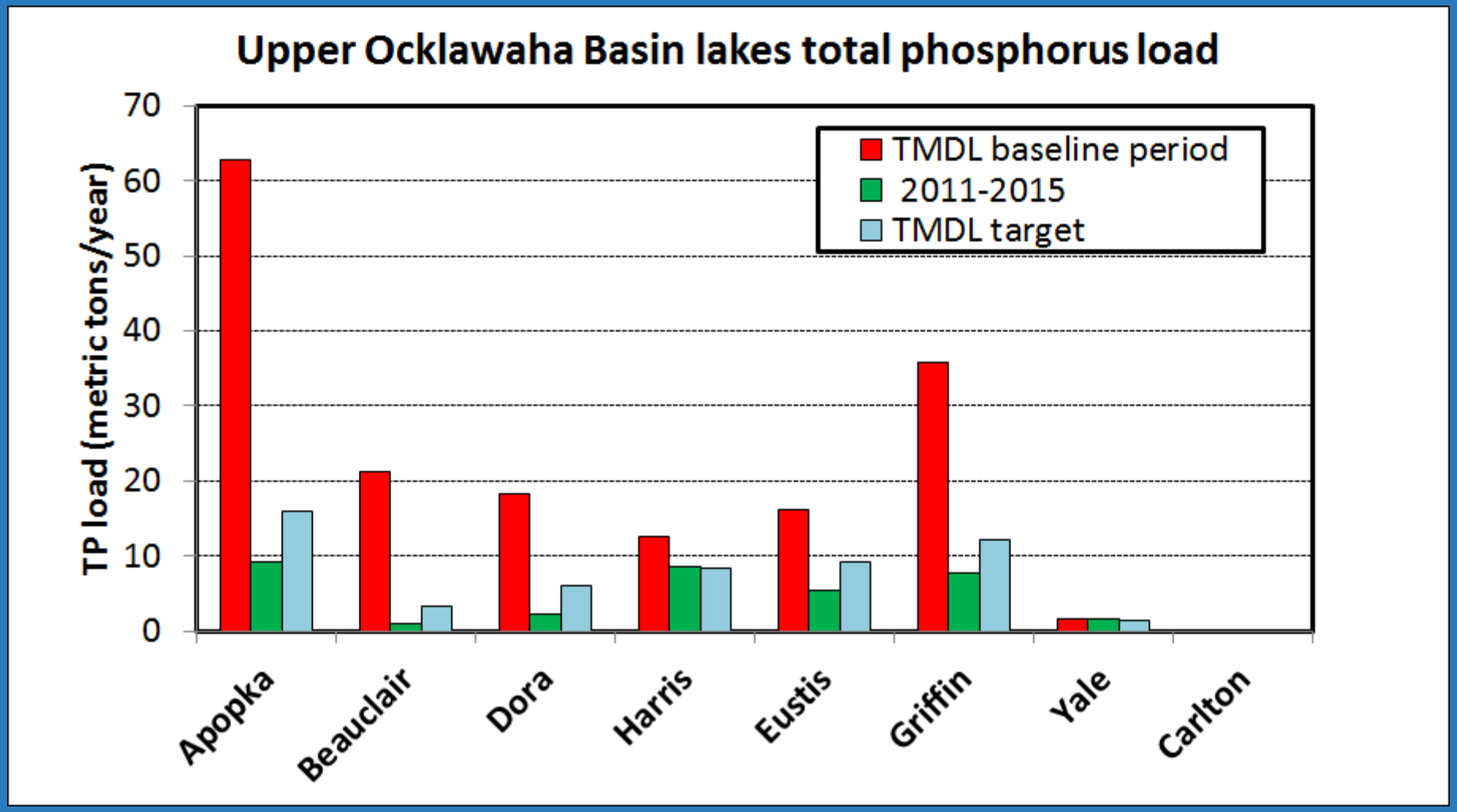
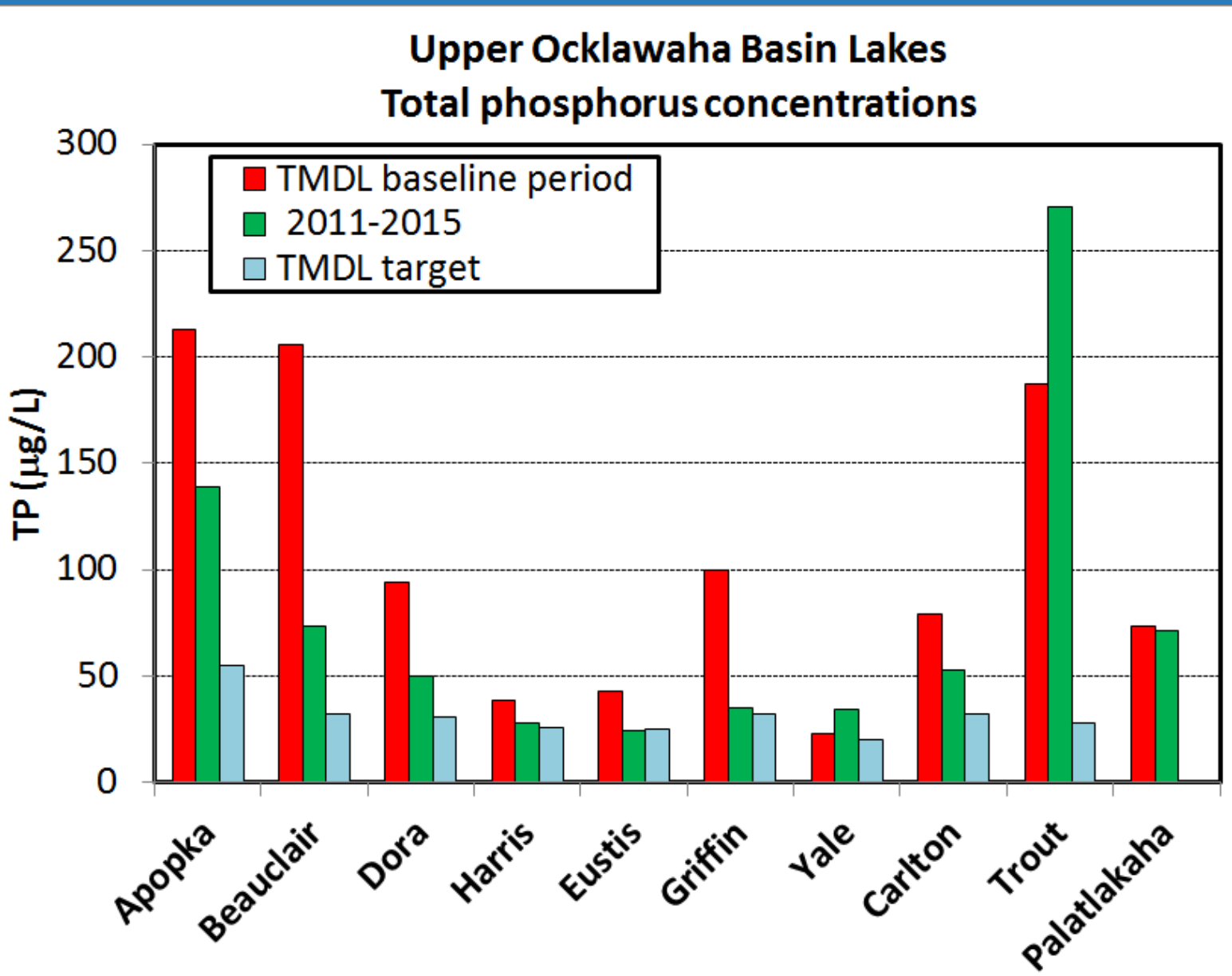
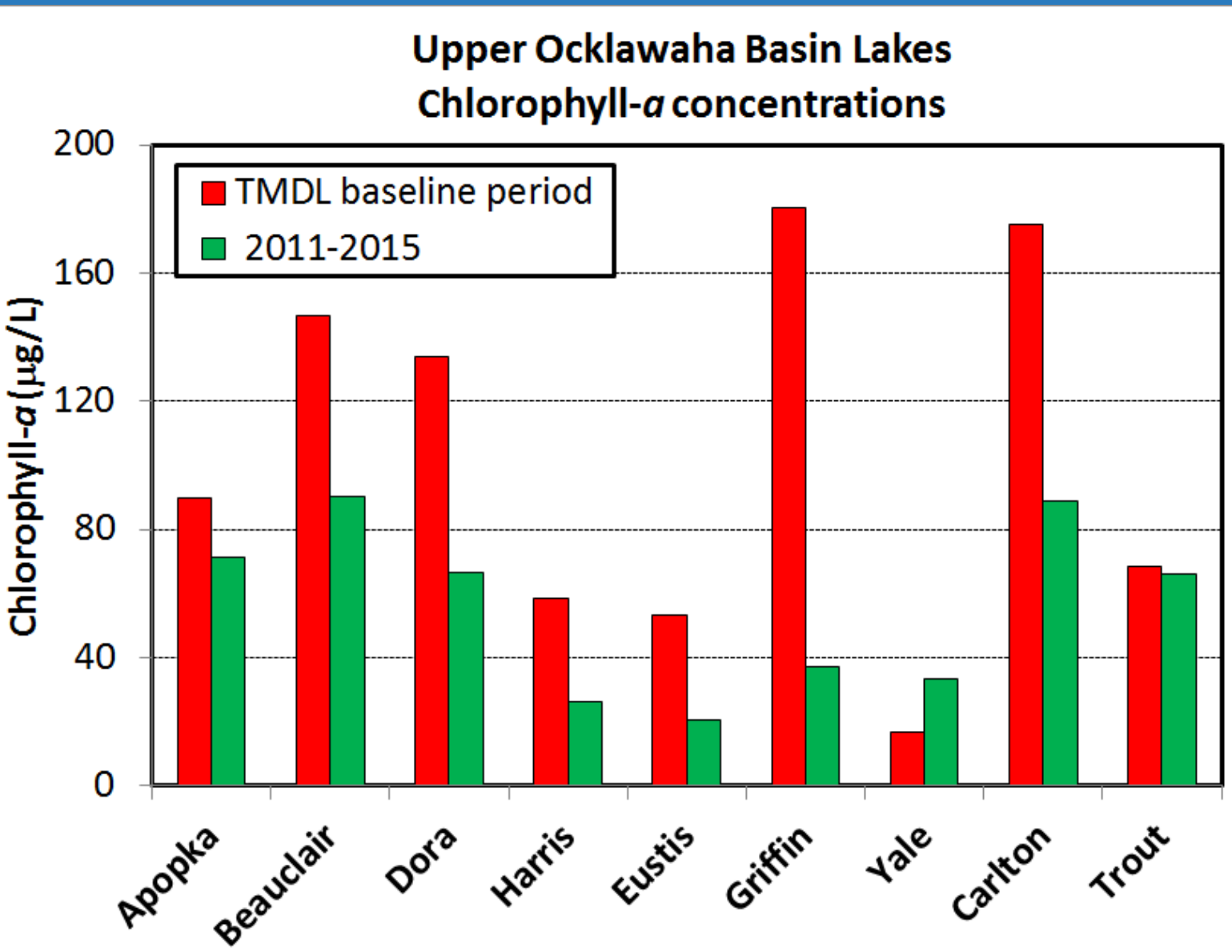
Trends in total phosphorus loading, water quality and phytoplankton in the Upper Ocklawaha BMAP lakes

