Algal Speciation Model and Calibration of Potomac Portion of Chesapeake Bay Water Quality Model

Proposed Algal Groups in Revised Algal Speciation Model

Victor J. Bierman, Jr., Amanda M. Flynn, Scott C. Hinz and Joseph V. DePinto
LimnoTech

Chesapeake Bay Program
Modeling Subcommittee Quarterly Review
Annapolis, MD

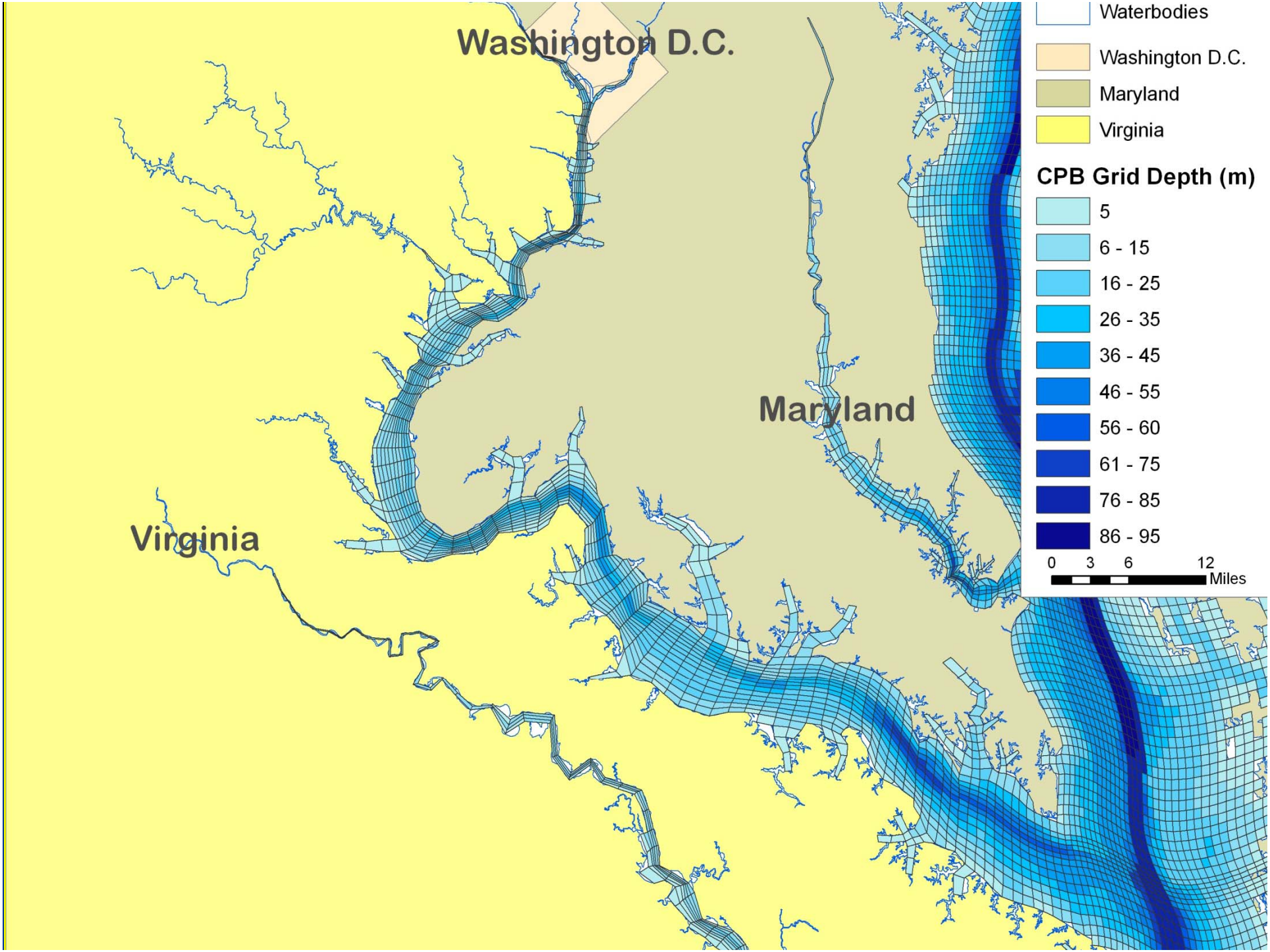
April 29, 2008

Study Objectives

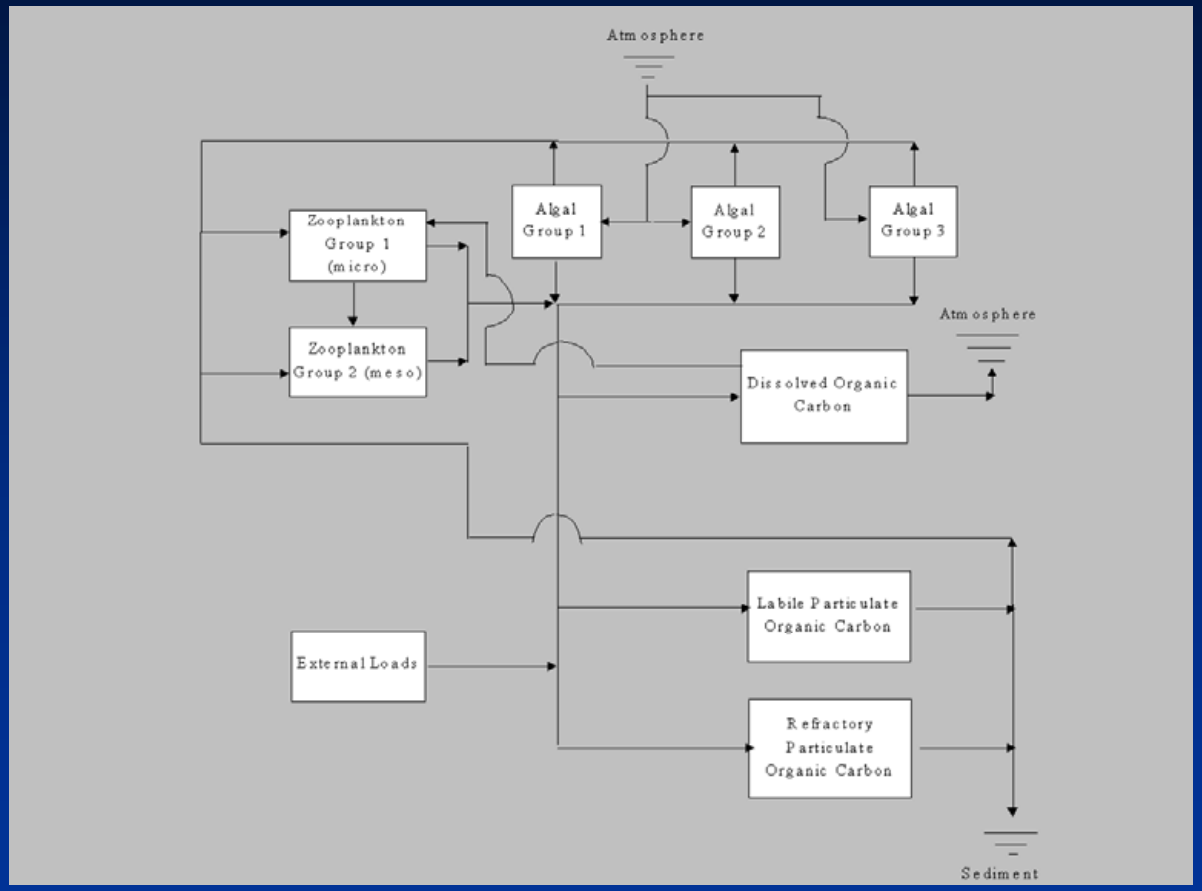
- Refine and improve representation of dominant algal groups in the Potomac
- Calibrate the revised Potomac portion of the 57K Chesapeake Bay Water Quality Model (CBWQM)

