Approaches for evaluating the effects of bivalve filter feeding on nutrient dynamics in Puget Sound, Washington

Christopher Konrad
US Geological Survey
Tacoma, Washington
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Overview

Mussels, clams, and oysters influence nutrients and phytoplankton in estuaries.

USGS reviewed approaches (measurements and models) for quantifying the effects of bivalves on nutrient dynamics in Puget Sound .

The purpose was to compare the information required and gained from different approaches.

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Rationale for the review

Management of nutrients in Puget Sound is important because of their influence on phytoplankton production and, indirectly, dissolved oxygen concentrations.

The water quality effects of bivalves are not understood in much of Puget Sound.

A range of models have been used in other estuaries to understand how bivalves affect water quality.

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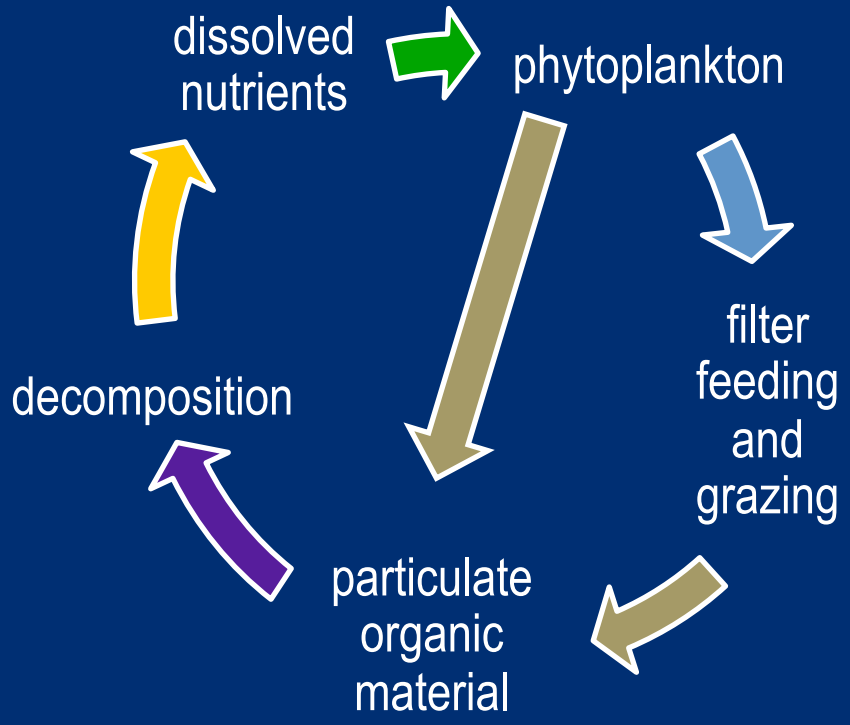
Premises for the review

EFFECTS OF BIVALVES ON WATER QUALITY ARE COMPLEX:

