Environmental Hydrodynamics in Lakes and Reservoirs

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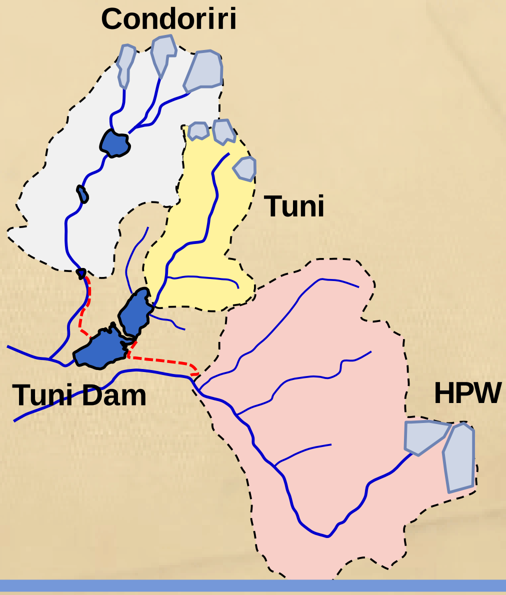
Introduction

For the group of Water Quality,

Tuni Reservoir = one of Main Research Objects

Tuni Reservoir

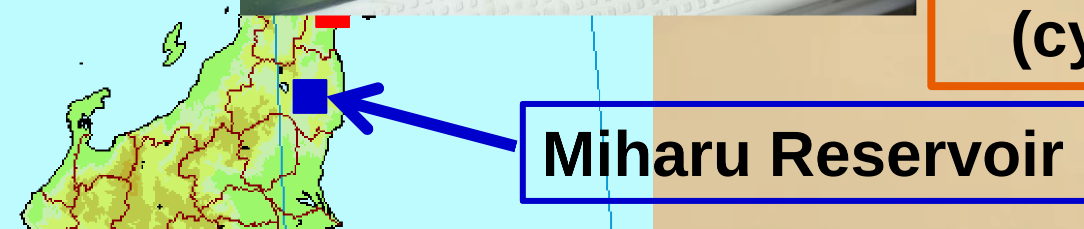
Basin of Tuni Reservoir



Today's Presentation:

Basic Methods from our previous studies in Lakes and Reservoirs.

Measurements in Miharu Reservoir



General Information

Catchment: 226.4 km^2

Capacity: 4.2$\times$10^6 m^3

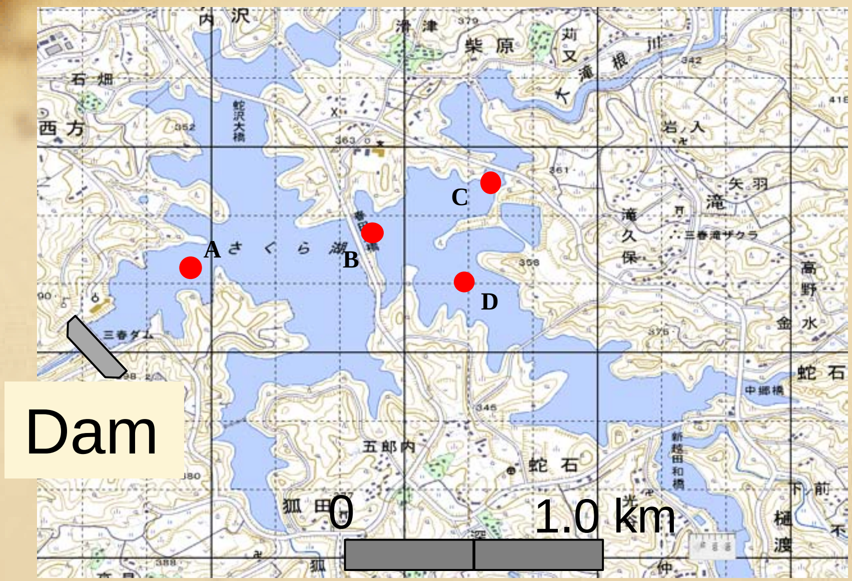
Purpose: Flood control,
Water supply,
Industrial water,
Irrigation, Power generation

Eutrophication Problems

Water Bloom, every summer
(cyanobacteria)

Field Measurements in a Reservoir

Plan view of Miharu



What we measure:

a) Stratification

Thermal stratification,
Vertical distribution of WQ

b) Temporal change of WQ

water temperature,
DO, Chlorophyll-a, etc.

c) Deposition flux

Including Sediment,
Detritus, etc.

