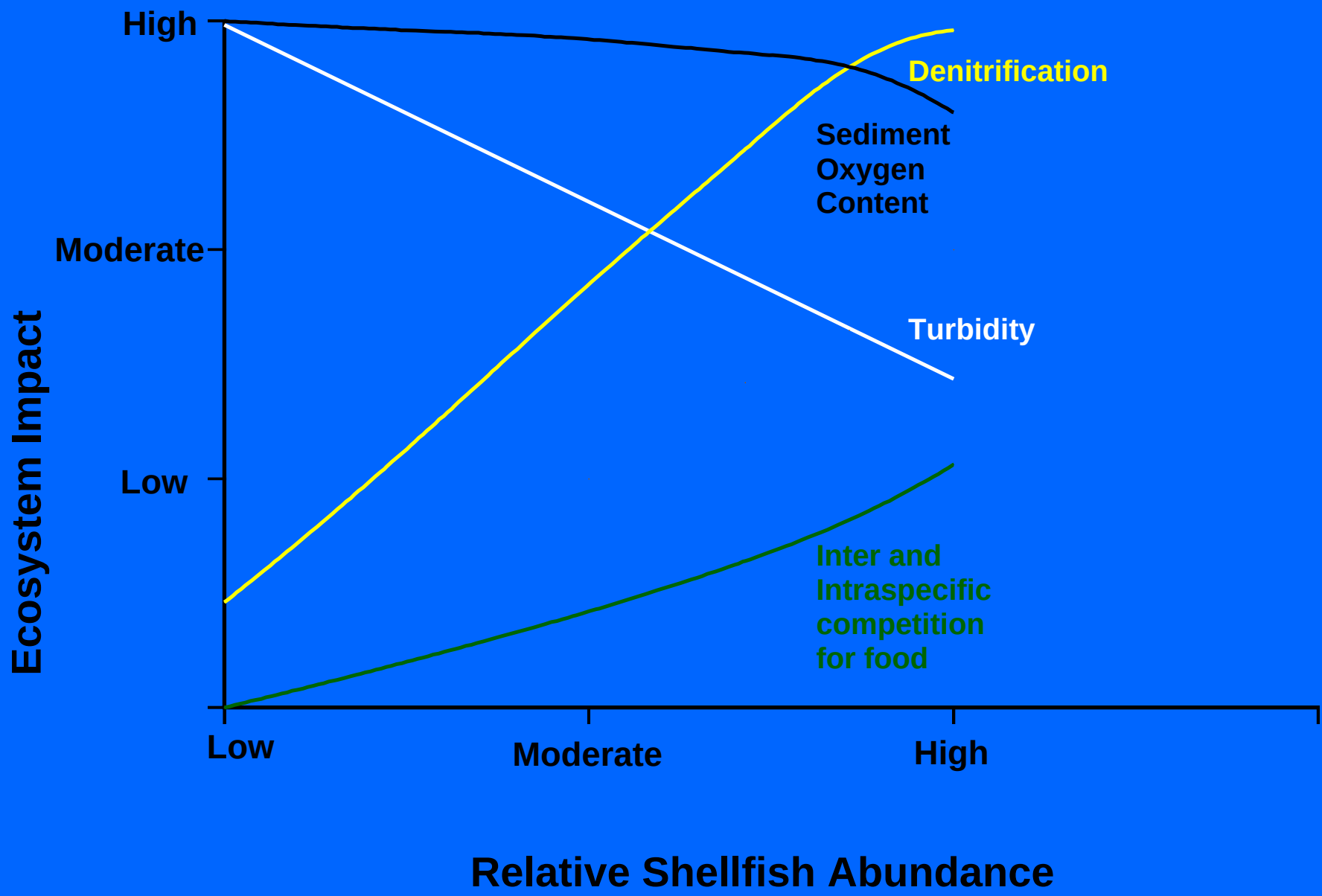
Nutrient (and sediment) Analyses

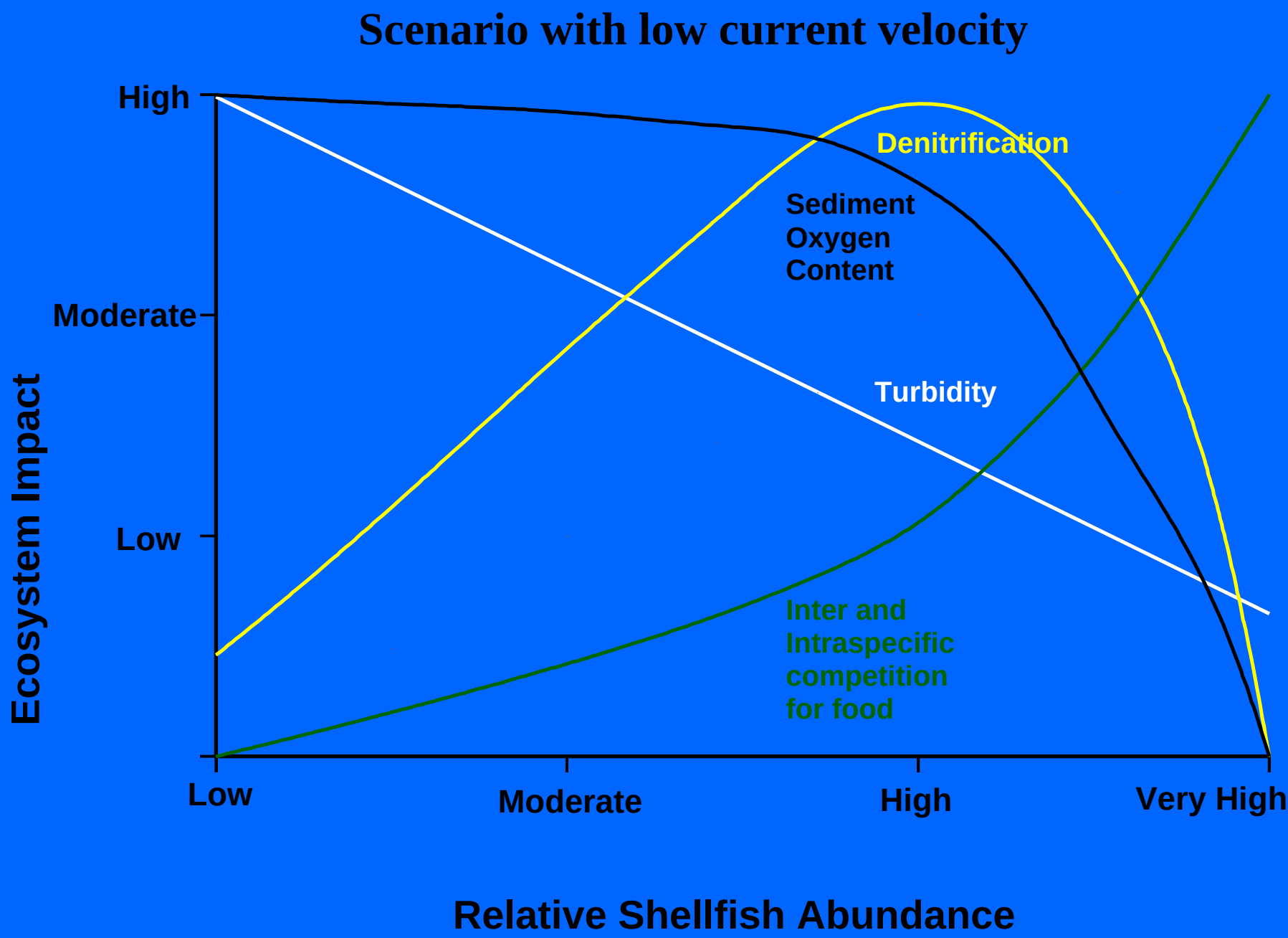
Pore water NH_4^+ and ΣH_2S and surface sediments collected in an N_2 glove bag