- depend on nutrient cycles



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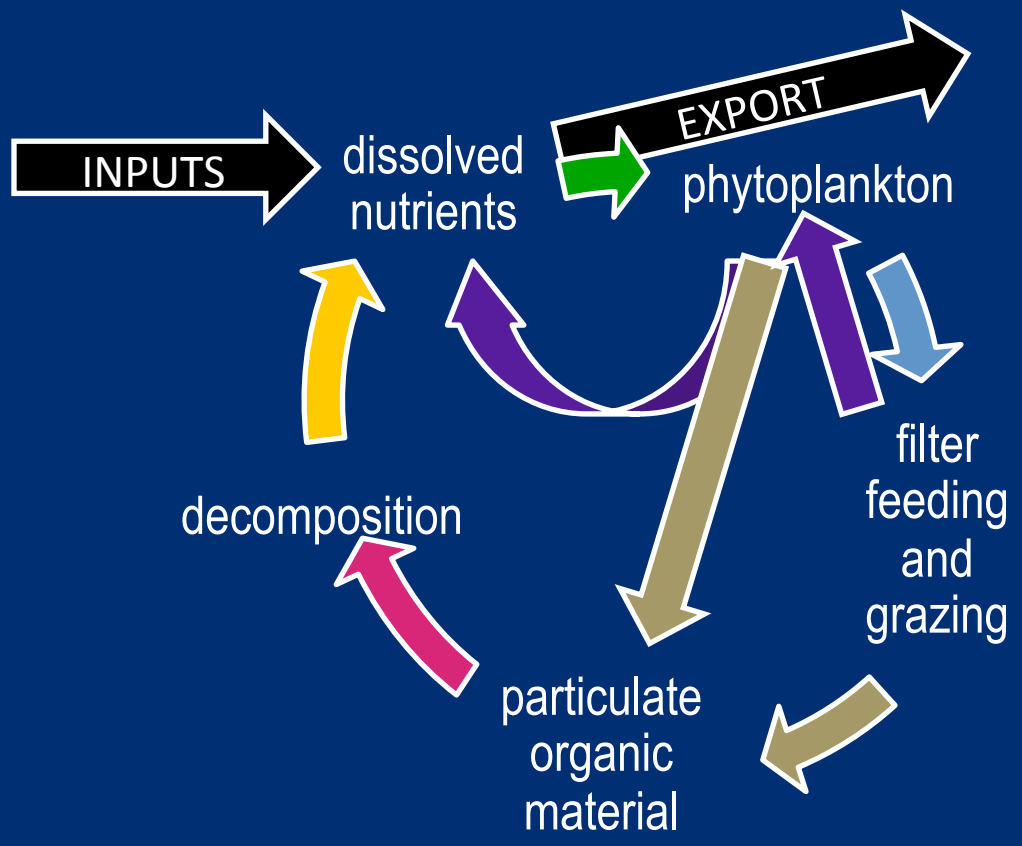
Premises for the review

EFFECTS OF BIVALVES ON WATER QUALITY ARE COMPLEX:

- depend on nutrient cycles, circulation, and feedbacks;
- not simple cause >> effect;
- relative magnitude of each link varies in space and time.



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DIFFERENT NEEDS FOR INFORMATION

The level of understanding depends on the management question/situation.

INFORMATION GAPS LIMIT APPLICATION OF MODELS

Complex models should be justified by information needs.

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Range of Approaches

Measurement-based

Mass balance

Clearance rates

Biophysical Indicators

Simple, feasible, limited information needed , answers general questions

Modelling

Spatially-Distributed Biophysical Model

Biogeochemical Model with Low Trophic Levels

Bioenergetics

Ecosystem

Complex, resource-intensive, much information required, can be used to answer specific questions