Field Measurements in a Reservoir

How we measure:

a) Stratification (Vertical distribution)

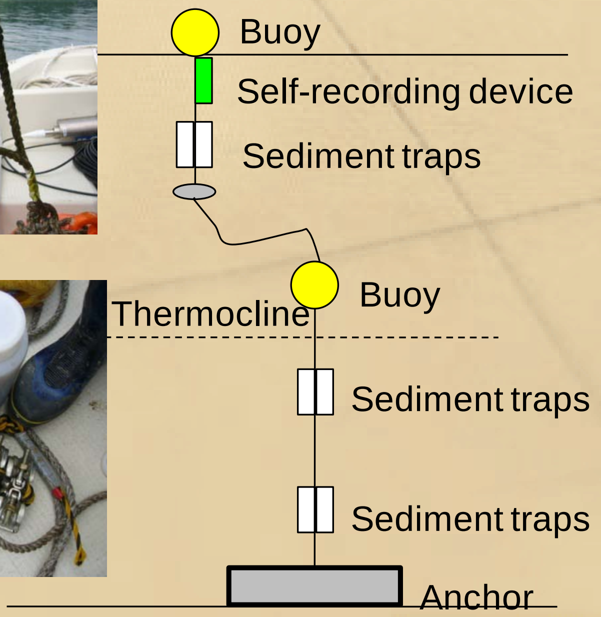
Hanging and sinking sensors from a boat.

