Lake Water Quality Models - Update

Lake Elsinore and Canyon Lake Nutrient TMDL Task Force

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Lake Simulation Tasks in 2020

Lake Modeling Tasks for 2020-2021

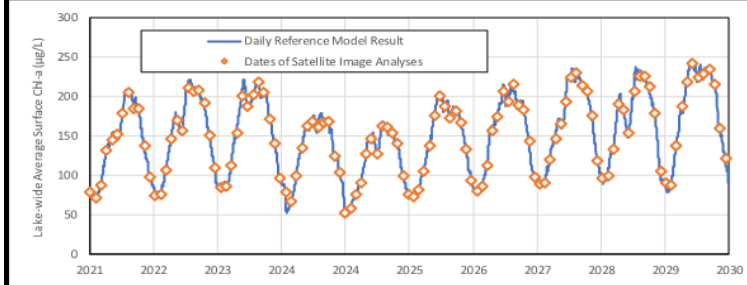
- Migration of sunsetting CAEDYM model, used in TMDL revision science basis for Lake Elsinore and Canyon Lake to new tools
- Extension of the simulation period for scenarios in TMDL revision simulation periods through 2020

Linkage Analysis Simulation Periods	Lake Elsinore	Canyon Lake
TMDL revision	1916 – 2016	2000 – 2016
Current effort	1916 – 2020	2000 – 2020

Why Update Models

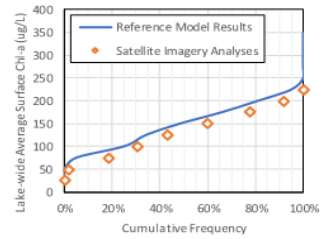
- Use of linkage analysis models included as one approach to demonstration compliance in revised TMDL
- Show that measured concentrations for response targets are better than modeled conditions for actual hydrology (gauged inflows extending beyond 2016) with reference watershed nutrient concentrations

Step 1. Run lake water quality model for preceding ten year period, output daily lakewide average surface chlorophyll-a concentration
Step 2. Compile satellite imagery analysis data for lakewide average surface chlorophyll-a
Step 3. Extract model results for dates when satellite imagery analysis was conducted



Step 4. Plot 120 paired results of lake-wide average surface chl-a as CDFs

Interval (ug/L chl-a)	Sateliite Image Data		Reference Condition Model	
	Frequency of Occurrence	CDF	Frequency of Occurrence	CDF
25	0	0	0	0
50	2	2%	0	0%
75	20	18%	6	5%
100	15	31%	24	25%
125	15	43%	11	34%
150	20	60%	17	48%
175	21	78%	21	66%
200	17	92%	18	81%
225	10	100%	17	95%
250	0	100%	6	100%
275	0	100%	0	100%
300	0	100%	0	100%
325	0	100%	0	100%
350	0	100%	0	100%