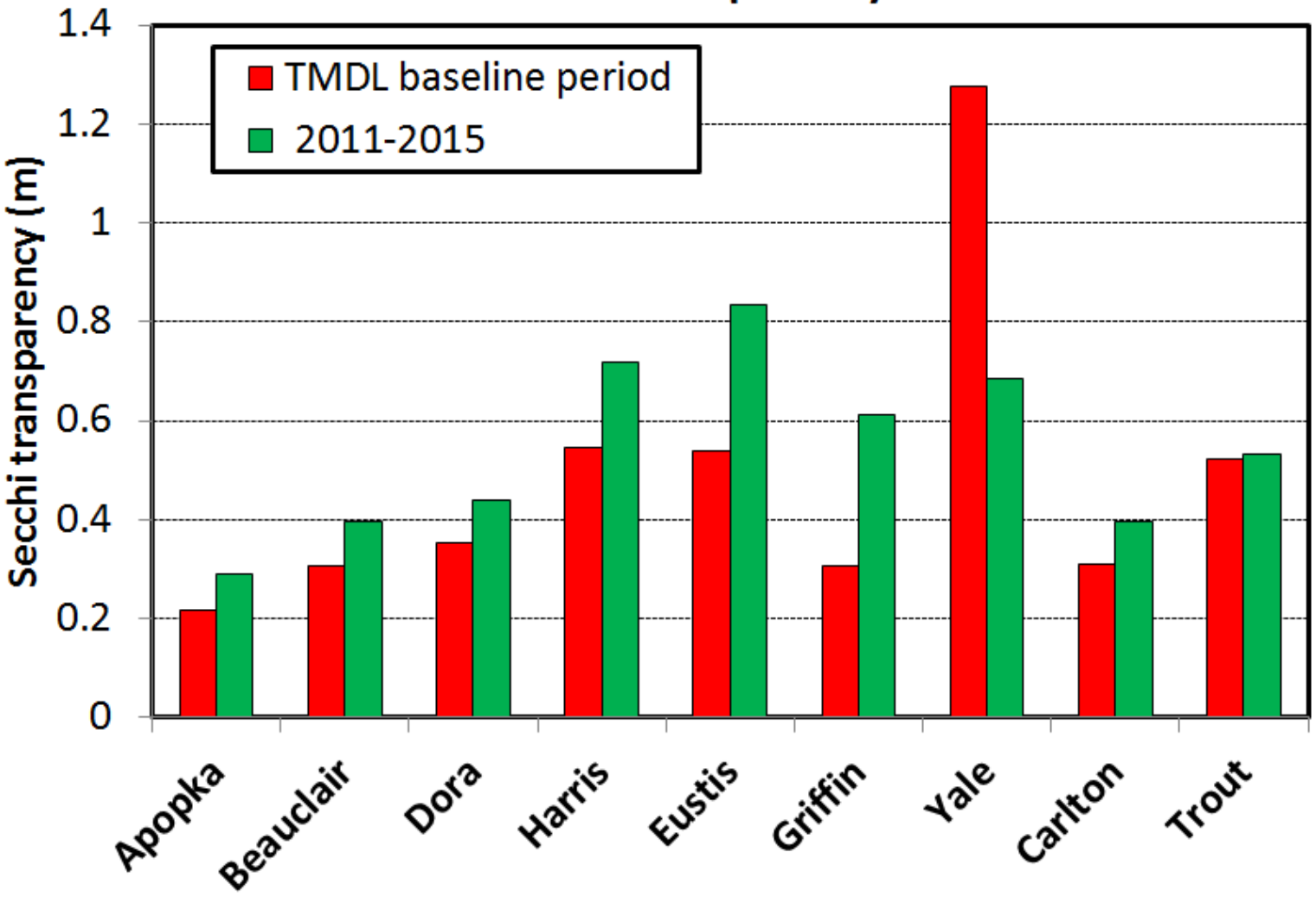
Rolland Fulton

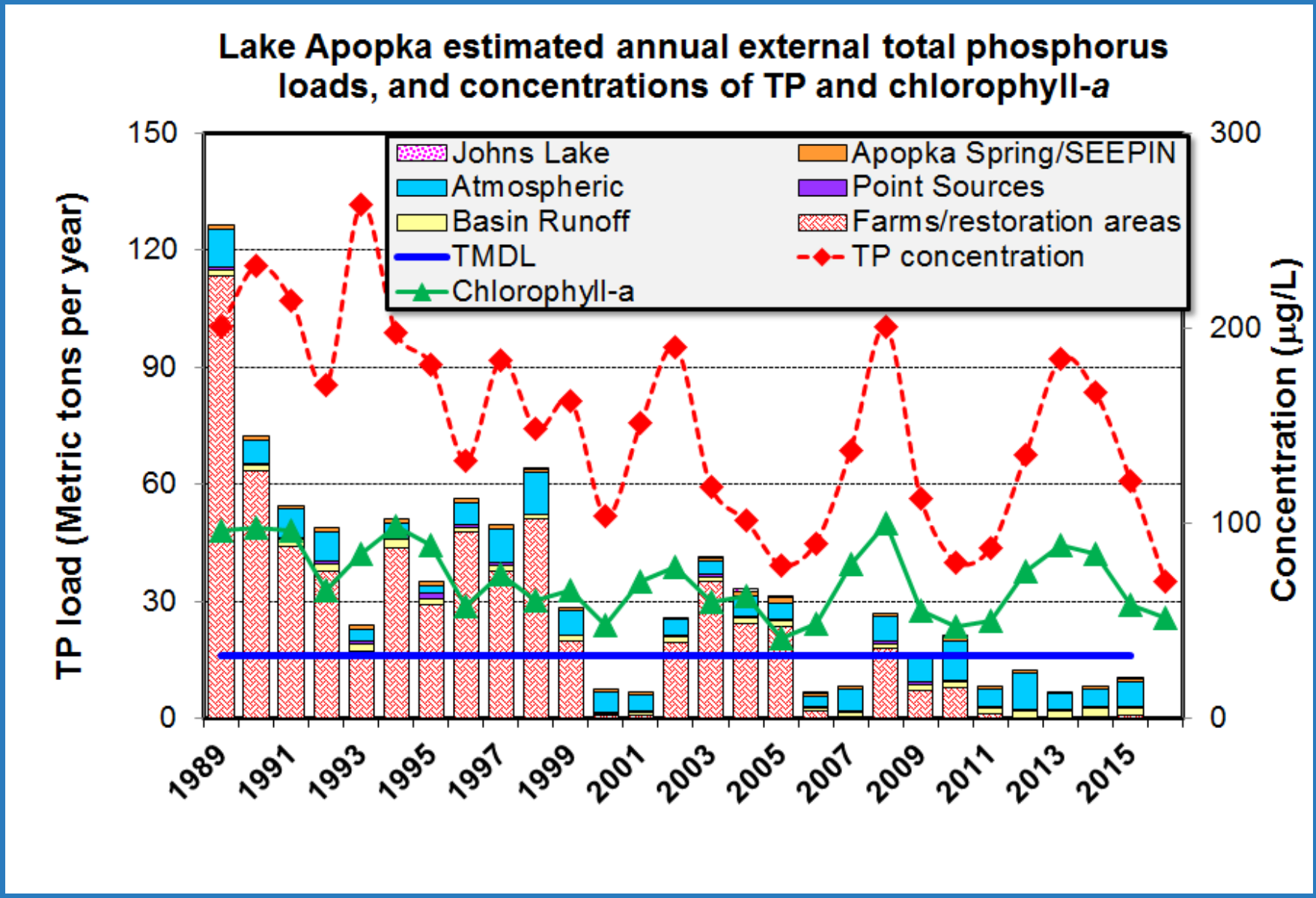
September 8, 2016

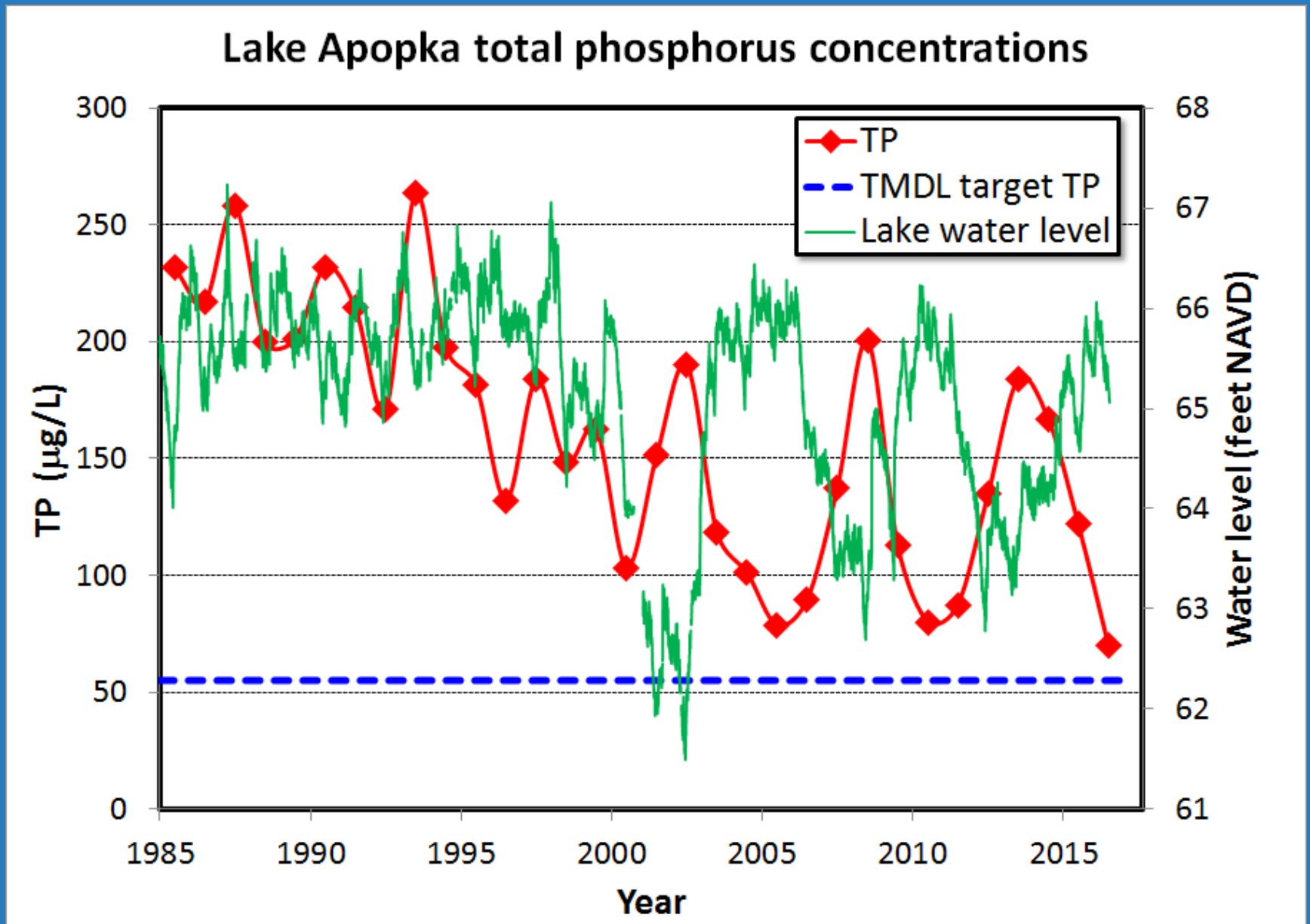

Upper Ocklawaha Basin lakes total phosphorus load
TP load (metric tons/year)
70
60
50
40
30
20
10
0
TMDL baseline period