b) Temporal change of WQ

Deploying self-recording devices on ropes with floats

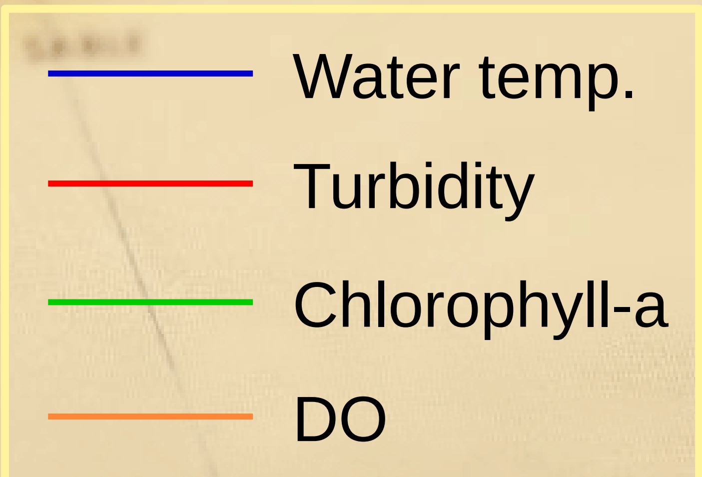
c) Deposition flux

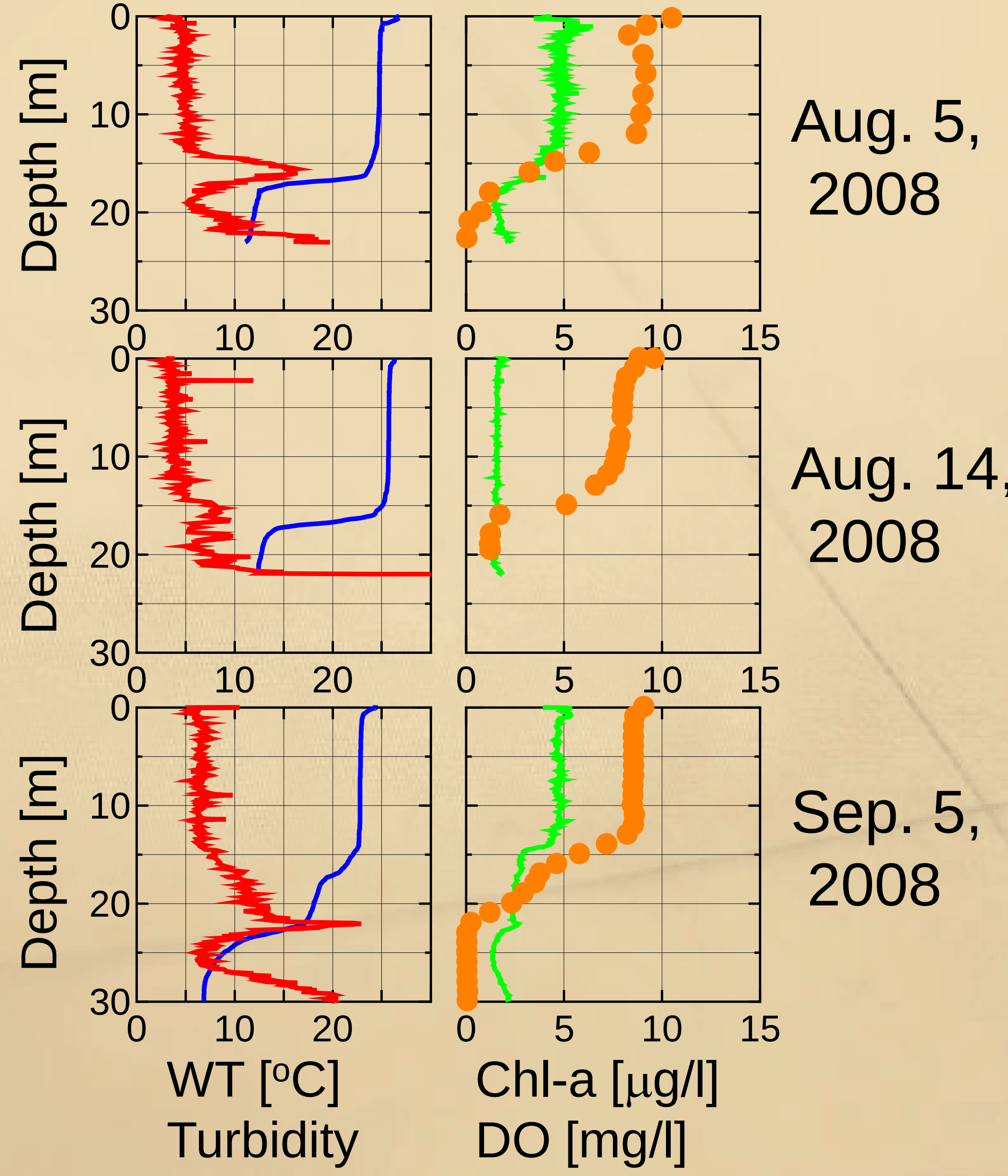
Using sediment traps deployed



Examples of Results - In Miharu Reservoir-

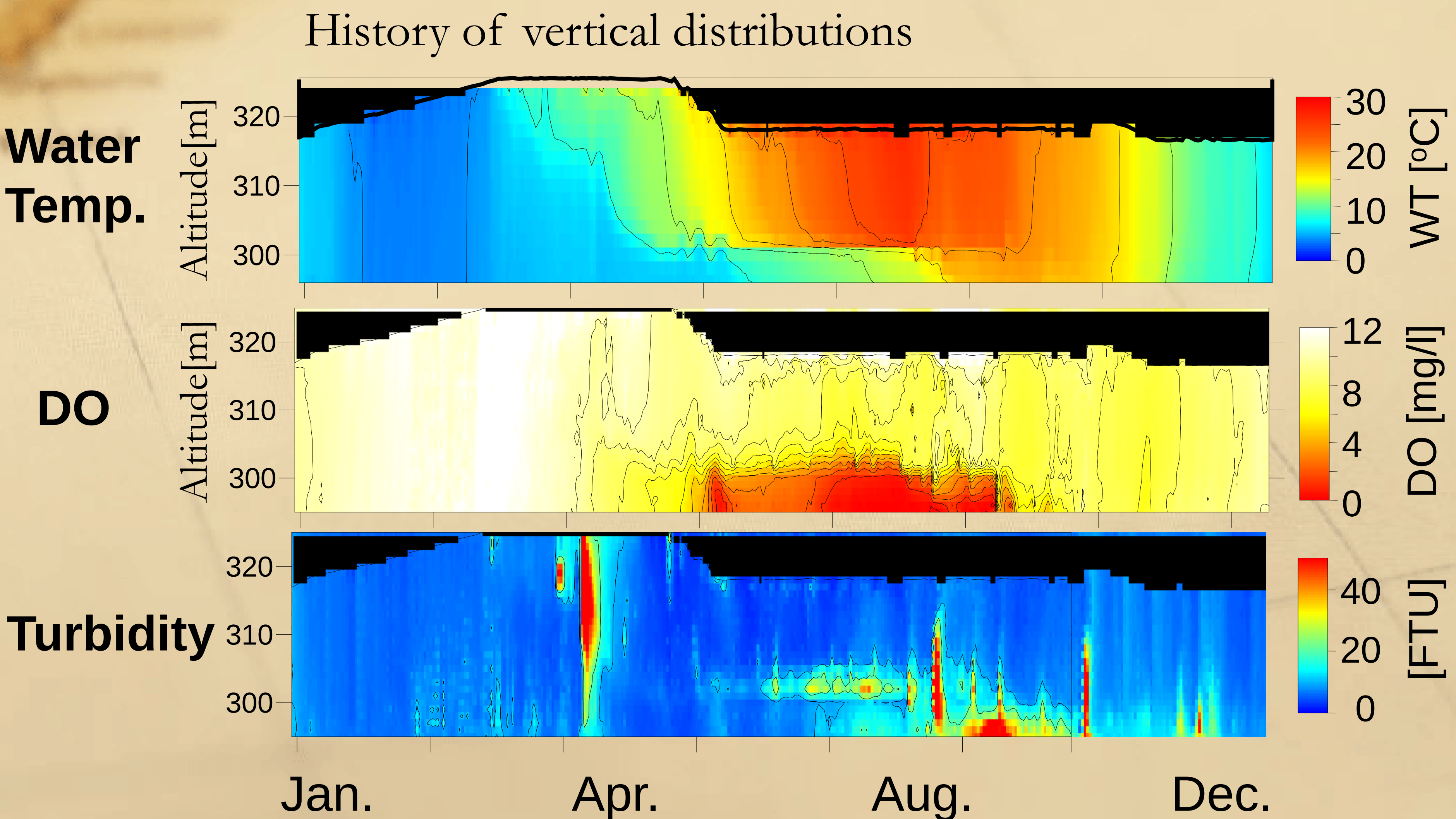
a) Stratification
(Vertical distribution)