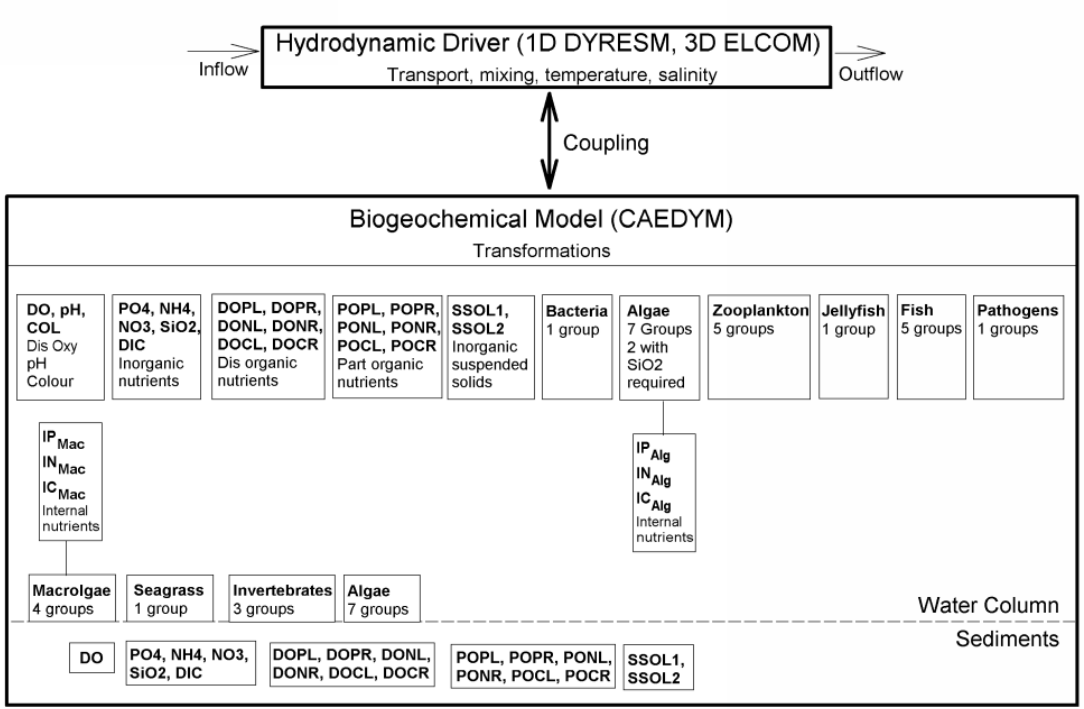
Compliance √

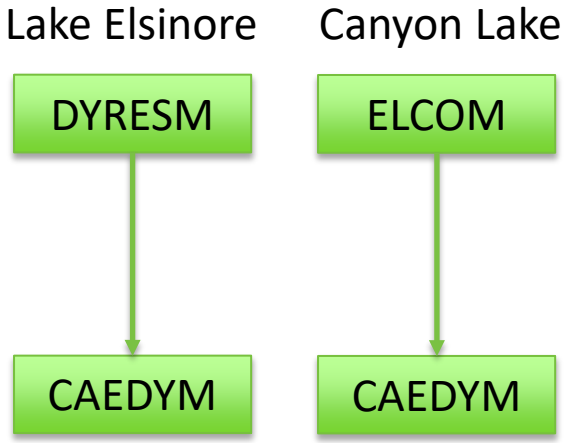
Why Update Models

- Support ongoing BPA adoption process, future regulatory changes, Task Force science questions
- Support future evaluations of in-lake water quality controls
  - Effectiveness of ongoing operation of existing controls
  - Evaluation of alternatives to retrofit existing or consider new in-lake controls
- Michael Anderson retirement, sunsetting of CAEDYM