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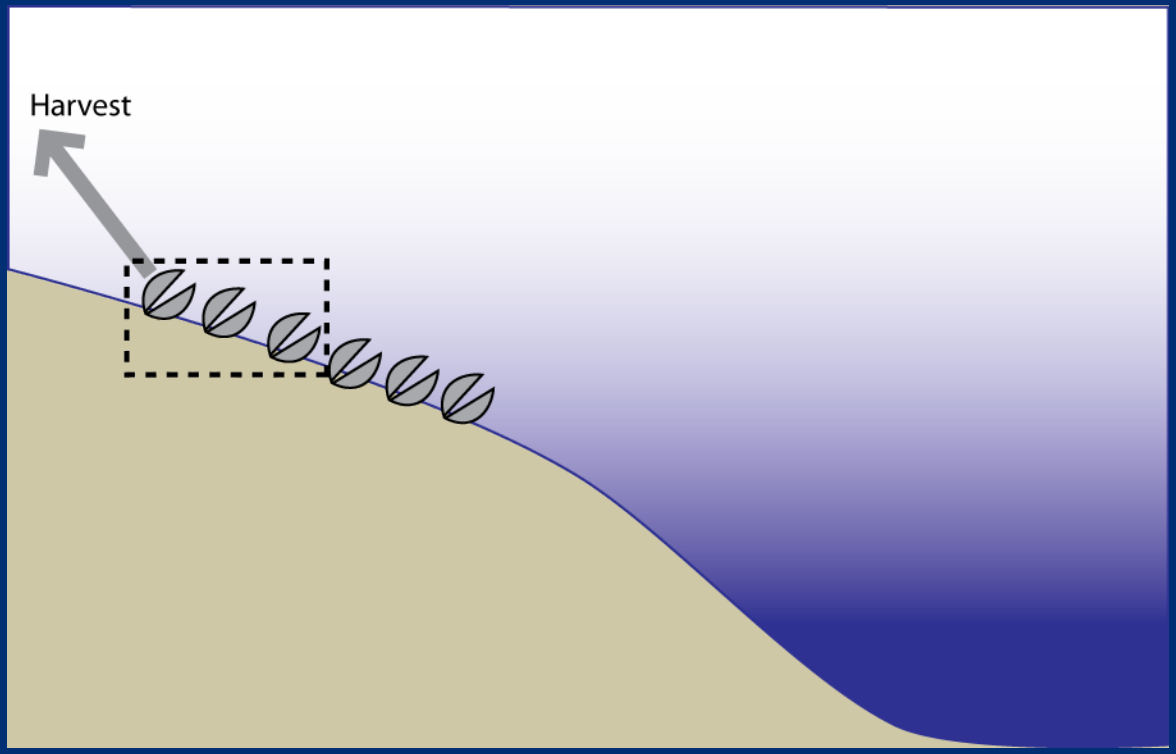
1. Shellfish biomass



Provides an estimate of gross amount of nutrients removed from an estuary by shellfish harvesting

This approach has been used in Puget Sound assuming nitrogen content ~ 1% of wet weight (Steinberg and Hampden, 2010)