b) Temporal change of WQ

(Measurement by the Dam Office, MLIT)



Hydraulic Numerical Modeling

Solvers are selected depending on requirements:

Spatial Resolution

- **1-dimensional (vertical)** → Simple, but sometimes gives more realistic solution than higher dimension analysis
- **2-dimensional (vertical)**
- **3-dimensional**

Variables

- **Water temperature**
- **Turbidity**
- **Salinity**

} related to density structure.

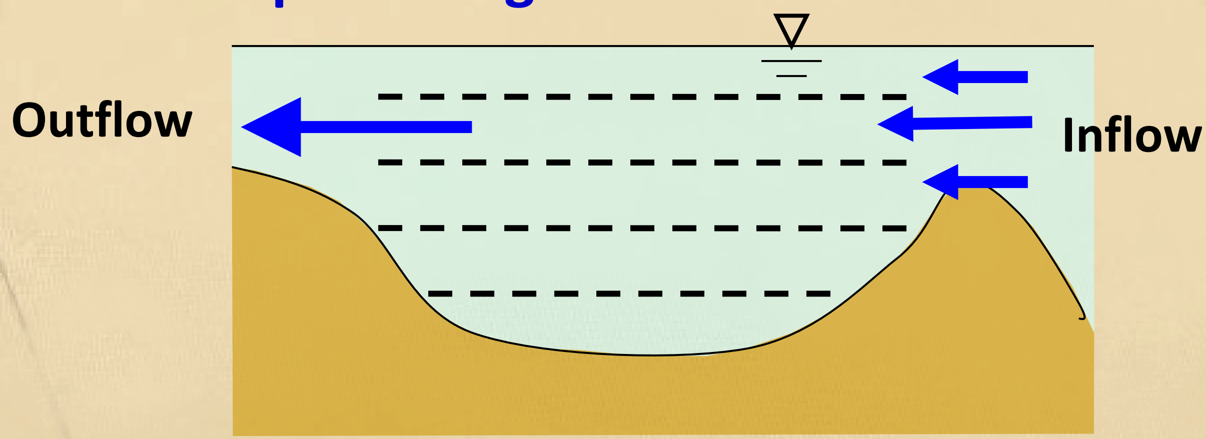
- **Chlorophyll-a (phytoplankton)**
- **Nutrients (Phosphorus, Nitrogen)**
- **Dissolved Oxygen**

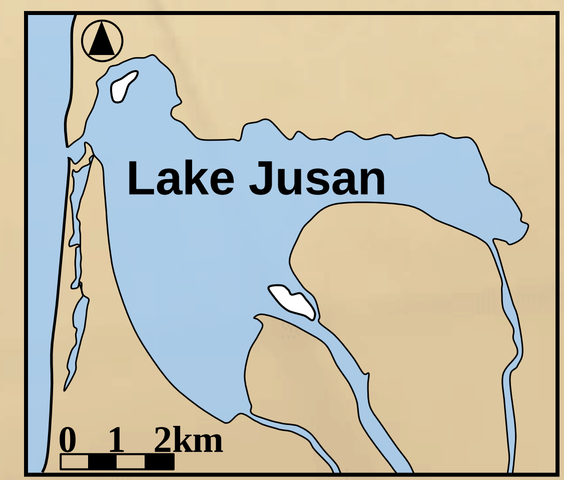
} related to eutrophication.