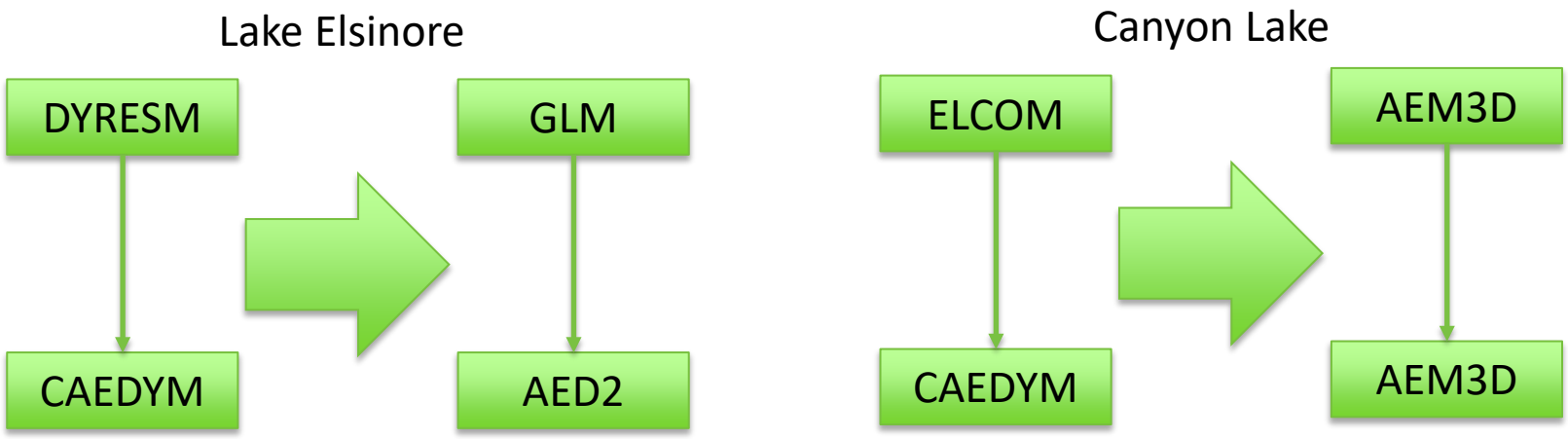
Old and New Model Platforms

CAEDYM-DYRESM Configuration



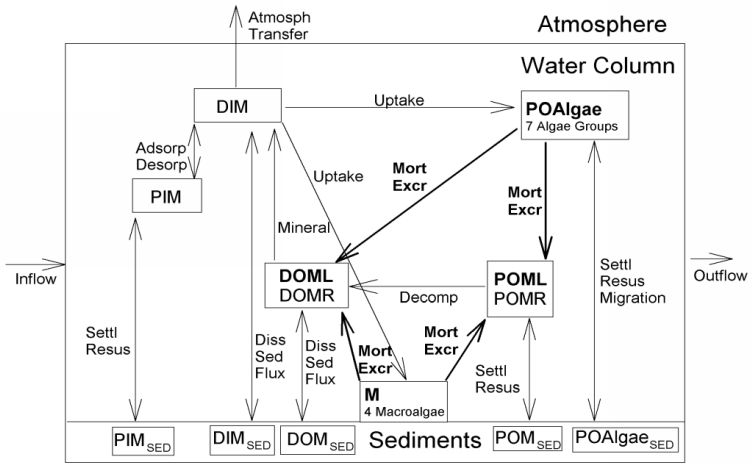


Updating the models



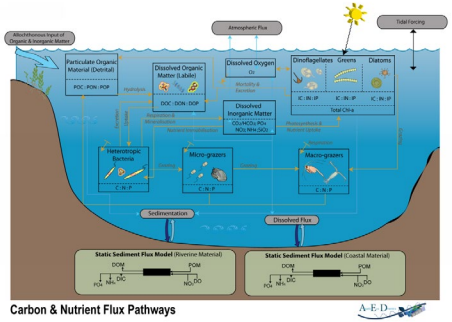
Three WQ Models

CAEDYM



Very similar
Some updates

AED2



Almost the same

AEM3D

Model Update Process

Mapping Modeled Processes and Parameters

- Documenting
  - Parameters
  - Options
- Examples
  - Light penetration
  - Temperature dependence
  - Salinity dependence
  - Zooplankton behavior
  - Phytoplankton speciation

- Setup Differences in AED2
  - Files arranges differently
  - Porting all settings/parameters over to AED2
  - *So far no differences in equations found*

AED2 Setup

- Modular
  - Tracers
  - Oxygen
  - Inorganic nutrients
  - Organic Matter
  - Phytoplankton
  - Zooplankton
  - Sediment flux