MIMS (O_2, N_2)

Nutrient fluxes:
NH_4^+, NO_2^- + NO_3^-,
N_2-N, O_2

Loss on ignition
Total Nitrogen
Total Carbon


High
Moderate
Low
Ecosystem Impact
Denitrification
Sediment
Oxygen
Content
Turbidity
Inter and
Intraspecific
competition
for food
Low
Moderate
High
Relative Shellfish Abundance


Scenario with low current velocity
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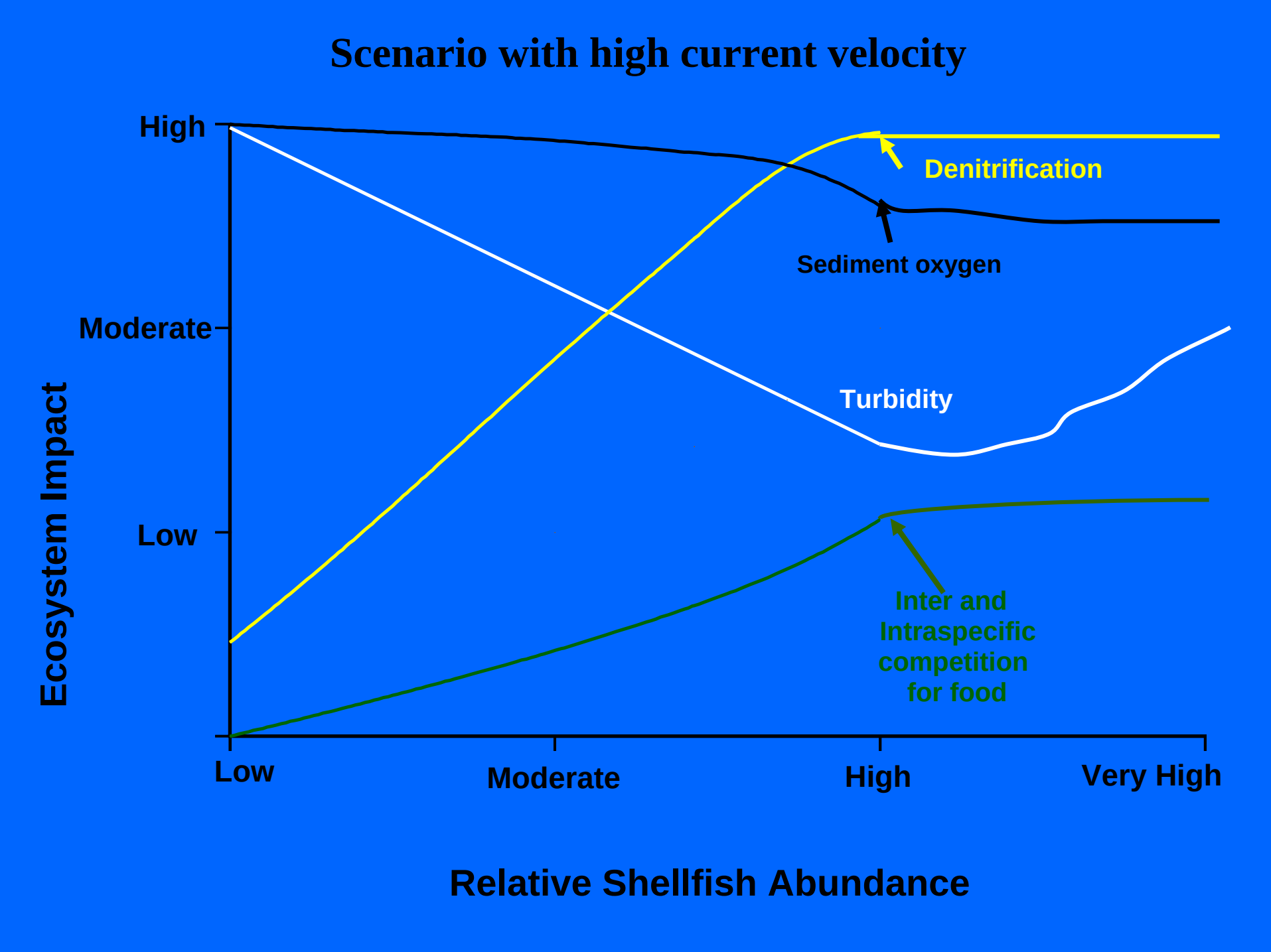
Relative Shellfish Abundance