Example of Computation

Vertical 1-D Modeling in a coastal lagoon

Conceptual diaguram of Vertical 1-D Model





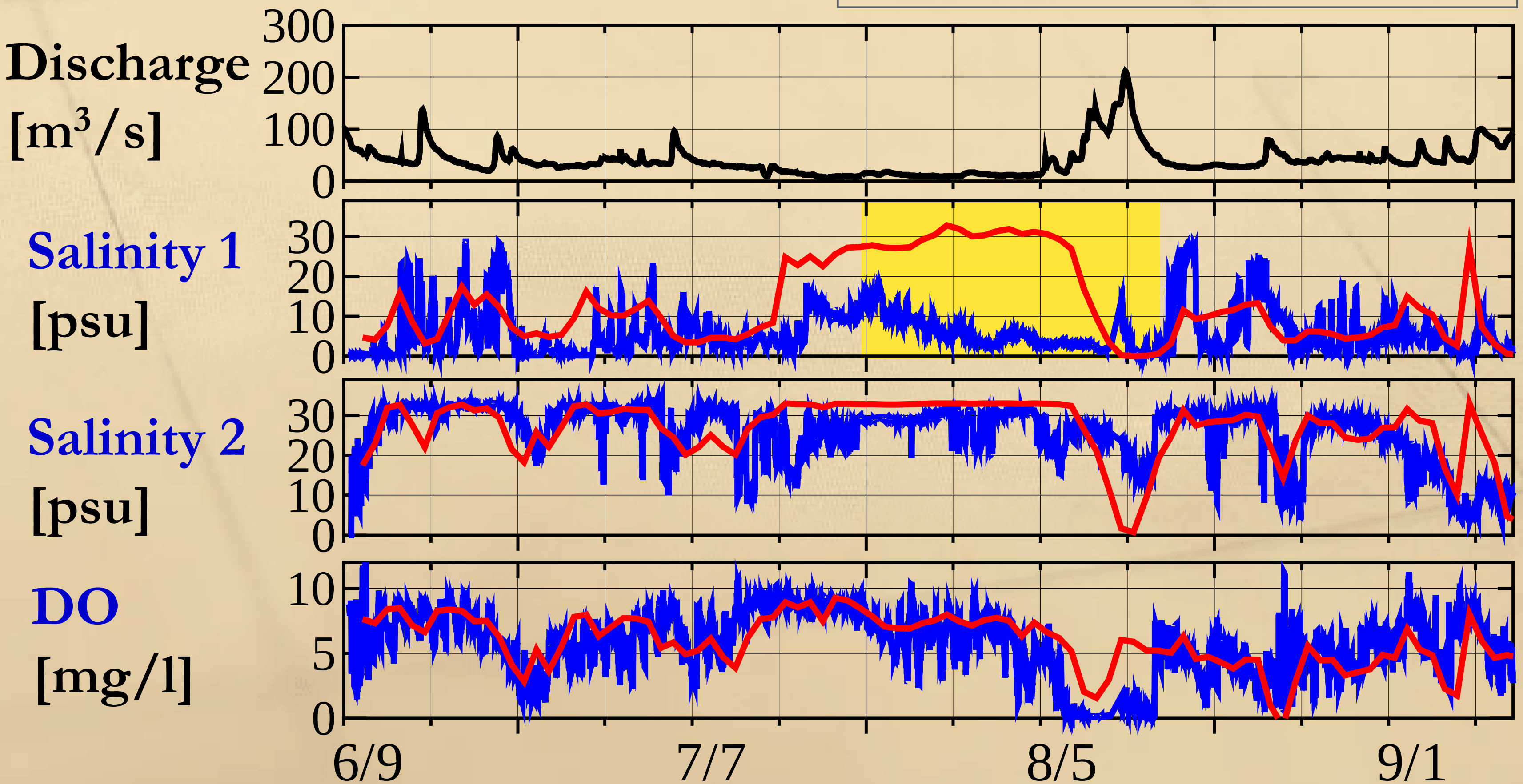
Famous for product of shelfish

Lake Jusan:

Results: Validation of Time Series

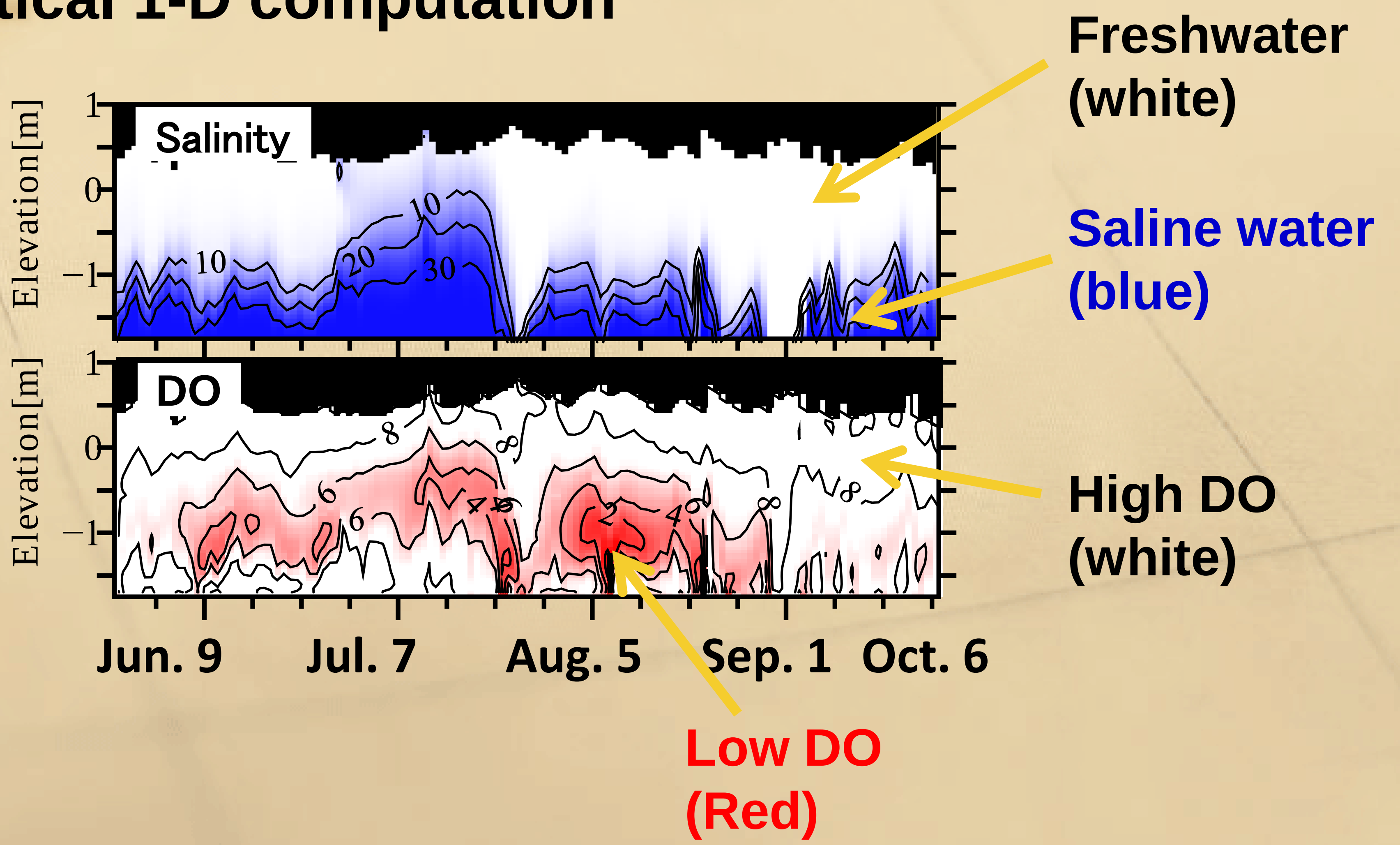
Vertical 1-D computation

Blue line: Measurement
Red line: Computation



Results: History of Vertical Structure

Vertical 1-D computation



Numerical Modeling

Solvers are selected depending on requirements:

Spatial Resolution

- **1-dimensional (vertical)**
- **2-dimensional (vertical)** → Most often used in practical works
- **3-dimensional**

Variables

- **Water temperature**
- **Turbidity**
- **Salinity**

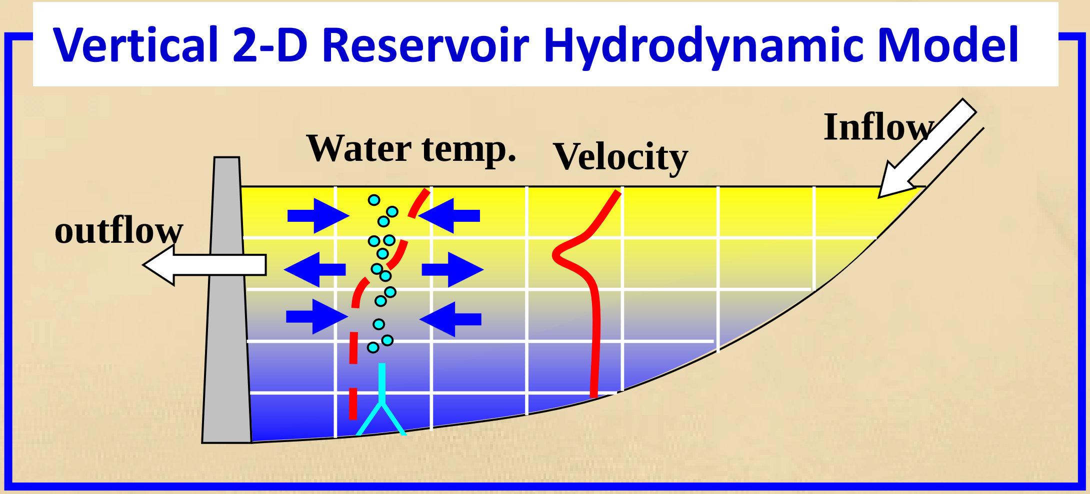
} related to density structure.