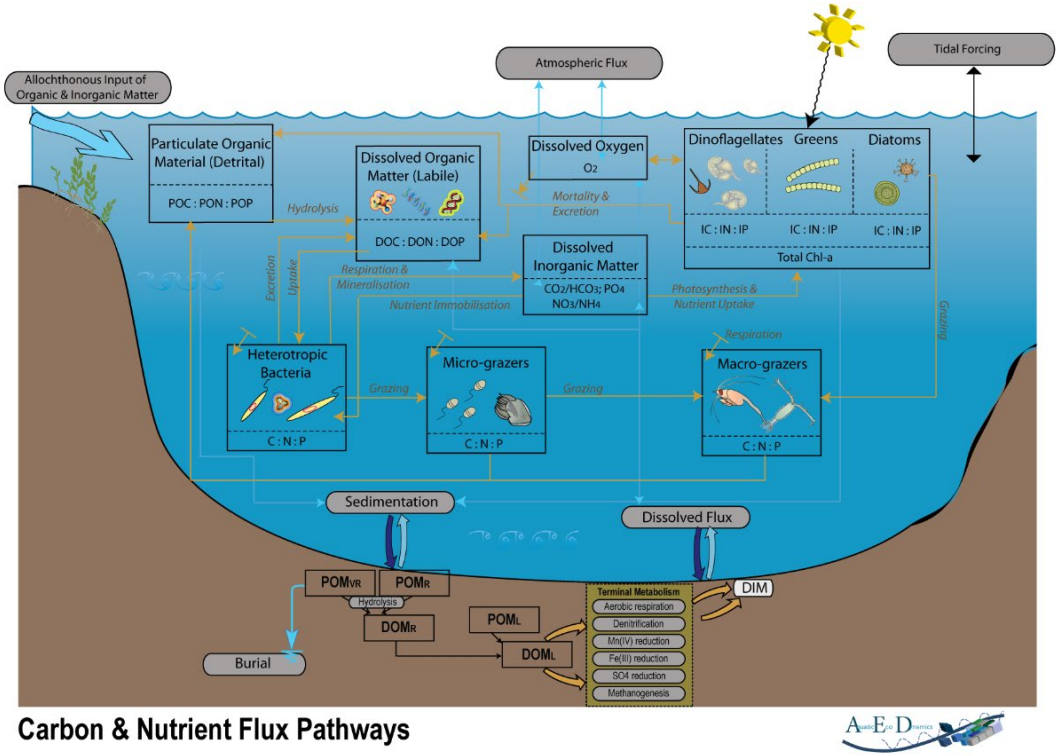
- Confirming that parameters are treated in the same way
  - Units, equations, options
  - Examples:
    - Light penetration
    - Temperature effect on phytoplankton/zooplankton
    - Salt effect on phytoplankton and on zooplankton

Next Steps

- Confirm CAEDYM vs AED2 equations/options
  - In progress
- Document all parameters in existing CAEDYM
  - In progress
- Compare new model results with CAEDYM
- Investigate some calibration parameters
  - Light penetration
  - Algal species, optimum temperature windows