2011-2015
TMDL target
Apopka
Beauclair
Dora
Harris
Eustis
Griffin
Yale
Carlton

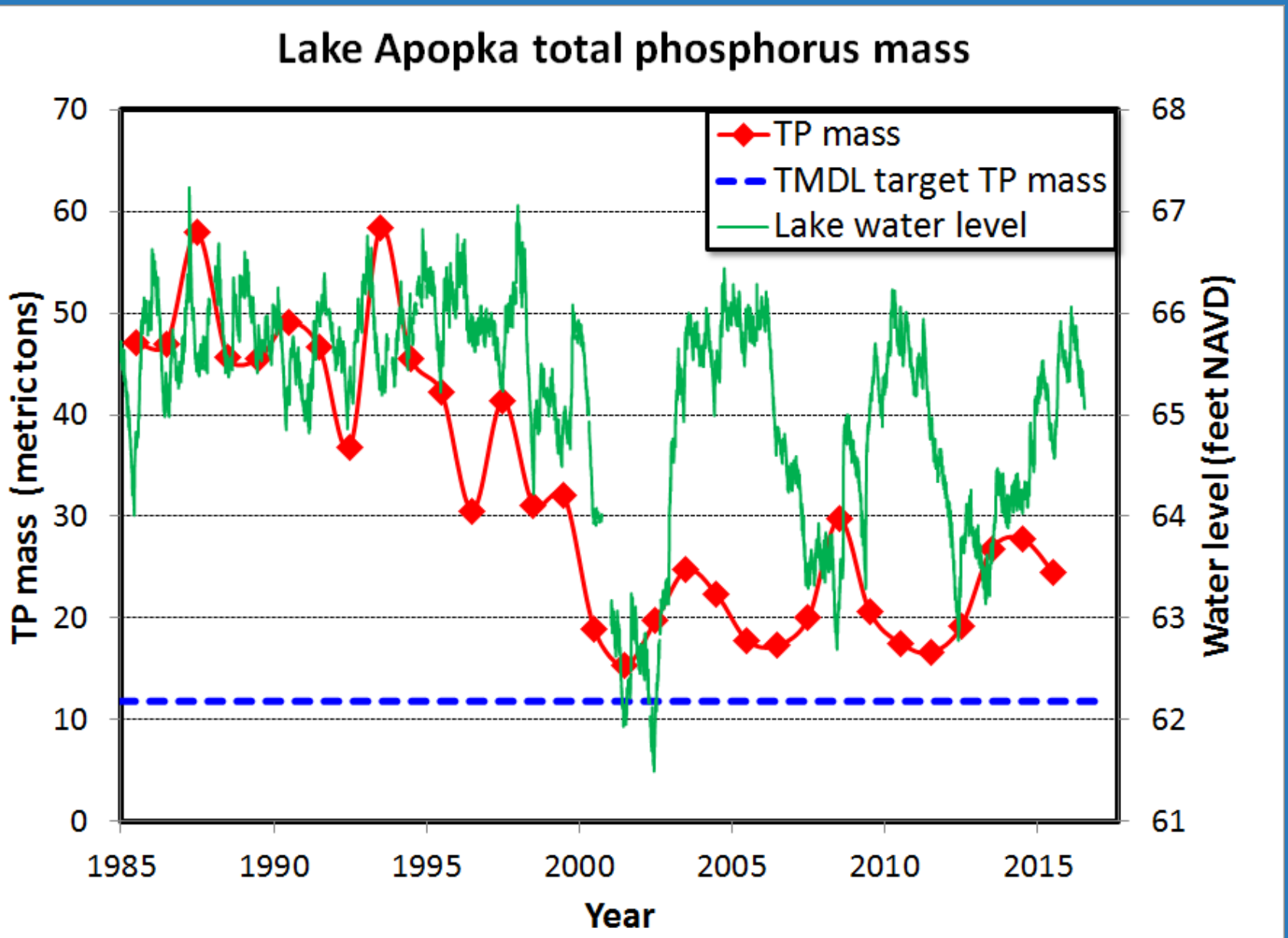

Upper Ocklawaha Basin Lakes
Total phosphorus concentrations
TMDL baseline period
2011-2015
TMDL target
TP (µg/L)
300
250
200
150
100
50
0
Apopka
Beauclair
Dora
Harris
Eustis
Griffin
Yale
Carlton
Trout
Palatlakaha


Upper Ocklawaha Basin Lakes
Chlorophyll-a concentrations
TMDL baseline period
2011-2015
Chlorophyll-a (µg/L)
200
160
120
80
40
0
Apopka
Beauclair
Dora
Harris
Eustis
Griffin
Yale
Carlton
Trout