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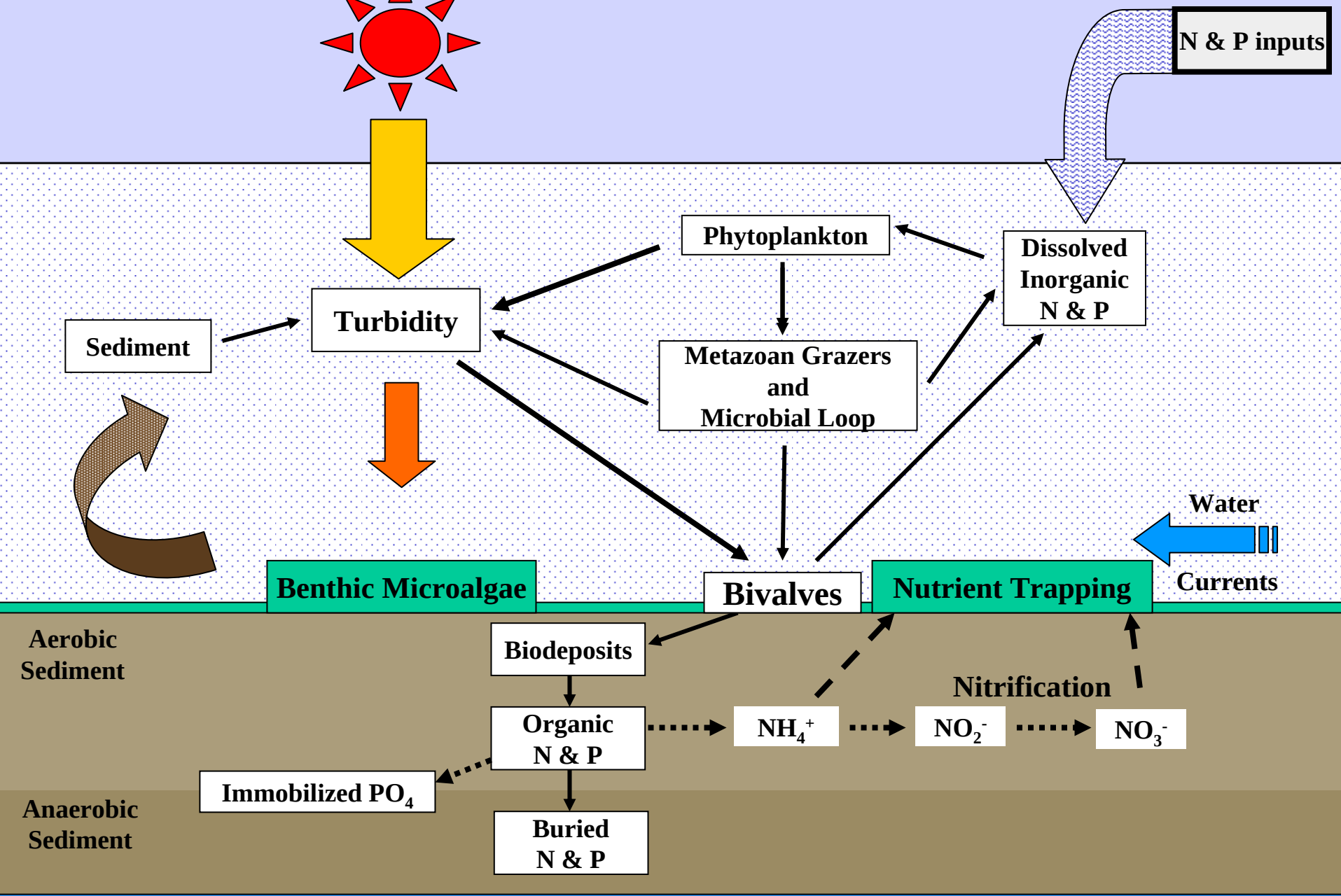
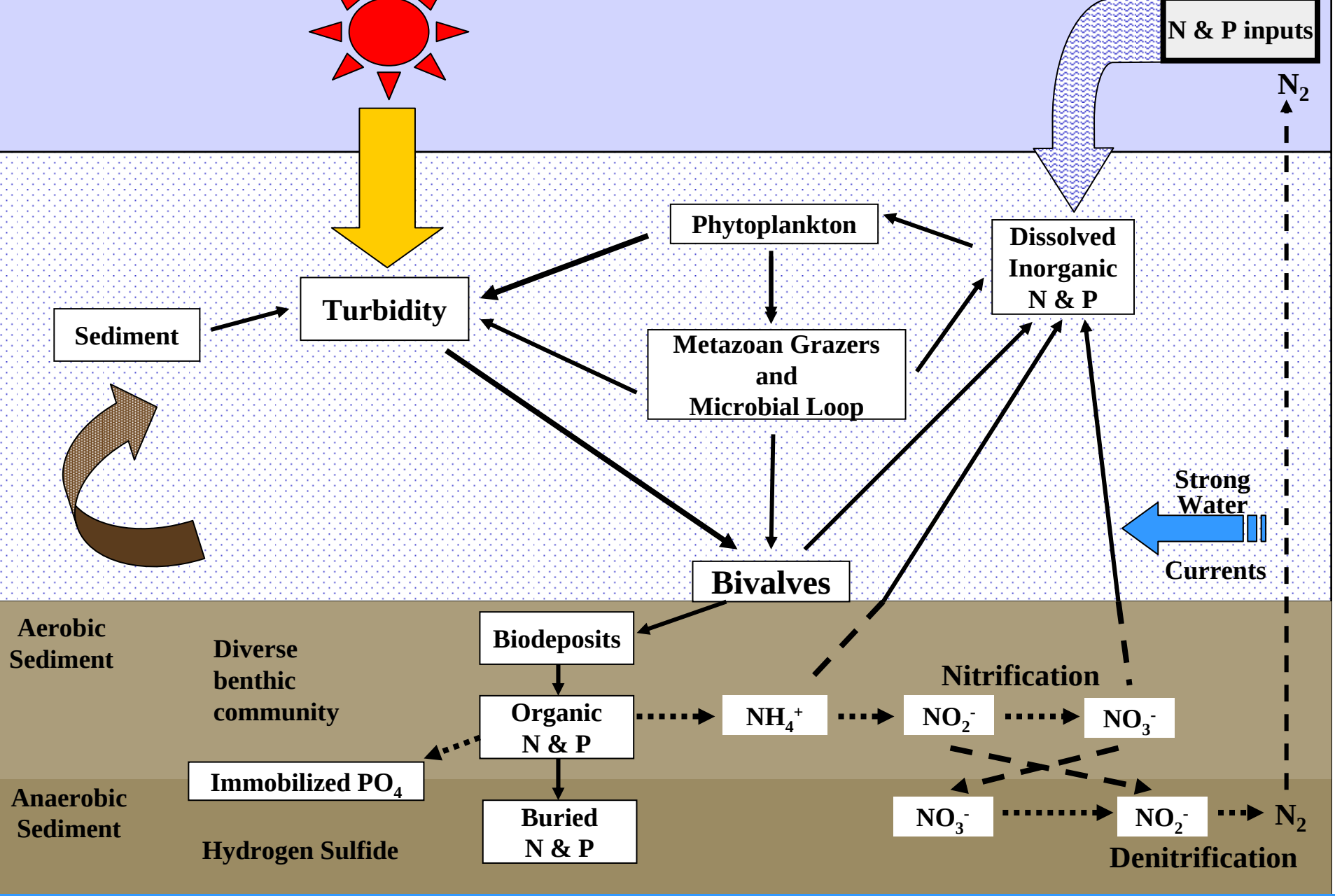
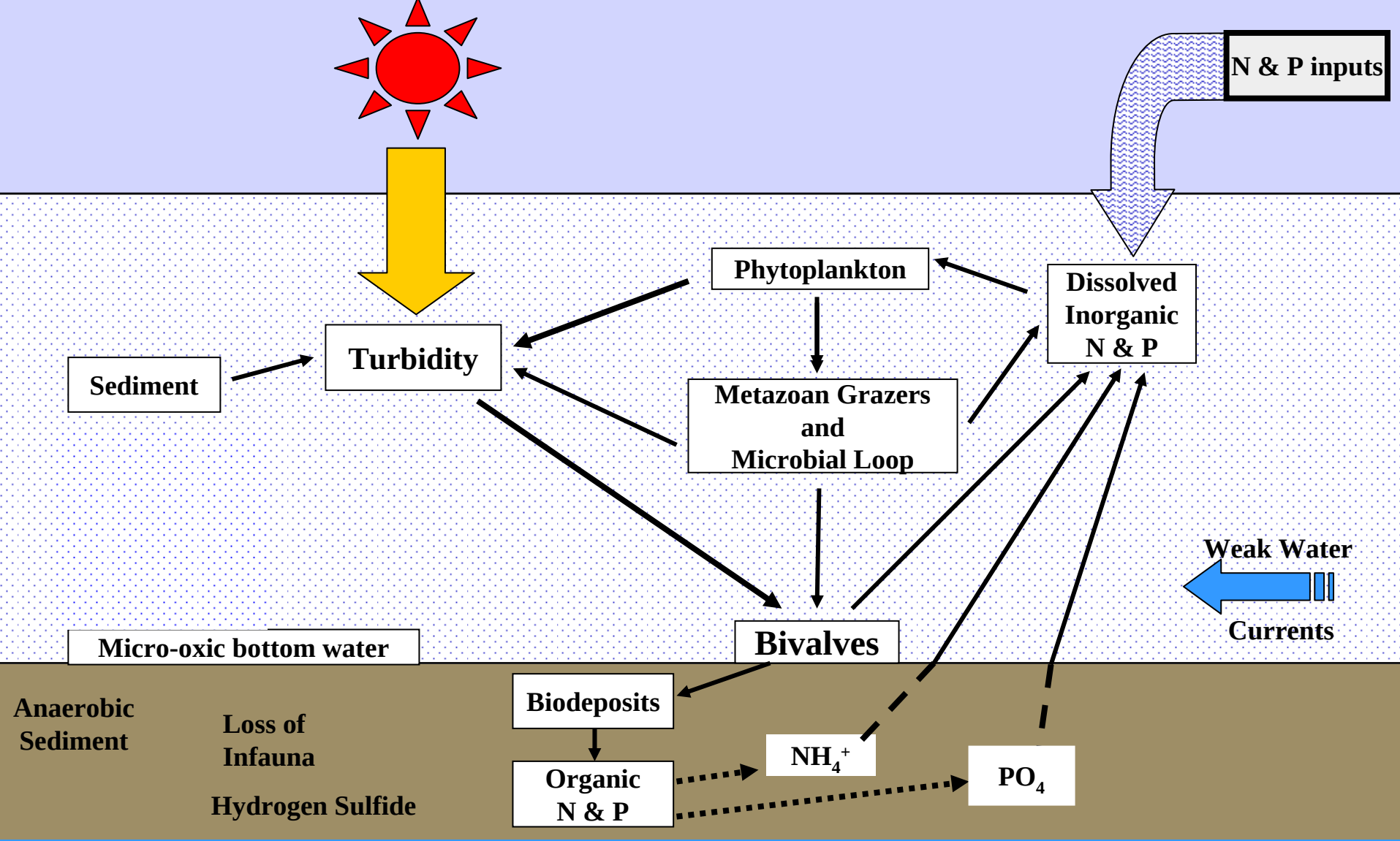