Parameters and other details: extra slides

AED2



Carbon & Nutrient Flux Pathways

Features included in Lake Elsinore CAEDYM

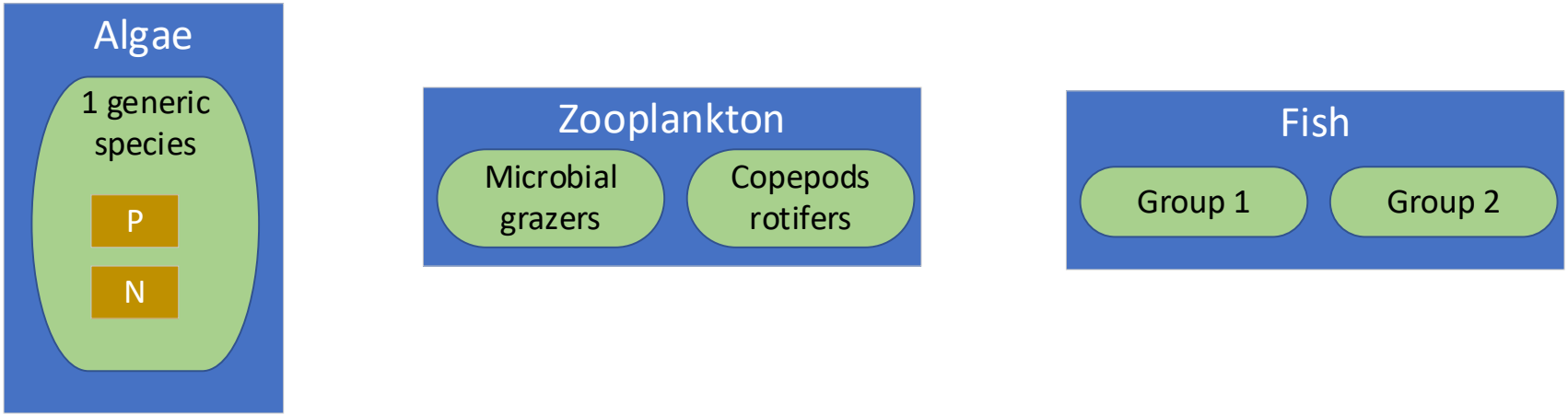
Included

- TSS (2 classes)
- Organic Carbon
- Inorganic Carbon
- Cyanobacteria
- Constant sediment flux
- Nutrients
- Zooplankton (2 species)

Not Included

- Metals
- Refractory Carbon
- pH
- DIC
- Bacteria
- Oceanic biology

Biological components in our CAEDYM Application – and porting into AED2

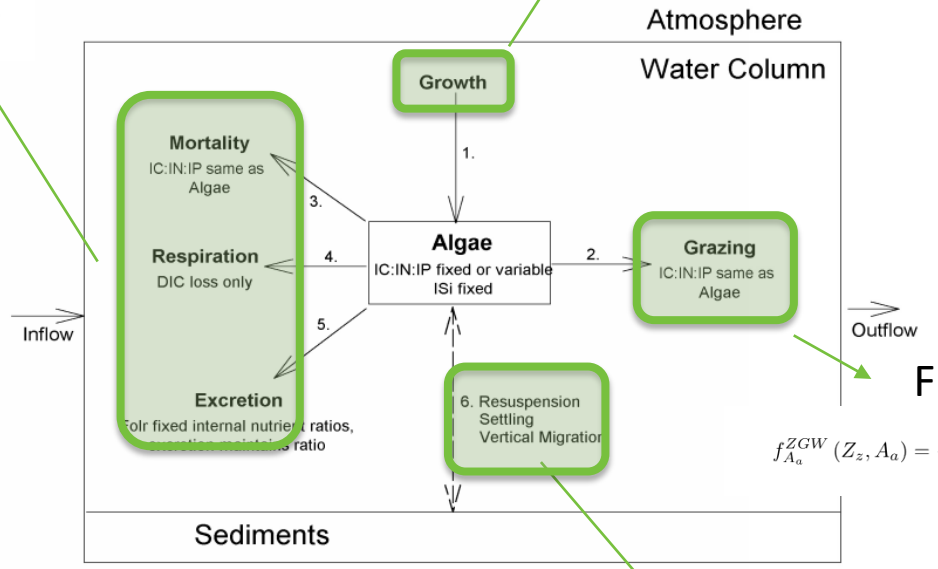


Phytoplankton Treatment in CAEDYM

$$\mu_{g_a} = \mu_{MAX_a} \min\left[f(I)_a^*, f(P)_a, f(Si)_a^{**}, f(C)_a^{***}\right] f_{A_a}^{T1}(T)\left[f_{NF_a} + f(N)_a\left(1 - f_{NF_a}\right)\right]$$

$$L = k_{r_a}\vartheta^{T-20} + k_{rp_a}\mu_{g_a}$$

$$f(S)$$



From zooplankton

$$f_{A_a}^{ZGW}(Z_z, A_a) = \frac{P_{za}\, A_a\, Y_{C:Chla_a}}{\sum_a^{N_A}[P_{za}\, A_a\, Y_{C:Chla_a}] + \sum_k^{N_Z}[P_{zk}\, Z_k] + \sum_d^{N_D}[P_{zd}\, POC_d]}$$

constants

Phytoplankton Settings for Lake Elsinore

- Single algae species
- Constant Settling and Resuspension
- Retain N and P in biomass
- Salinity limitation on respiration
- No photo-inhibition of production

Resuspension

- Constant settling velocity
- Settling velocity = -.230E-06 m/s
- Critical shear stress for resuspension = 0.001 N/m^2
- Resuspension rate = 0.800E-02 mg/m^2/sec
- Half saturation constant for resuspension = 0.010 mg/m^2
- Sediment survival time = 2.000 days