Study Tasks

- Literature Review
  - Freshwater and marine phytoplankton species
  - Microcystis
  - Process representation and parameterization
- Data Analysis
  - CBP Living Resource Database
  - Data from 20-year Gunston Cove study (R. Chris Jones)
- Development of New Algal Speciation Sub-Model
  - How many algal groups?
  - How should they be characterized?
- Calibration of Potomac Portion of CBWQM
  - Stand-alone Potomac portion of 57K model
  - Will include revised pH-alkalinity sub-model
  - Period of simulation 1994-2000


Washington D.C.
Maryland
Virginia
Waterbodies
Washington D.C.
Maryland
Virginia
CPB Grid Depth (m)
5
6 - 15
16 - 25
26 - 35
36 - 45
46 - 55
56 - 60
61 - 75
76 - 85
86 - 95
0 3 6 12
Miles

Existing Algal Sub-Model



- Spring diatoms
- Greens
- Cyanobacteria (blue-greens)

Design Considerations

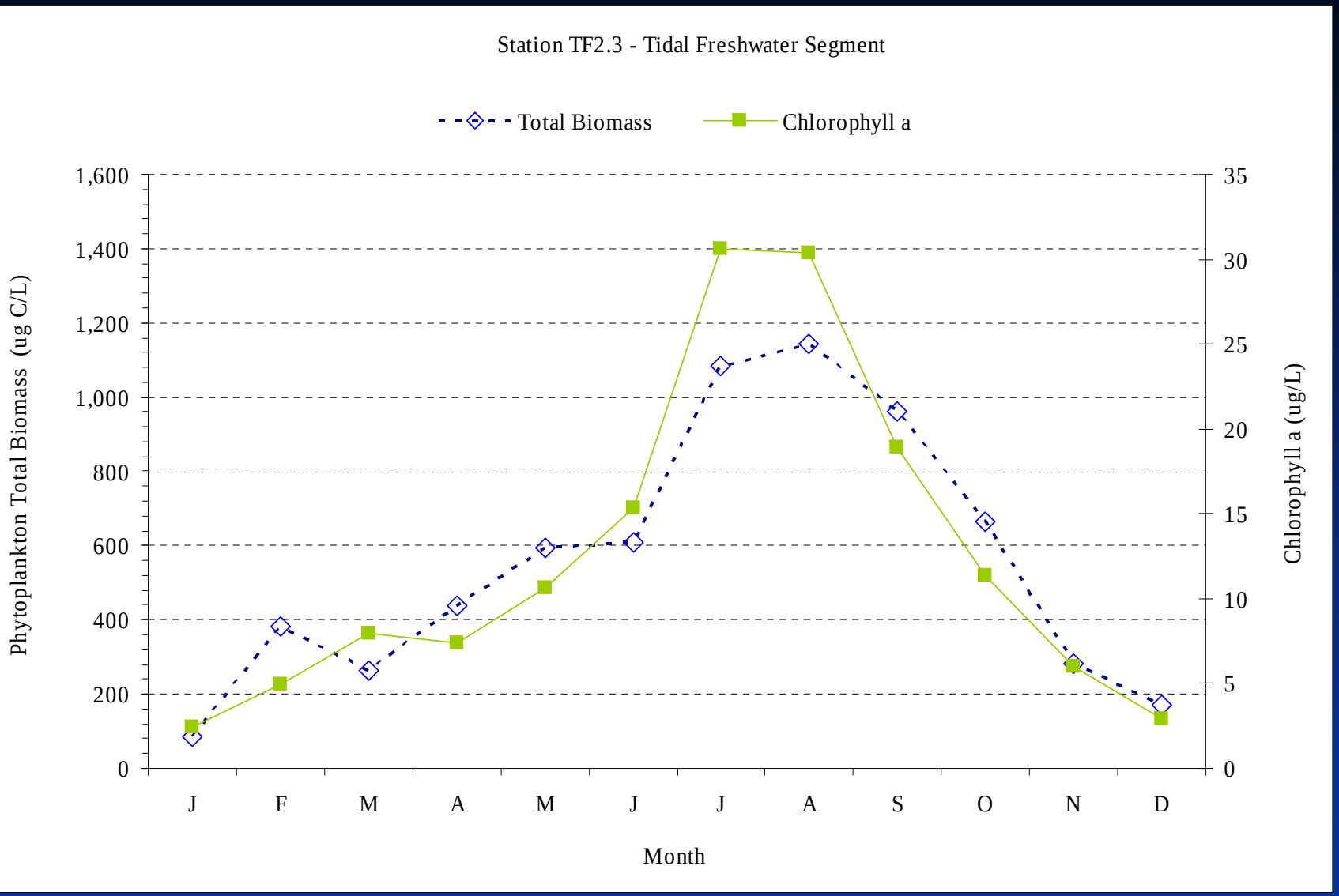
- Nutrient requirements
- Salinity tolerance
- Temperature requirements
- Physiological parameters
  - Growth, death, metabolism, settling, etc.
- Susceptibility to grazing
- Water quality management issues
  - Microcystis blooms
- Model complexity
  - Difficult to model more than five groups
- Mass balance
  - Want to capture $\geq$ 95% of algal biomass