Enhancement of benthic primary production when bivalve biodeposits are processed under aerobic conditions within the euphotic zone



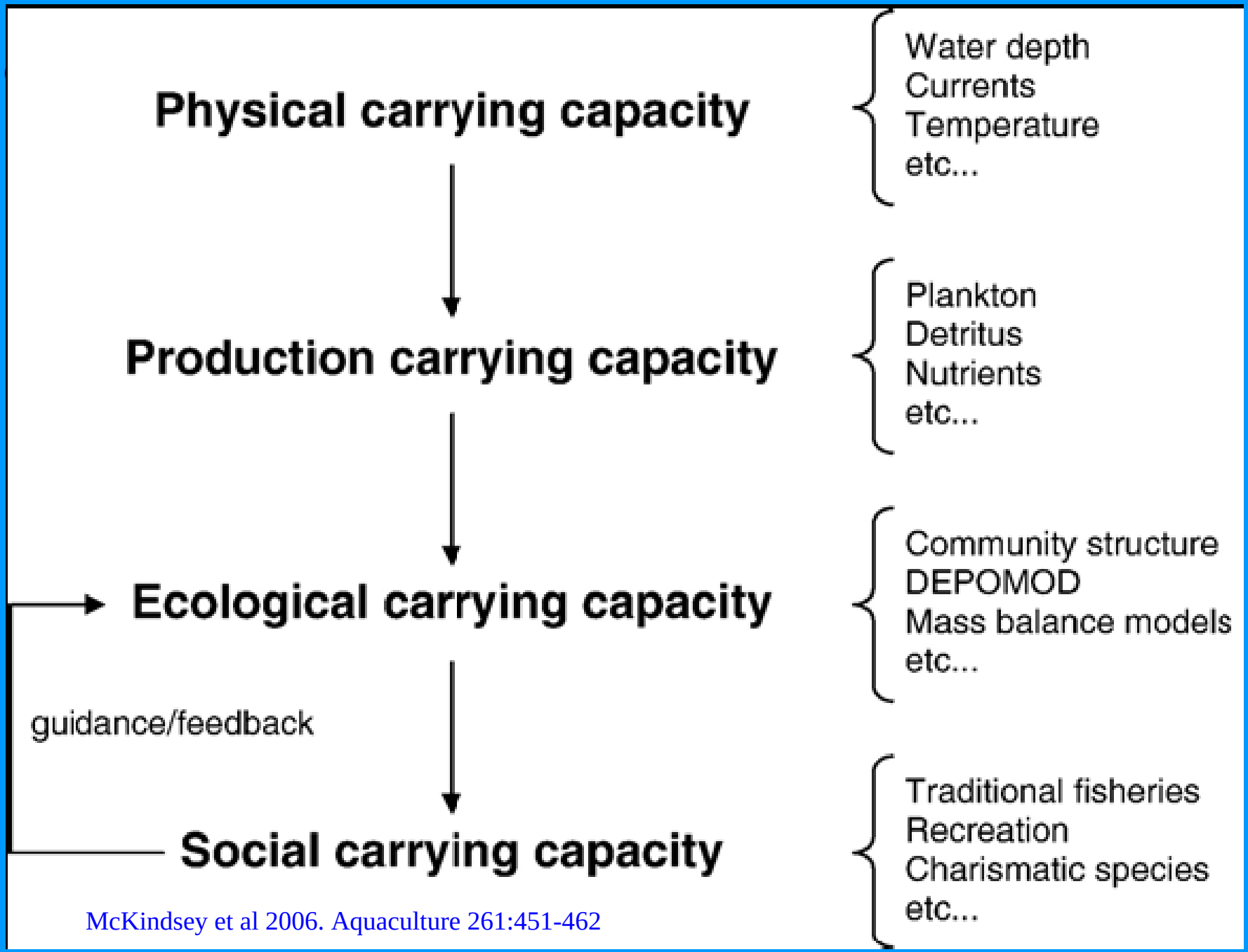
Normal benthic processes when bivalve biodeposits are processed under aerobic conditions beneath the euphotic zone