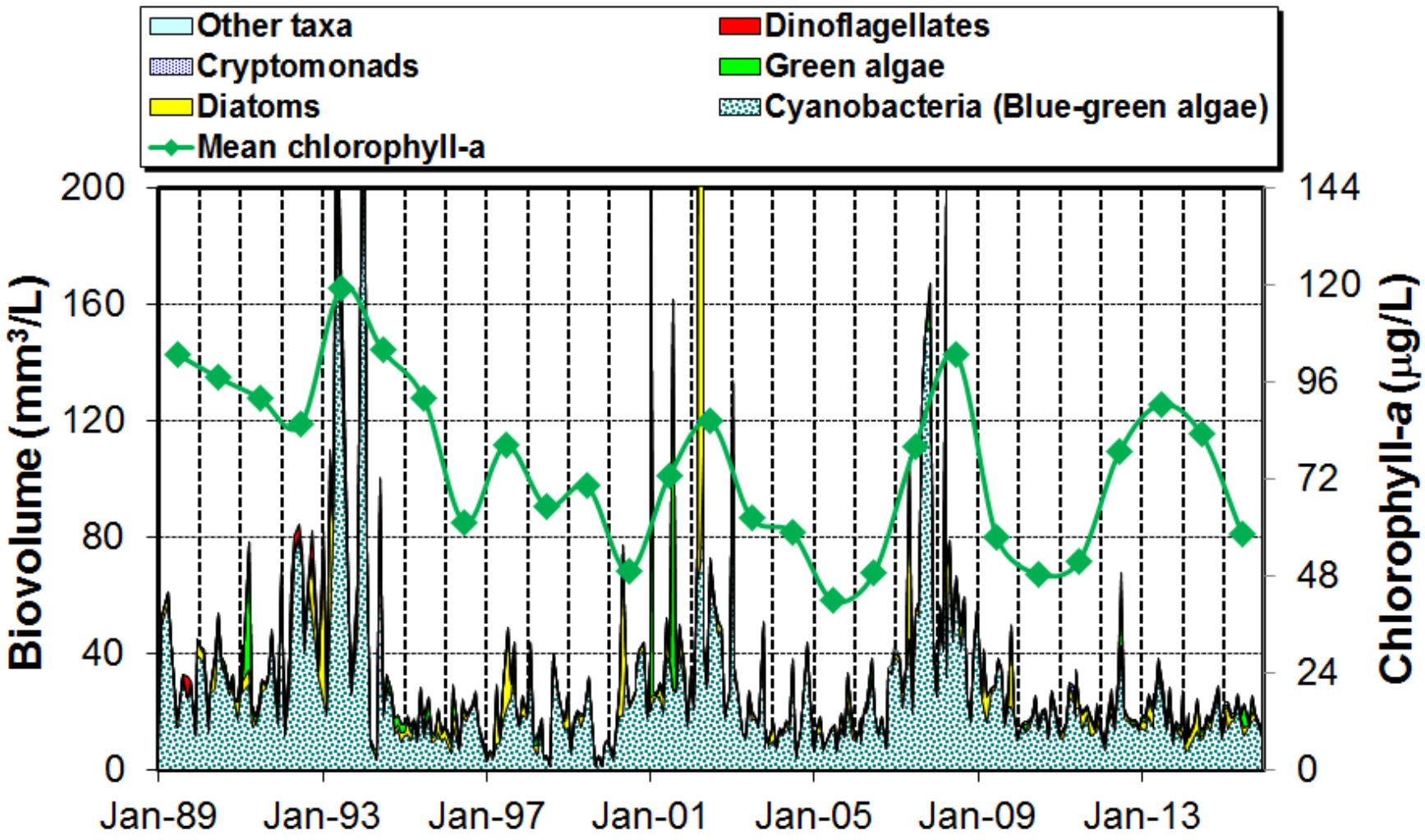

Upper Ocklawaha Basin Lakes
Secchi transparency
TMDL baseline period
2011-2015
Secchi transparency (m)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Apopka
Beauclair
Dora
Harris
Eustis
Griffin
Yale
Carlton
Trout