- **Chlorophyll-a (phytoplankton)**
- **Nutrients (Phosphorus, Nitrogen)**
- **Dissolved Oxygen**

} related to eutrophication.

Method of 2-D analysis

The most typical modeling for reservoirs.



Governing Equations

- **Momentum Eq.**
- **Continuity Eqs**
- **Transport Eqs of scalars**
- **K-ε turbulence model Eqs**

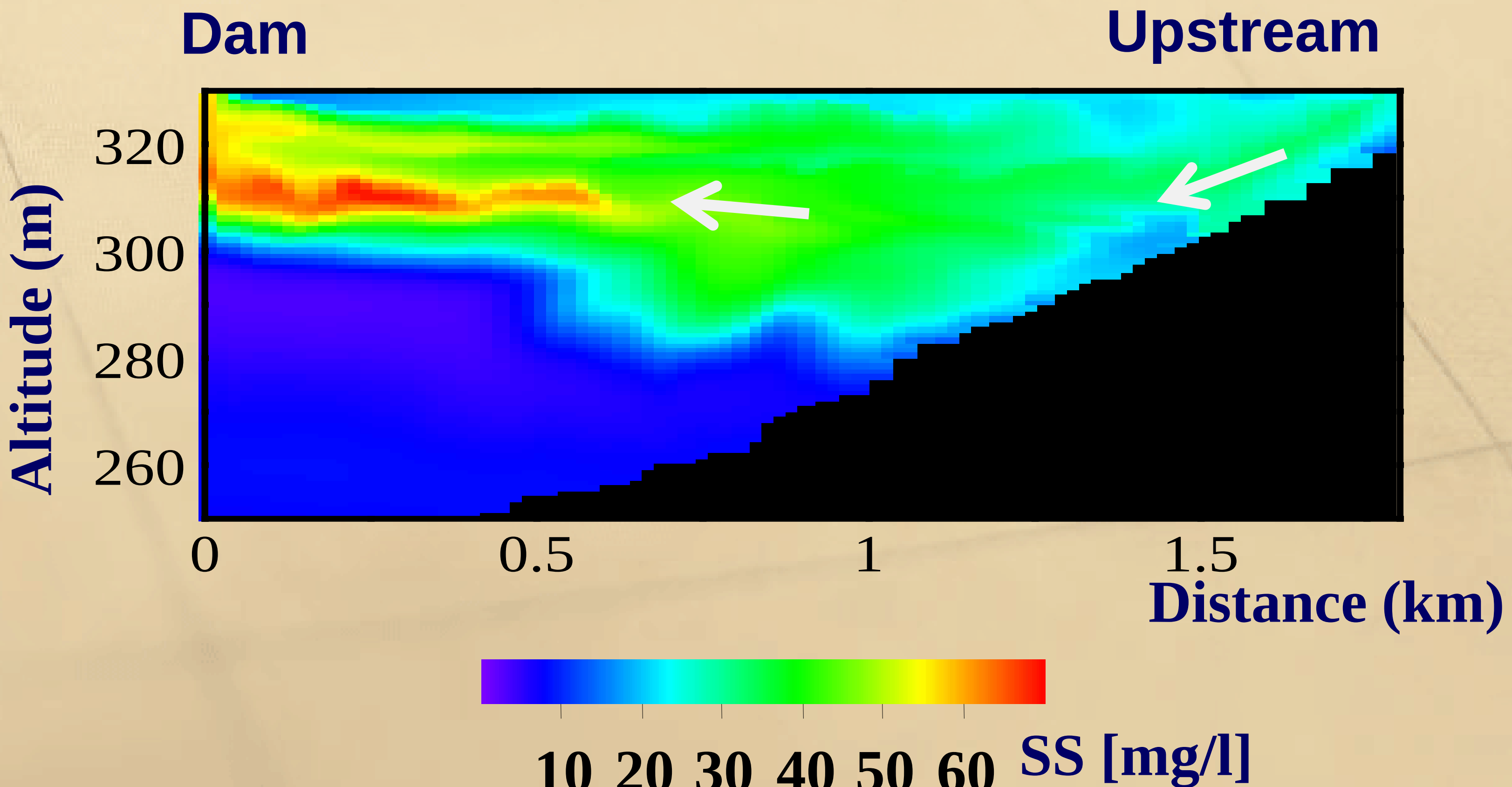
$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}=-\frac{1}{\rho}\frac{\partial p}{\partial x}+\frac{1}{B}\left[\frac{\partial}{\partial x}\left(\nu_L B\frac{\partial u}{\partial x}\right)\frac{\partial}{\partial z}\left(\nu_{eff} B\frac{\partial u}{\partial z}\right)\right]$$

$$\frac{\partial}{\partial x}(uB)+\frac{\partial}{\partial z}(wB)=0$$, etc..