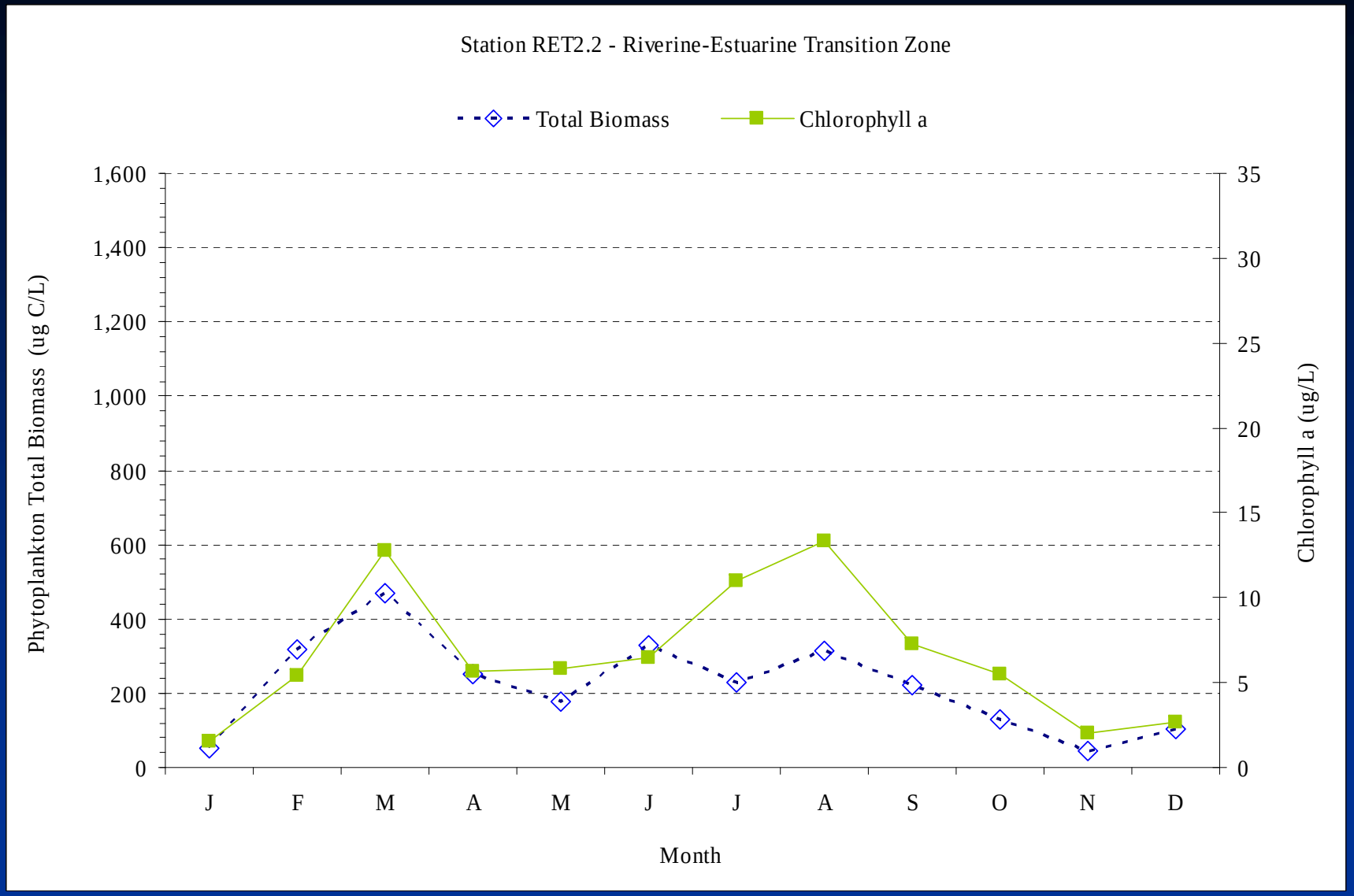
Data Analysis

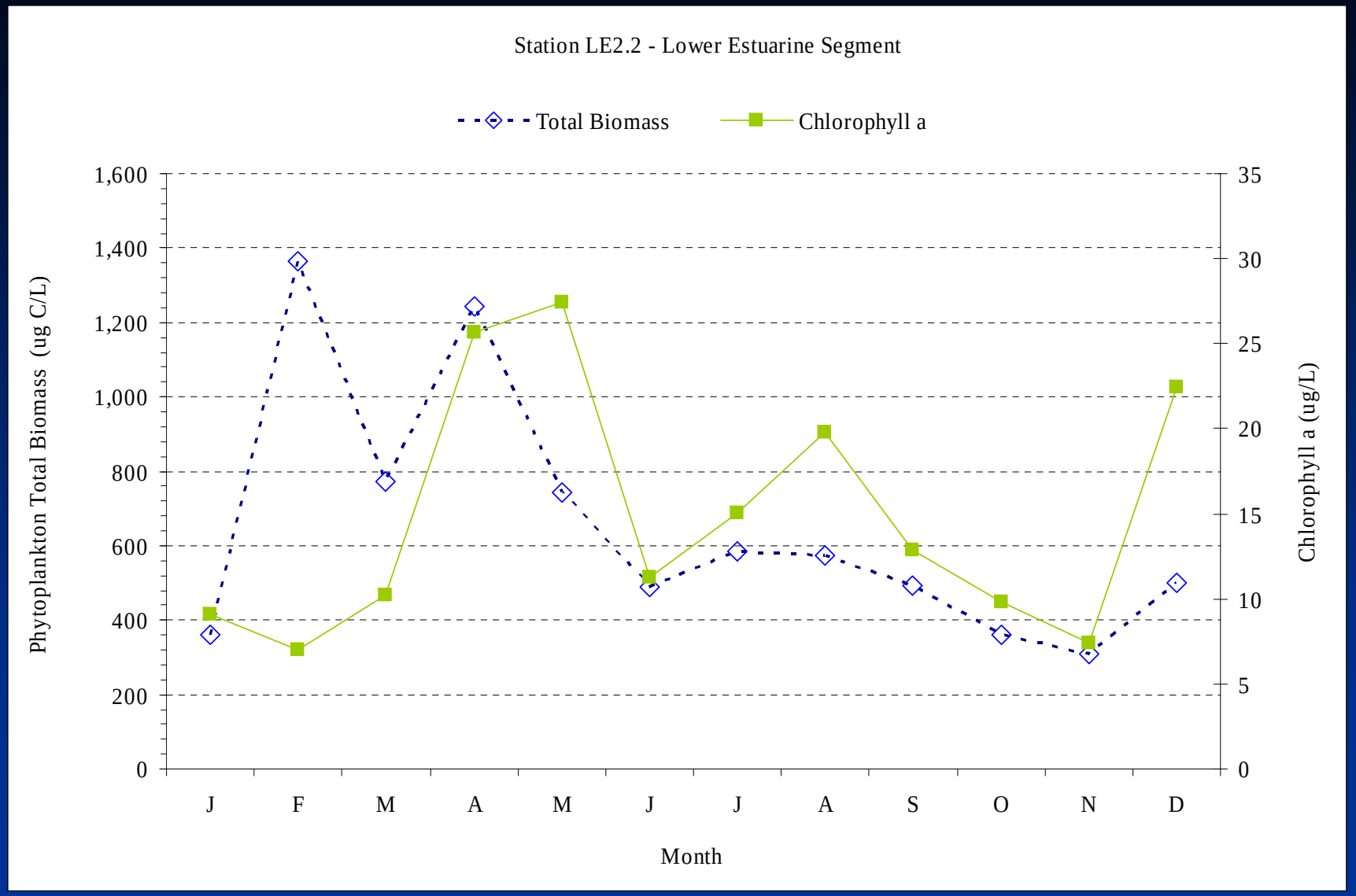
- Source
  - CBP Data Hub, Living Resources Database
- Spatial scale
  - Tidal fresh (TF2.3)
  - River-estuary transition zone (RET2.2)
  - Lower estuary (LE2.2)
- Temporal domain
  - 1984-2006
- Parameters
  - Phytoplankton biomass, abundance, cell size
  - Temperature, salinity, light attenuation, nutrients