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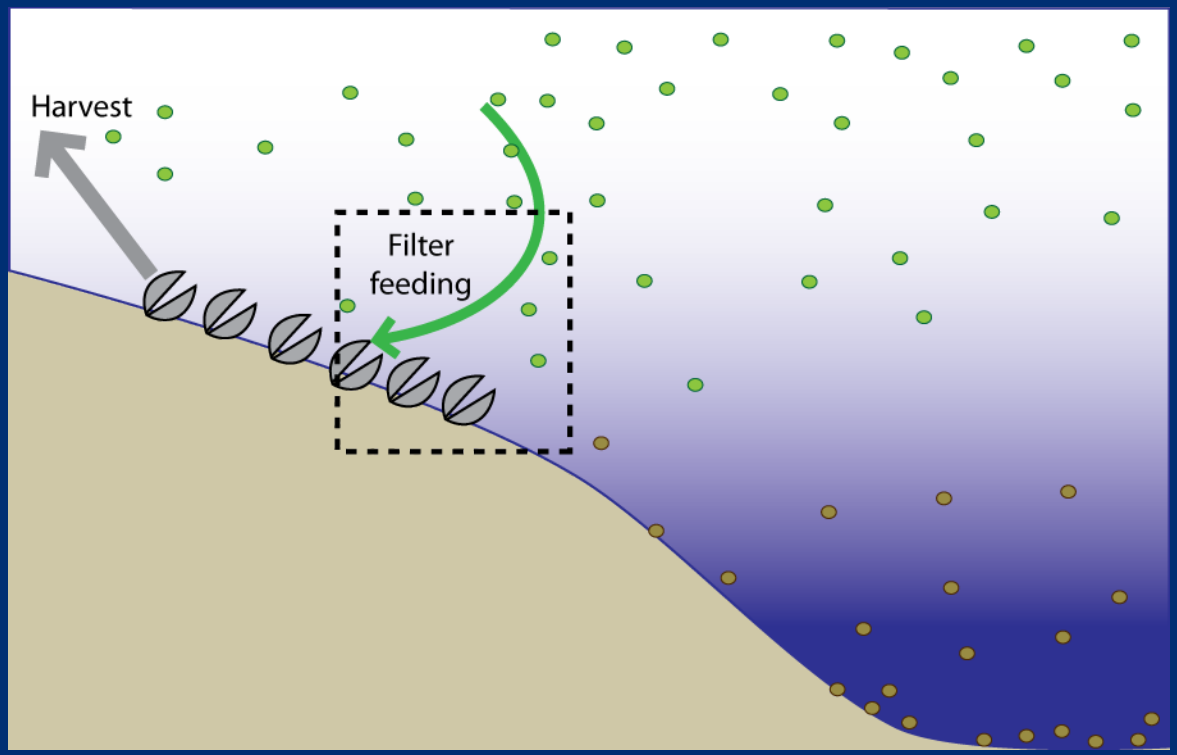
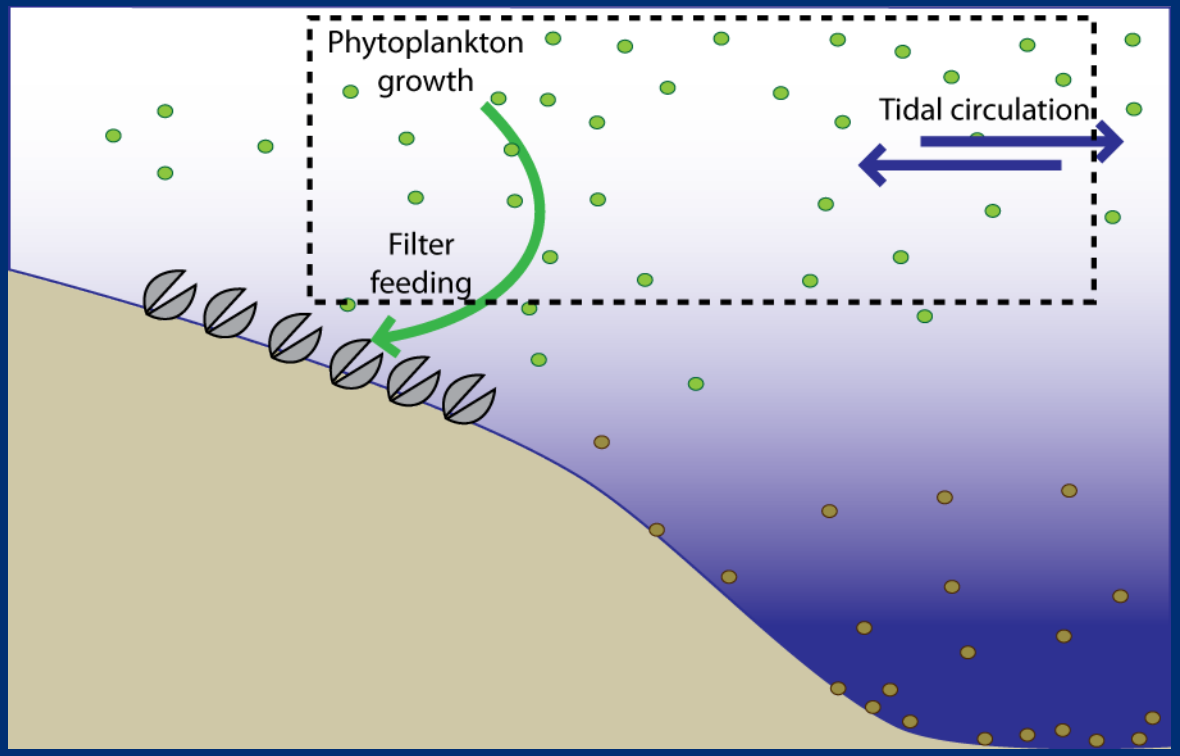
2. Clearance rates



Clearance rates (the mass of seston removed from the water column over time) are measured in the laboratory or in the field. Rates are highly variable (so *measurements represent specific conditions*) and do not scale linearly (*density effects*). No published measurements for Puget Sound shellfish as of 2013.