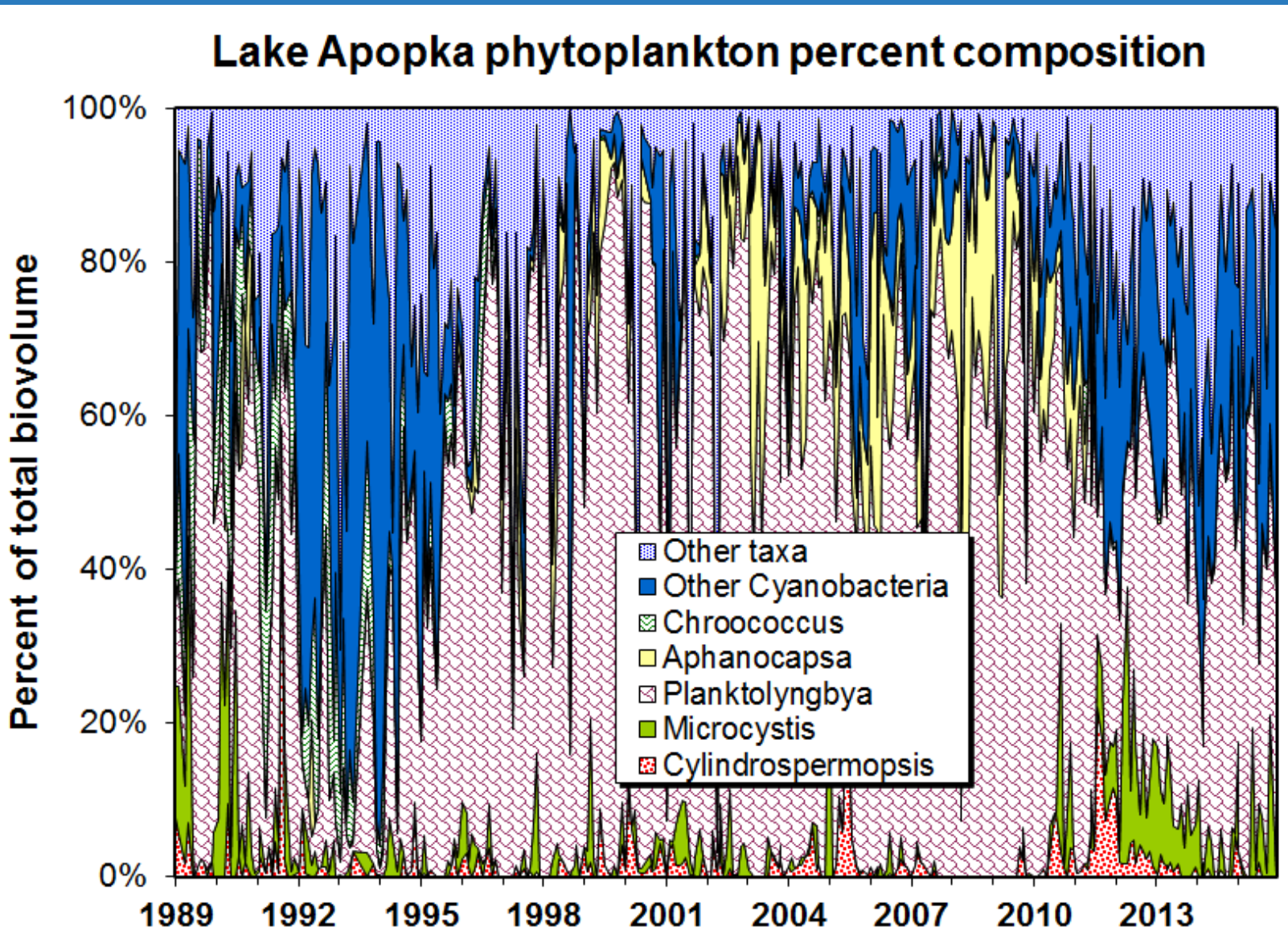

Lake Apopka estimated annual external total phosphorus loads, and concentrations of TP and chlorophyll-a
TP load (Metric tons per year)
Concentration (µg/L)
150
120
90
60
30
0
300
200
100
0
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Johns Lake
Atmospheric
Basin Runoff
TMDL
Chlorophyll-a
Apopka Spring/SEEPIN
Point Sources
Farms/restoration areas
TP concentration


Lake Apopka total phosphorus concentrations
TP
TMDL target TP
Lake water level
TP (µg/L)
Water level (feet NAVD)
Year
300
250
200
150
100
50
0
68
67
66
65
64
63
62
61
1985
1990
1995
2000
2005
2010
2015