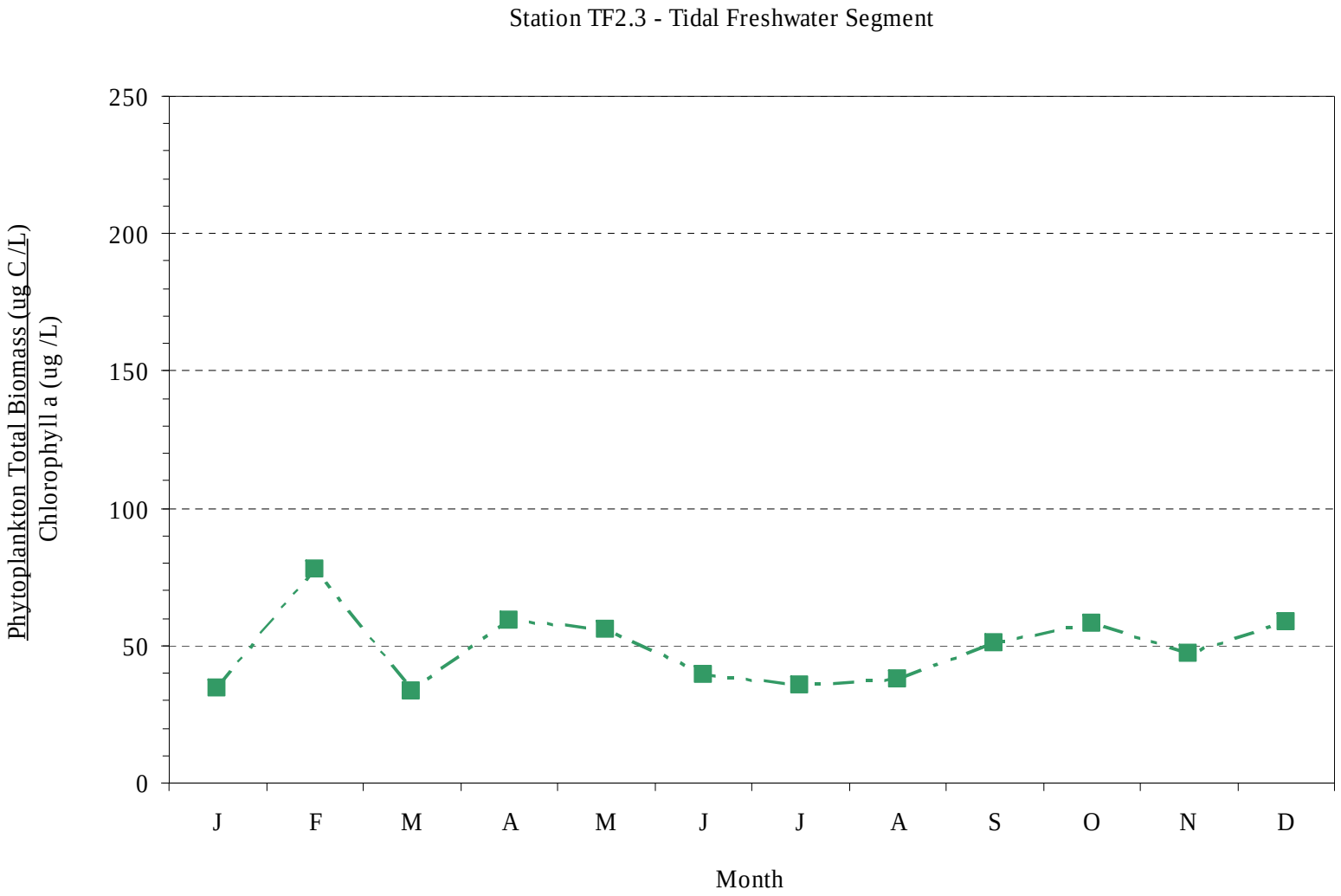
Measures of Total Phytoplankton Concentration

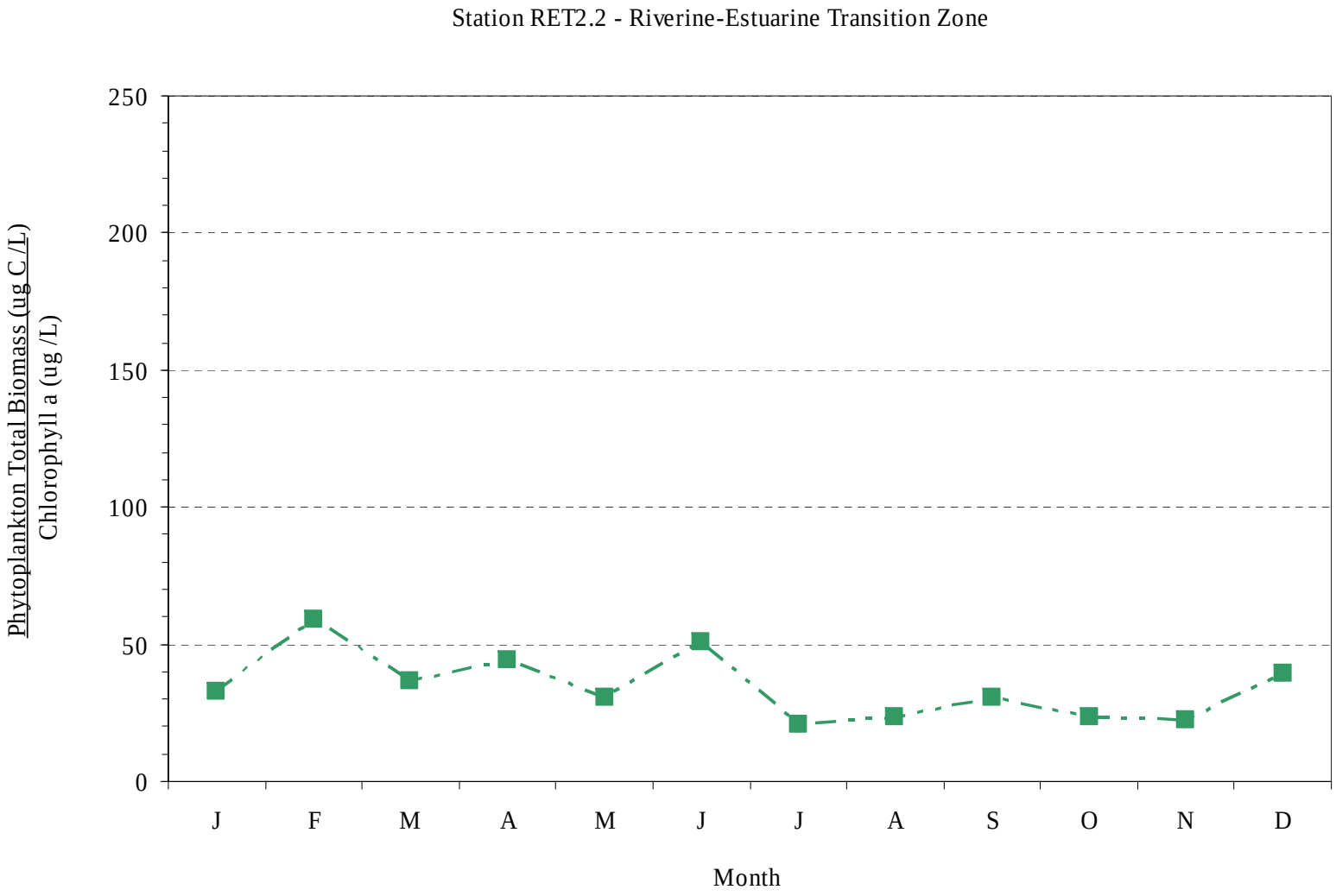
How does total phytoplankton biomass (as carbon) compare with chlorophyll?