Adverse ecosystem effects of bivalve aquaculture where biodeposits accumulate and generate anaerobic sediments

"Carrying capacity is the standing stock of suspension-feeding bivalves where the consumption of phytoplankton, enhancement of nutrient removal, and other ecosystem services are maximized without negatively affecting water quality, sediment biogeochemistry, and overall ecosystem function."

Newell, R.I.E. 2007. A framework for developing "ecological carrying capacity" mathematical models for bivalve mollusc aquaculture. Bulletin of Fisheries Research Agency. 18:41-51



McKindsey et al 2006. Aquaculture 261:451-462

SUMMARY: Scale and Location Influence the Role of Bivalves in Mediating Benthic-Pelagic Coupling in Coastal Waters

Bivalves are naturally abundant and are cultivated in shallow coastal waters; consequently they can be extremely important in mediating Benthic-Pelagic Coupling.

Bivalves graze on phytoplankton growing on ambient inorganic nutrients; hence no additional nutrients are introduced as occurs when caged fish are fed food pellets.

N & P are removed from the environment in the tissue of harvested shellfish.

Strong seasonality in bivalve activity alters rates of phytoplankton consumption.

Shift aquatic systems away from pelagic microbial loop to benthic control, and make particulate nutrients available to other benthic organisms.

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Biodeposits enrich sediments and alter their geochemistry

Where water flow and oxygen are adequate, N may be lost as gaseous N_2 and N and P buried.

When biodeposition is high and either flow or oxygen are low, sediments may become anoxic, leading to mortality of benthic organisms, release of bound P,and inhibition of nitrification/denitrification.

Bivalve feeding reduces turbidity thereby permitting growth of benthic plants. Beneficial if benthic microalgae and seagrass grow but possible adverse if macroalgal (e.g.,*Ulva* spp) colonize.

Benthic microalgae, an important food source for many invertebrates, can take up large amounts of N & P regenerated from bivalve biodeposits.

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Information required on transport, sinking, and dispersion of bivalve biodeposits under local conditions.

Important to undertake adequate site categorization and monitoring prior to initiation of aquaculture so that ecosystem changes over time can be compared to suitable reference sites (Quarterly: sediment grain size, porosity, organic carbon content, particulate and dissolved acid volatile sulfide content; Annually: benthic community surveys).

Management of aquaculture may require fallowing of leases and allowing more extensive and less intensive stocking

GIS systems can be used to categorize conditions at potential aquaculture sites to help identify those that have the most suitable physical conditions.

Ecosystem models can be developed to estimate physical carrying capacity, production carrying capacity, and ecological carrying capacity. These will help managers to make decisions concerning aquaculture placement, system-wide intensity, and resource conservation.

Impossibly high standard to expect that bivalve aquaculture will not have any discernible effects on the ecosystem. Management should aim to maximize the beneficial effects while minimizing the negative effects.

"Effects on the ecosystem" is a subjective assessment and what level of change is permissible needs to be defined by discussion and consensus among all stakeholders.