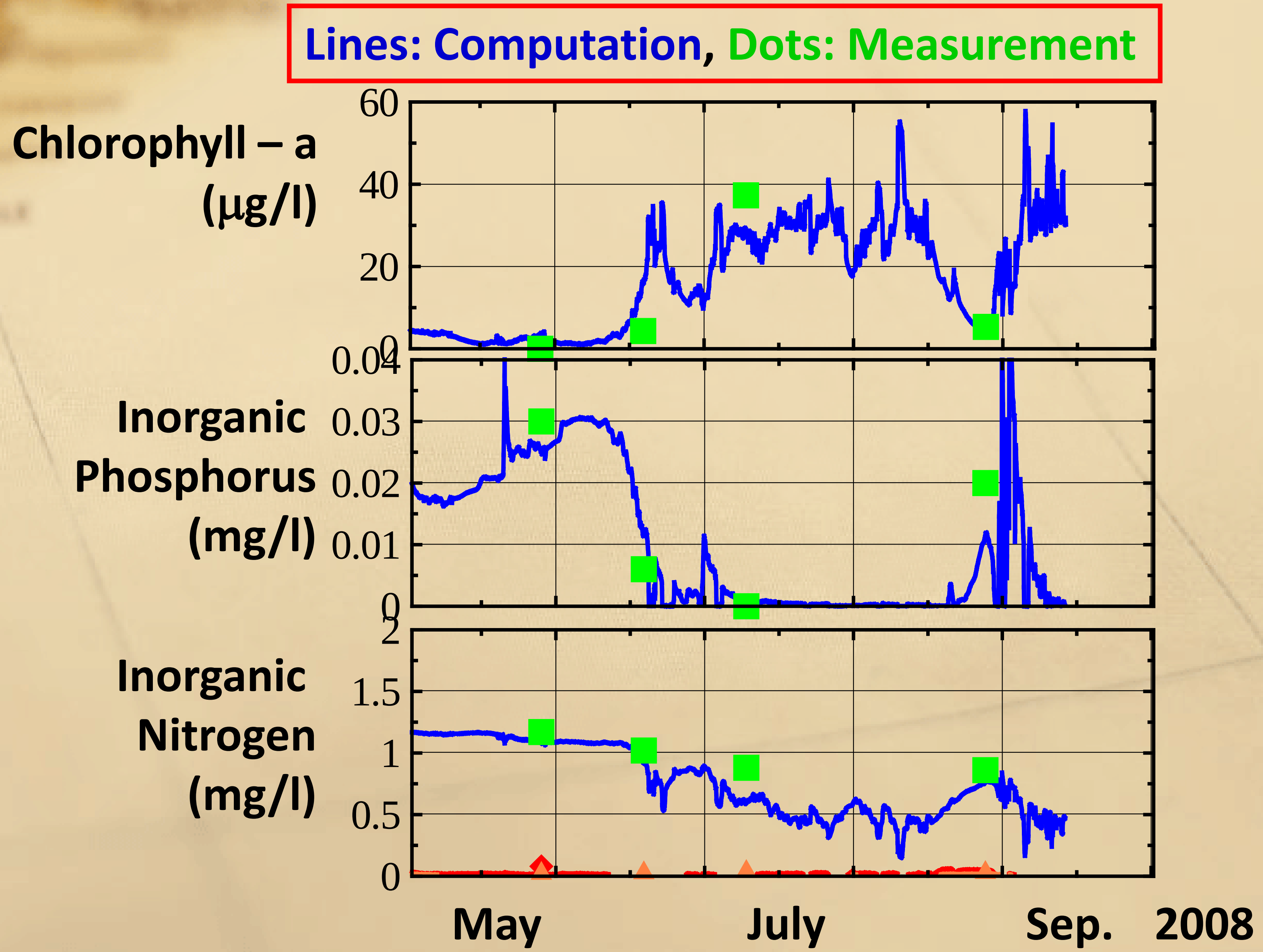
Including the bathymetry effect of breadth B.

Longitudinal & Vertical Distribution of Suspended Sediment

From an Investigation of High Turbidity Problem Caused by Flood Water Intrusion



Water Quality in Miharu Reservoir



Summary

- Basic research methods for environmental hydraulics in lakes and reservoirs were presented.
- Field measurements in Miharu Reservoir was shown as a typical example.
- Water quality numerical modeling s in a coastal lagoon (case of 1-D) and a reservoir (2-D) were demonstrated.