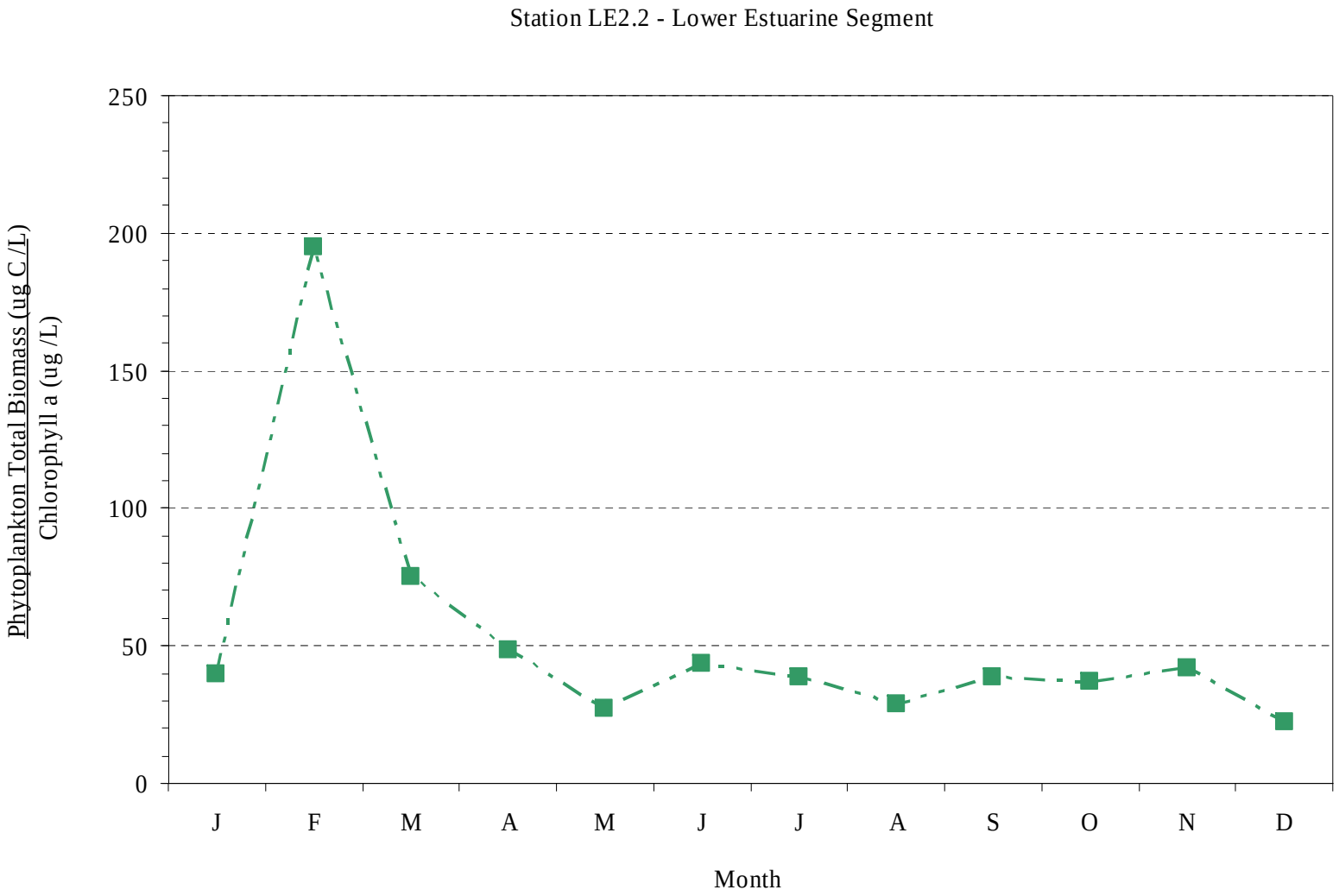

Station TF2.3 - Tidal Freshwater Segment
Total Biomass
Chlorophyll a
Phytoplankton Total Biomass (ug C/L)
Chlorophyll a (ug/L)
1,600
1,400
1,200
1,000
800
600
400
200
0
35
30
25
20
15
10
5
0
J
F
M
A
M
J
J
A
S
O
N
D
Month


Station RET2.2 - Riverine-Estuarine Transition Zone
Total Biomass
Chlorophyll a
Phytoplankton Total Biomass (ug C/L)
Chlorophyll a (ug/L)
1,600
1,400
1,200
1,000
800
600
400
200
0
35
30
25
20
15
10
5
0
J
F
M
A
M
J
J
A
S
O
N
D
Month


Station LE2.2 - Lower Estuarine Segment
Total Biomass
Chlorophyll a
Phytoplankton Total Biomass (ug C/L)
Chlorophyll a (ug/L)
1,600
1,400
1,200
1,000
800
600
400
200
0
35
30
25
20
15
10
5
0
J
F
M
A
M
J
J
A
S
O
N
D
Month


Station TF2.3 - Tidal Freshwater Segment
Phytoplankton Total Biomass (ug C /L)
Chlorophyll a (ug /L)
250
200
150
100
50
0
J
F
M
A
M
J
J
A
S
O
N
D
Month


Station RET2.2 - Riverine-Estuarine Transition Zone
Phytoplankton Total Biomass (ug C /L)
Chlorophyll a (ug /L)
250
200
150
100
50
0
J
F
M
A
M
J
J
A
S
O
N
D
Month


Station LE2.2 - Lower Estuarine Segment
Phytoplankton Total Biomass (ug C /L)
Chlorophyll a (ug /L)
250
200
150
100
50
0
J
F
M
A
M
J
J
A
S
O
N
D
Month

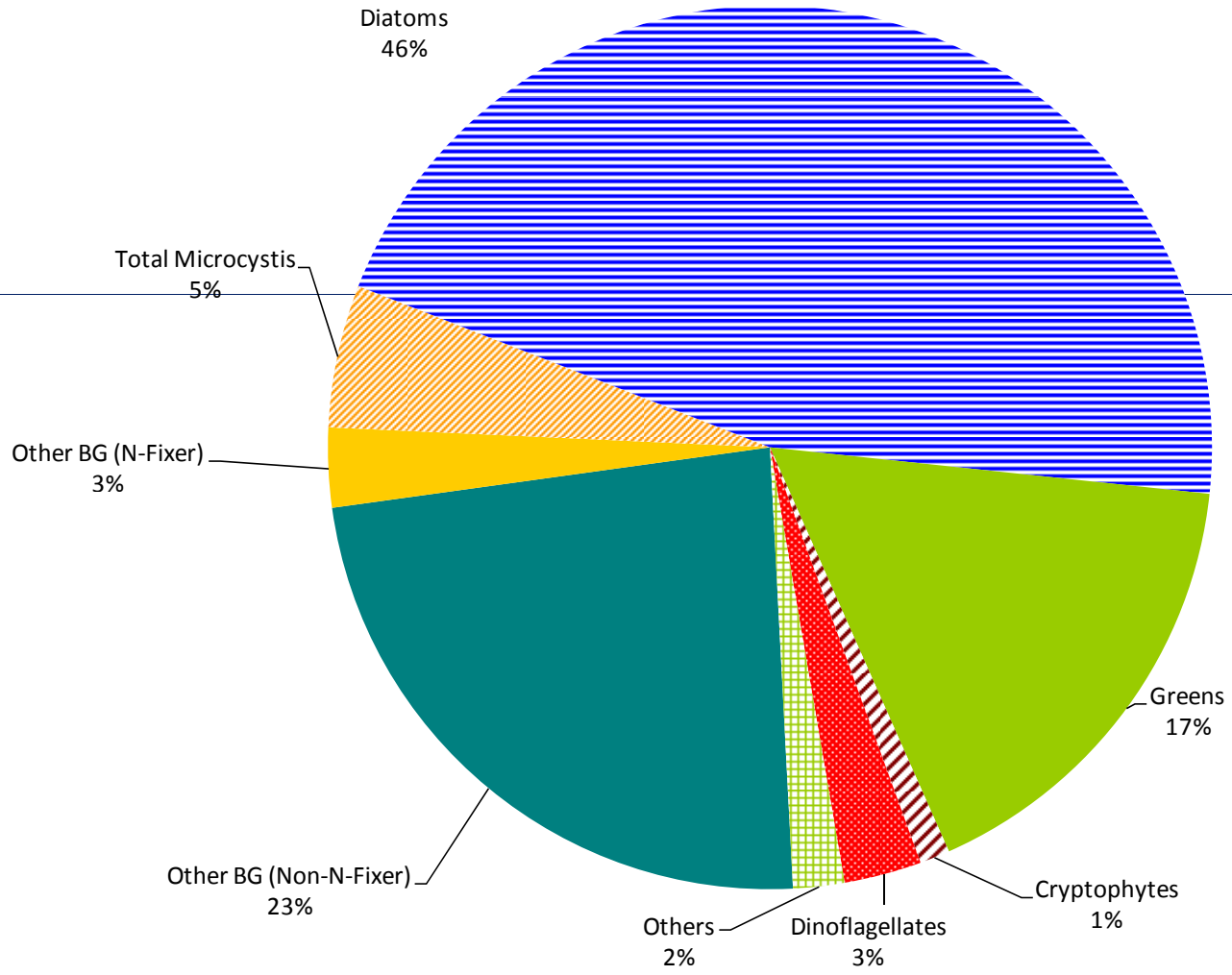
Observations

- Carbon:chlorophyll ratio tends to be higher during winter-spring than summer-fall, especially in RET and LE
- Carbon:chlorophyll ratio during summer-fall is higher in TF than in RET or LE