3. Spatially-Aggregated Biophysical Indicators

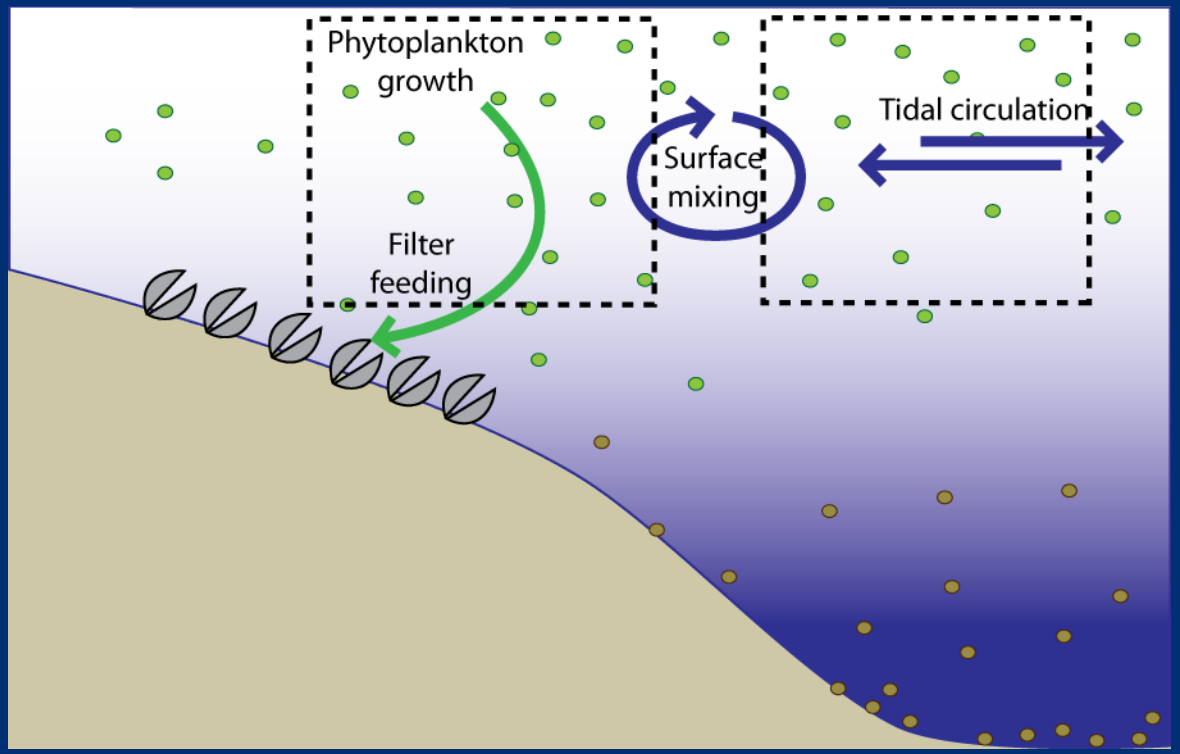


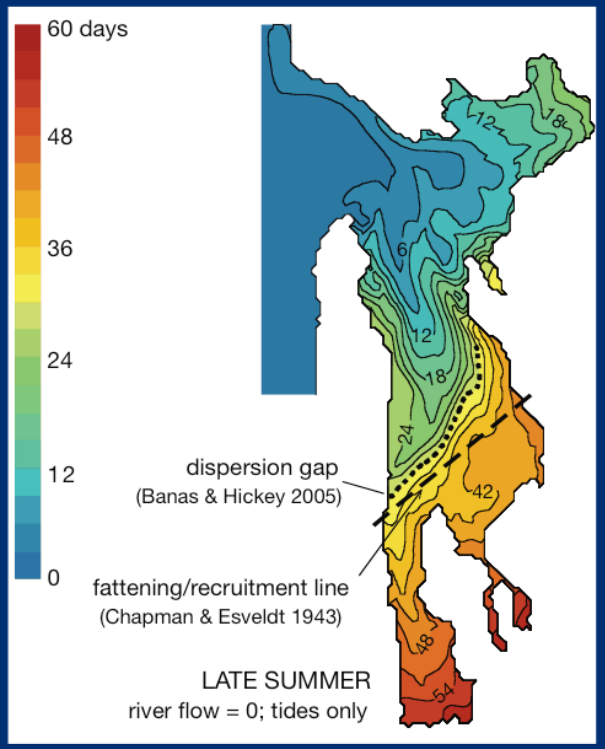
Tidal flushing to filter feeding: residence time / clearance time