Light impact on growth

- Non-photoinhibited light limitation
- Photosynthesis-irradiance curve parameter = 130.0 uE/m^2/s
- Specific attenuation coefficient = 0.01400 ug Chla/L/m

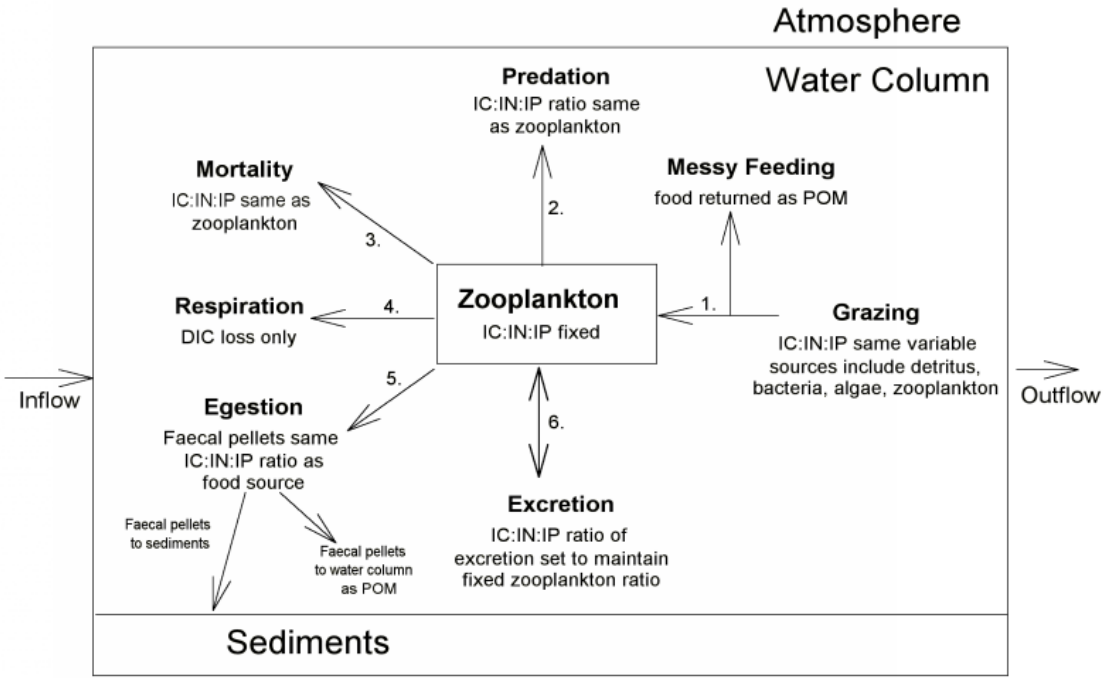
$$
\begin{aligned}
K_d &= K_w \text{(attenuation due to pure water - constant)} \\
&+ \sum_{i}^{nphy} K_{A_i} \text{specific attenuation due to phytoplankton groups} \\
&+ \sum_{b}^{ndom} K_{DOC_b} \text{specific attenuation due to dissolved organic carbon} \\
&+ \sum_{b}^{npom} K_{POC_b} \text{specific attenuation due to particulate organic matter} \\
&+ \sum_{s}^{nsol} K_{SS_s} \text{specific attenuation due to inorganic particles} \\
&+ \sum_{j}^{nmac} K_{M_j} \text{specific attenuation due to macroalgae}
\end{aligned}
$$

Basic Phytoplankton Parameters

- Growth rate = 1.200 /day
- Respiration rate = 0.080 /day
- Fraction of respiration relative to total loss = 0.700
- Temperature multiplier for respiration = 1.030
- Temperature multiplier for growth = 1.060
- Standard temperature = 20.000 deg C
- Optimum temperature = 28.000 deg C
- Maximum temperature = 35.000 deg C

Zooplankton

Representation in CAEDYM



Zooplankton Features

- Grazing = f(Phytoplankton)
  - Constant rate
- Temperature dependent respiration
- Salinity dependence
- DO tolerance limit