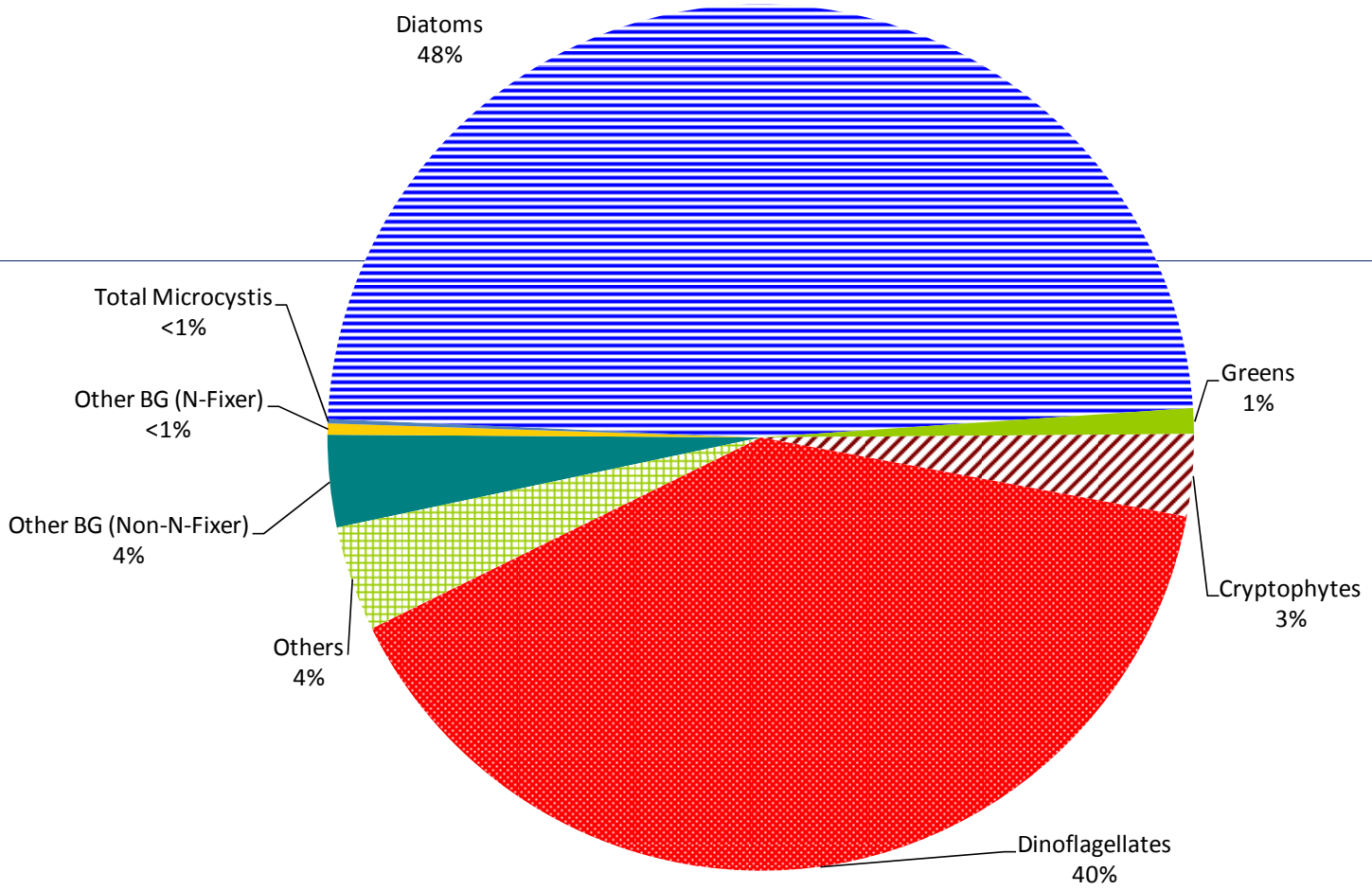
Measures of Phytoplankton Composition

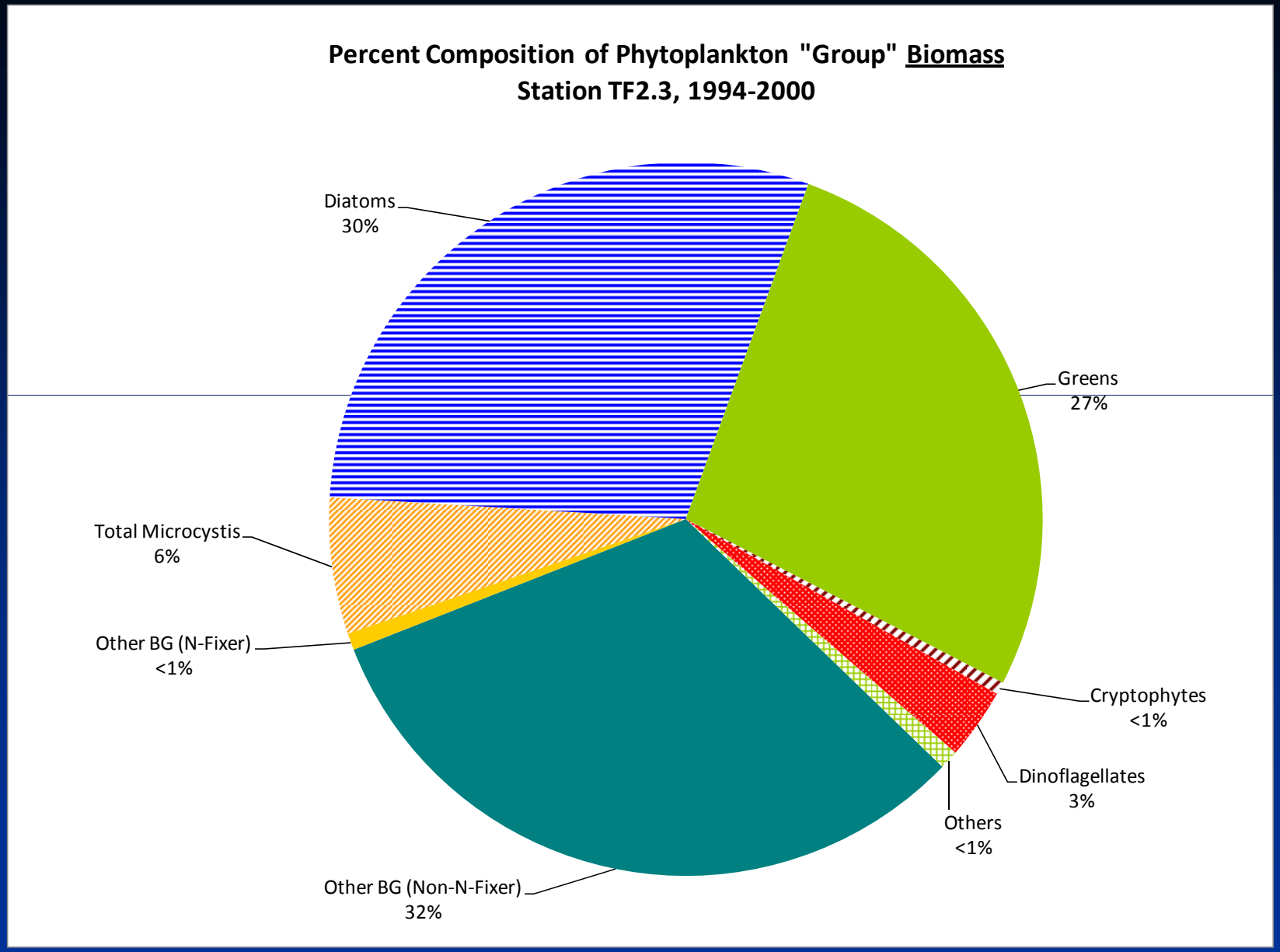
What groups contribute most of the biomass as carbon?