Tidal flushing to growth: residence time / production time

Use to assess the potential importance of tidal flushing (residence time) to filter feeding (clearance time) and to phytoplankton growth (production time) (Dame and Prins, 1998). These could be estimated for different parts of Puget Sound

4. Spatially-explicit biophysical model





Banas and others (2007) incorporated uniform phytoplankton growth and filter feeding rates in a hydro-dynamic circulation model to account for how residence time influenced the effects of filter feeders across Willapa Bay.

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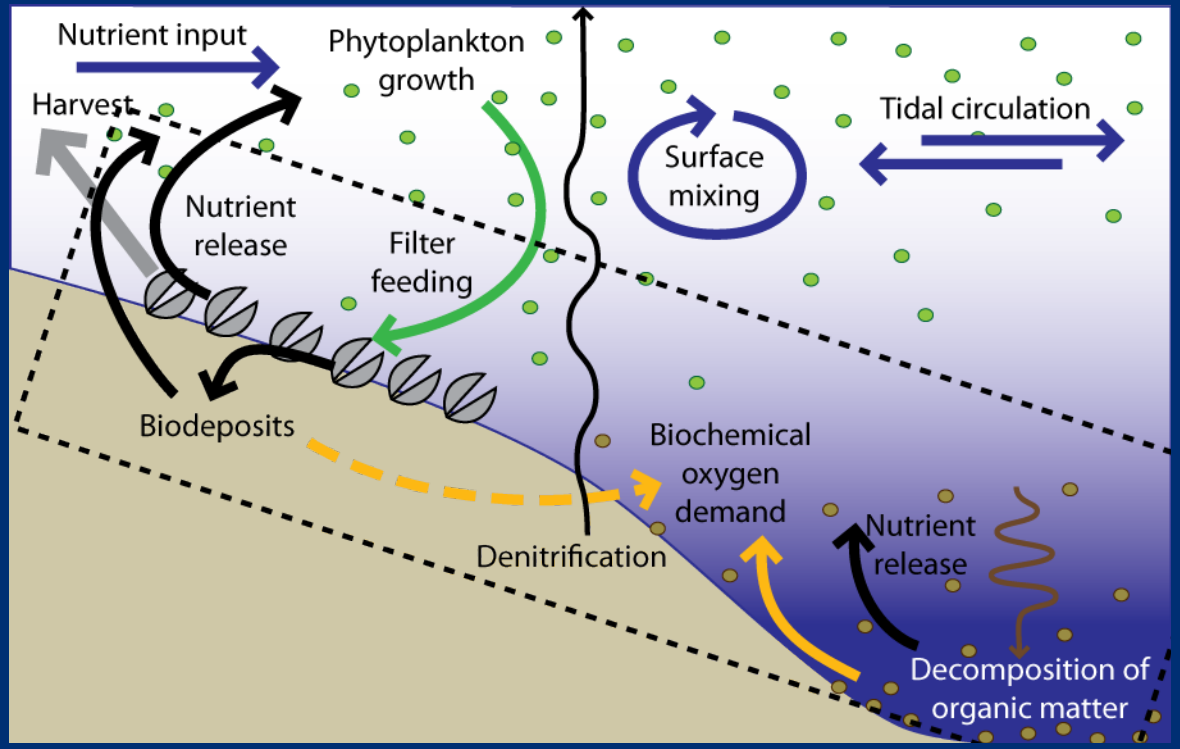
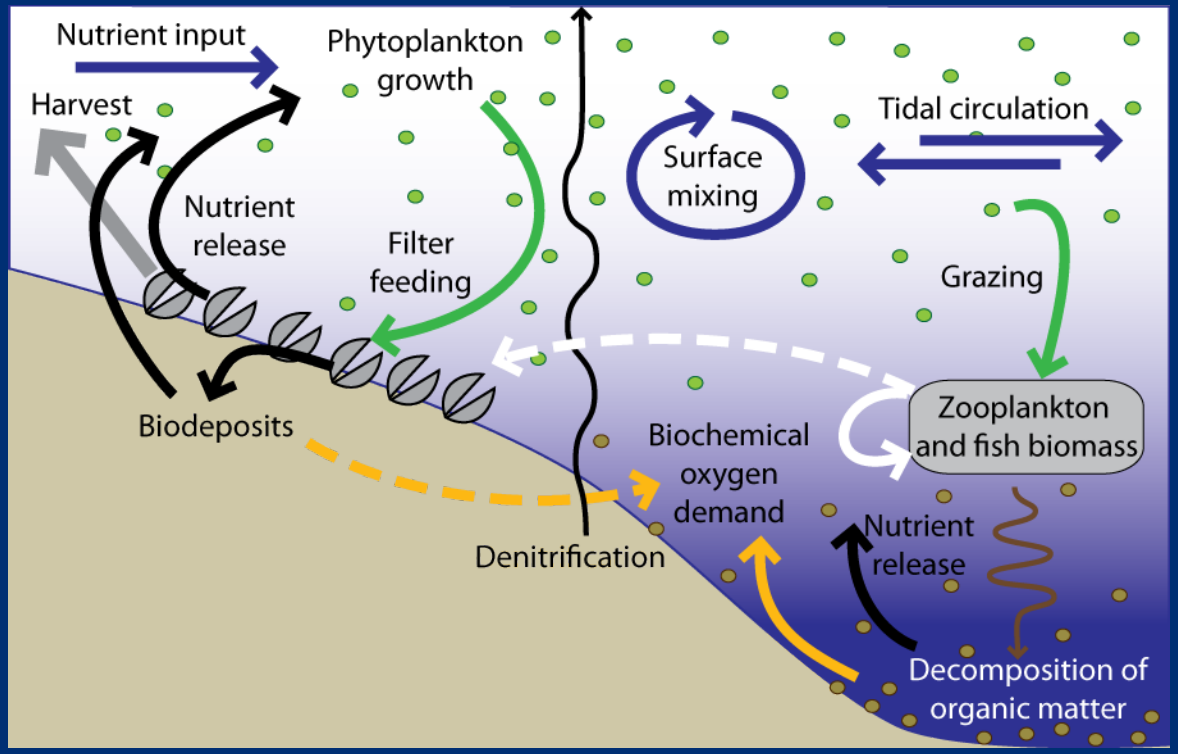
Biogeochemical model with low-level trophic dynamics that account for eutrophication