Percent Composition of Phytoplankton "Group" Biomass
Station TF2.3, 1984-2006

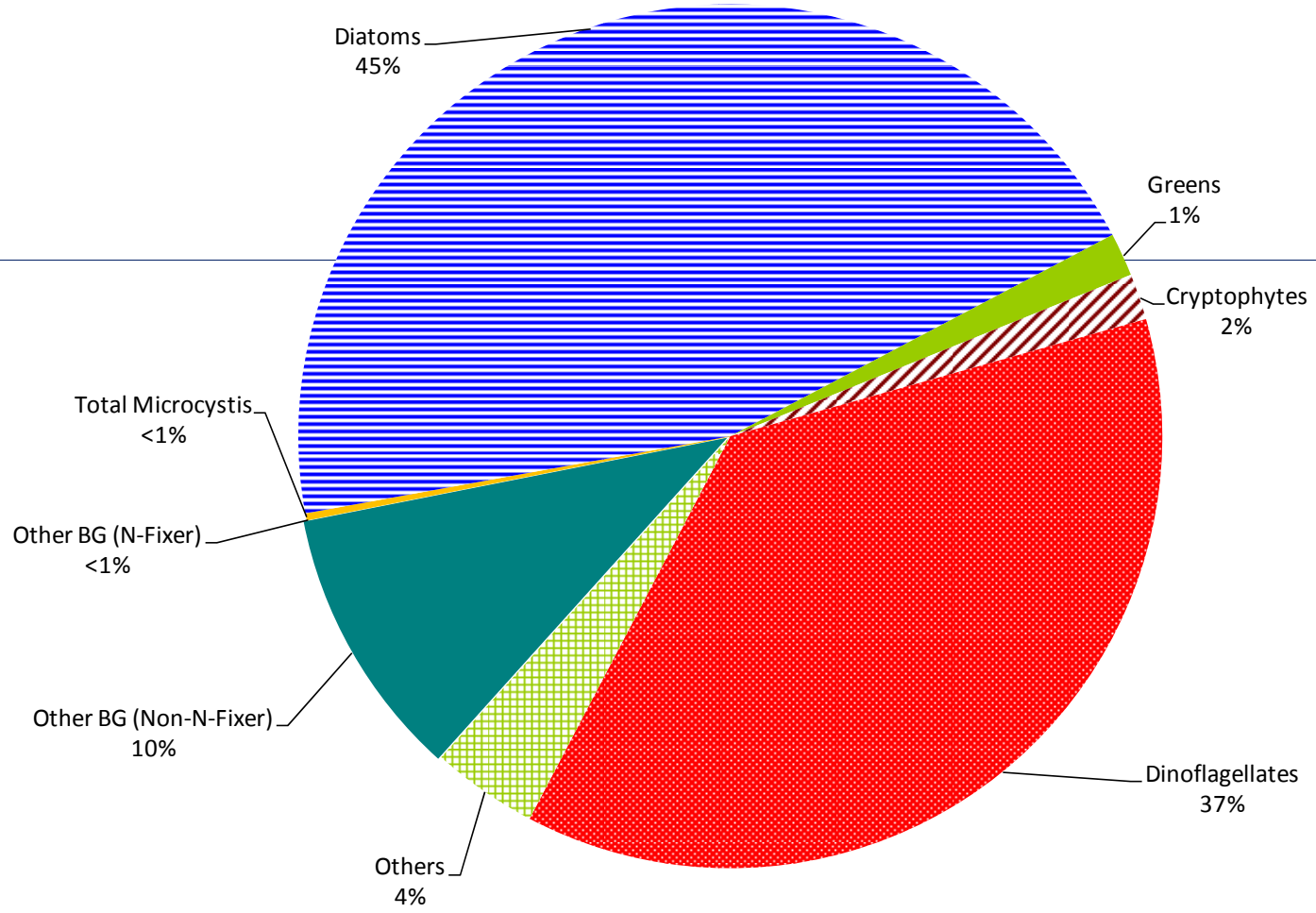


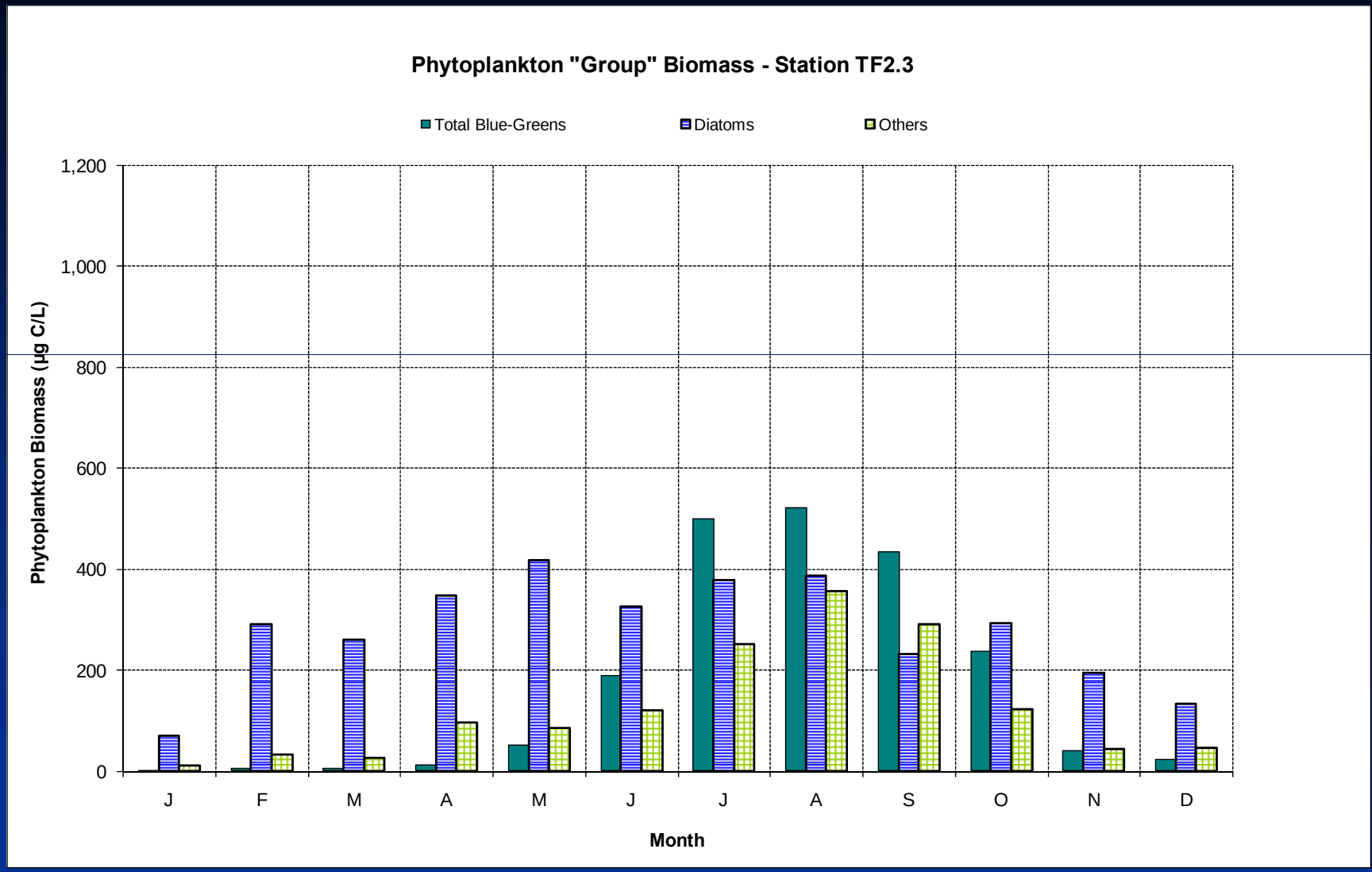
Percent Composition of Phytoplankton "Group" Biomass
Station LE2.2, 1984-2006