Effects of bivalves on dissolved oxygen can be addressed with a model that addresses processes in the dashed box

Applications include Tracadie Bay, Prince Edward Island, Canada (Cranford et al. 2008) and SWEM Long Island Sound (Miller and Wands, 2009). This approach could potentially be integrated into existing water quality models for Puget Sound.

6. Bioenergetics model with full trophic dynamics



Estimates of many of these quantities are not readily available for Puget Sound

Approach has been used in Chesapeake Bay, but may only be justified where high-level trophic dynamics (e.g., those involving fish) represent large nutrient fluxes (Fulford et al. 2010)

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Summary

Bivalves influence nutrient dynamics and water quality in estuaries.

In general, their influence depends on the magnitude of clearance rates (filter feeding) relative to tidal flushing and phytoplankton production.

Specific effects depend on spatial patterns, seasonal dynamics, biogeochemical processes, and trophic interactions.

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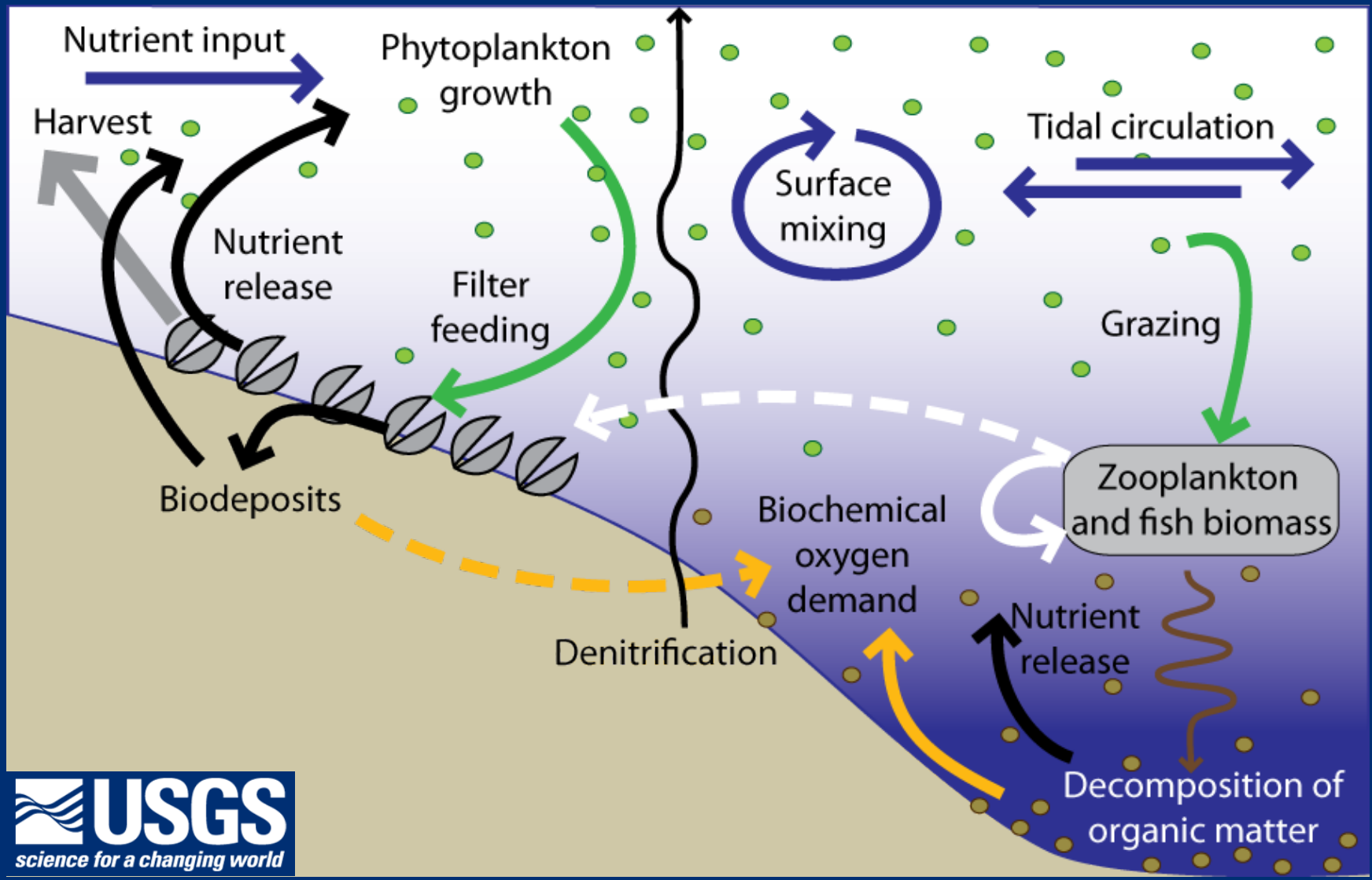
Questions?


Nutrient input
Harvest
Phytoplankton growth
Nutrient release
Filter feeding
Surface mixing
Tidal circulation
Grazing
Biodeposits
Zooplankton and fish biomass
Biochemical oxygen demand
Nutrient release
Denitrification
Decomposition of organic matter
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