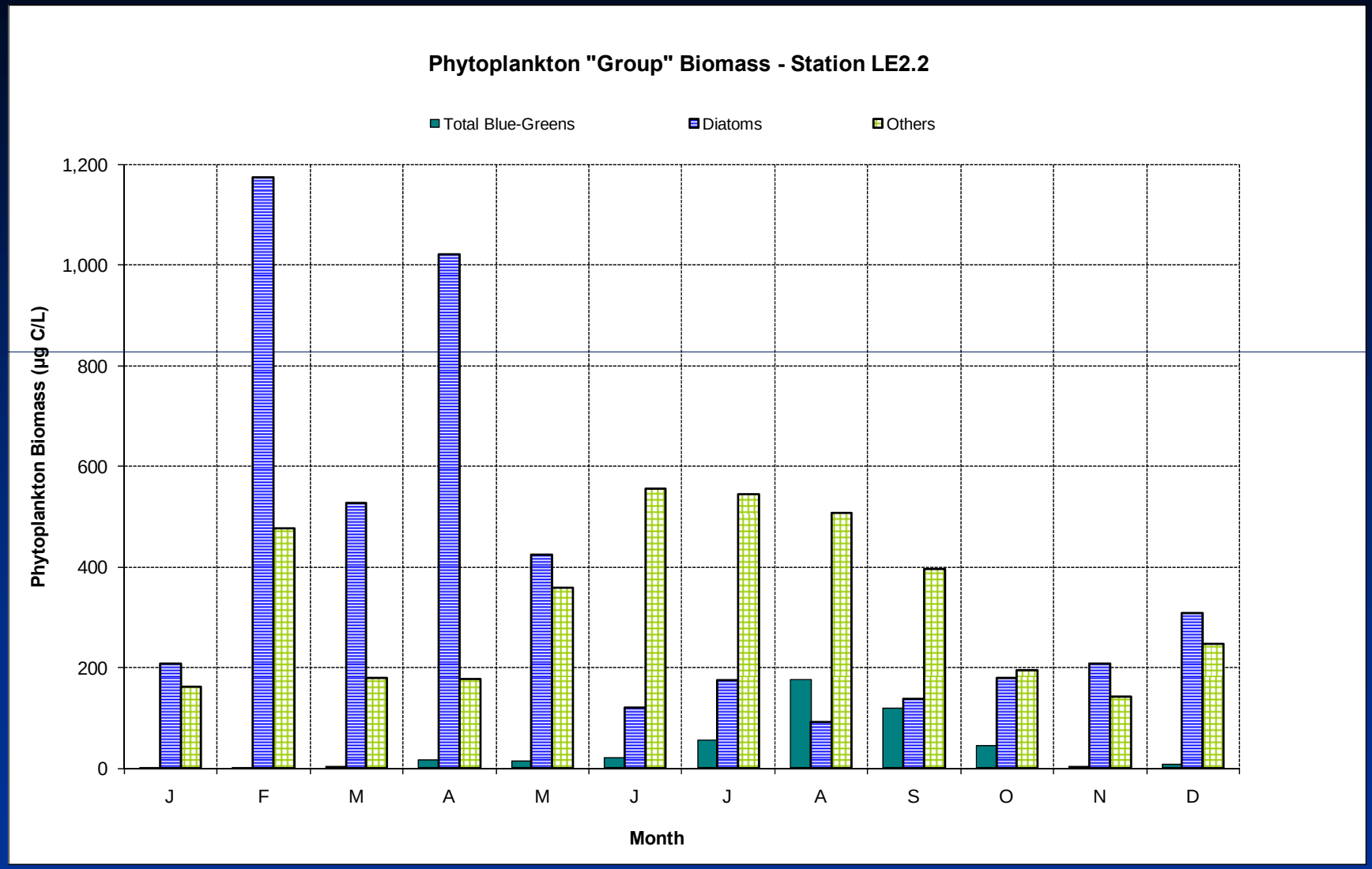



Percent Composition of Phytoplankton "Group" Biomass
Station TF2.3, 1994-2000
Diatoms
30%
Greens
27%
Cryptophytes
<1%
Dinoflagellates
3%
Others
<1%
Other BG (Non-N-Fixer)
32%
Other BG (N-Fixer)
<1%
Total Microcystis
6%

Percent Composition of Phytoplankton "Group" Biomass
Station LE2.2, 1994-2000




Phytoplankton "Group" Biomass - Station TF2.3
Total Blue-Greens
Diatoms
Others
1,200
1,000
800
600
400
200
0
Phytoplankton Biomass (µg C/L)
J
F
M
A
M
J
J
A
S
O
N
D
Month


Phytoplankton "Group" Biomass - Station LE2.2
Total Blue-Greens
Diatoms
Others
Phytoplankton Biomass (µg C/L)
1,200
1,000
800
600
400
200
0
J
F
M
A
M
J
J
A
S
O
N
D
Month

Proposed Model Algal Groups

- Freshwater Diatoms
- Marine Diatoms
- Dinoflagellates
- Greens
- Total Blue-Greens

Model and Data Groups

- Model World
  - Freshwater diatoms
  - Marine diatoms
  - Greens
  - Dinoflagellates
  - Total blue-greens
- Data World
  - Diatoms
    - TF2.3
    - RET2.2
    - LE2.2
  - Greens
  - Dinoflagellates
  - Total blue-greens
  - *Cryptophytes*
  - *Others*

Model Calibration Issues

- How to parameterize freshwater and marine diatom groups and compare with observations?
- How to handle “unaccounted” biomass from Cryptophytes and Others?
- How to represent potential nitrogen-fixation under conditions of low dissolved inorganic nitrogen concentration?

Parameterization of Model Groups

- Salinity
  - Low salinity tolerance
    - Freshwater diatoms
    - Greens
    - Total blue-greens
  - High salinity tolerance
    - Marine diatoms
    - Dinoflagellates
- Physiological parameters
  - Stoichiometry, growth, death, metabolism, settling, etc.
- Ecological parameters
  - Predation
- Nitrogen fixation
  - Function of DIN concentration

Proposed Model-Data Comparisons

Computed	Observed
Freshwater + Marine Diatoms	Total Diatoms
Greens	Greens [1]Cryptophytes [1]Others
Dinoflagellates	Dinoflagellates
Total Blue-Greens	Total Blue-Greens

[1]Mass balance check

Next Steps

- Complete Gunston Cove biomass determinations
- Develop model calibration targets
- Develop upstream/downstream boundary conditions
  - Translate chlorophyll concentrations into algal carbon and apportion among five model algal groups
- Develop carbon:chlorophyll conversion factors
  - Compare computed vs observed chlorophyll as consistency check
  - Compare computed chlorophyll to results from Potomac portion of whole bay model
- Revise model code to include two additional algal state variables
- Set up model post-processing algorithms
- Begin preliminary calibration runs