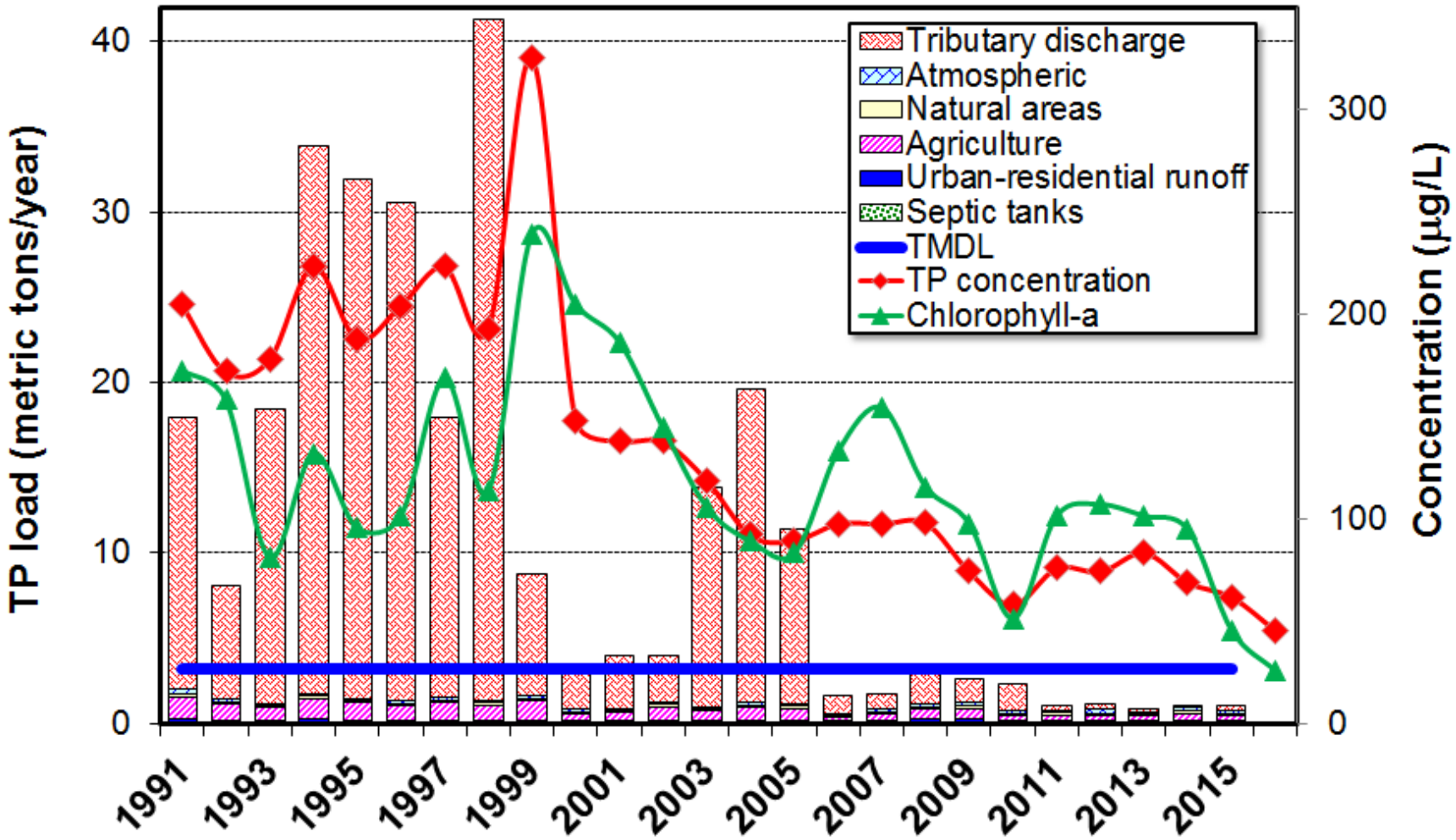

Lake Apopka total phosphorus mass
TP mass
TMDL target TP mass
Lake water level
TP mass (metrictons)
Water level (feet NAVD)
Year
0
10
20
30
40
50
60
70
61
62
63
64
65
66
67
68
1985
1990
1995
2000
2005
2010
2015

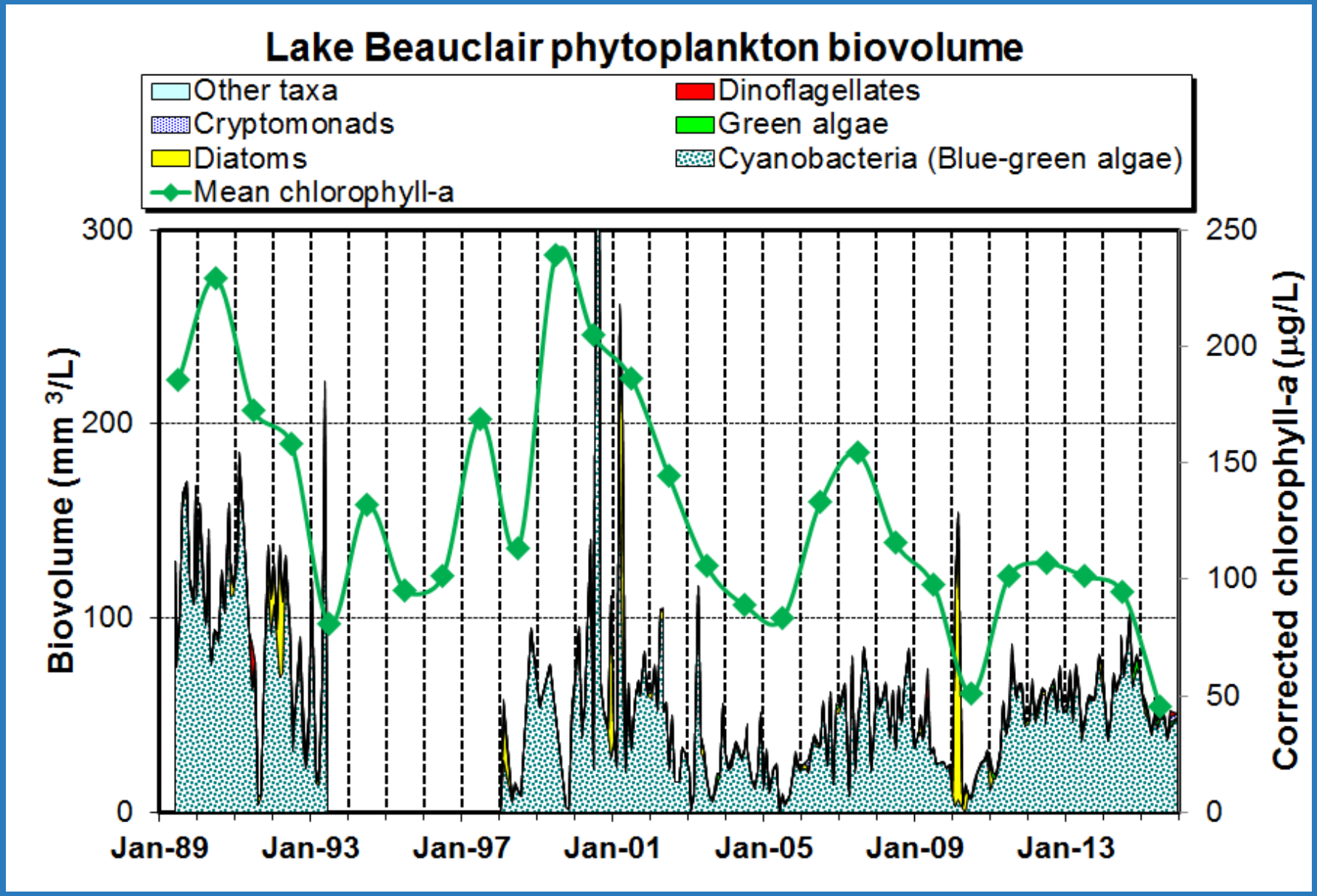
Lake Apopka phytoplankton taxa biovolume



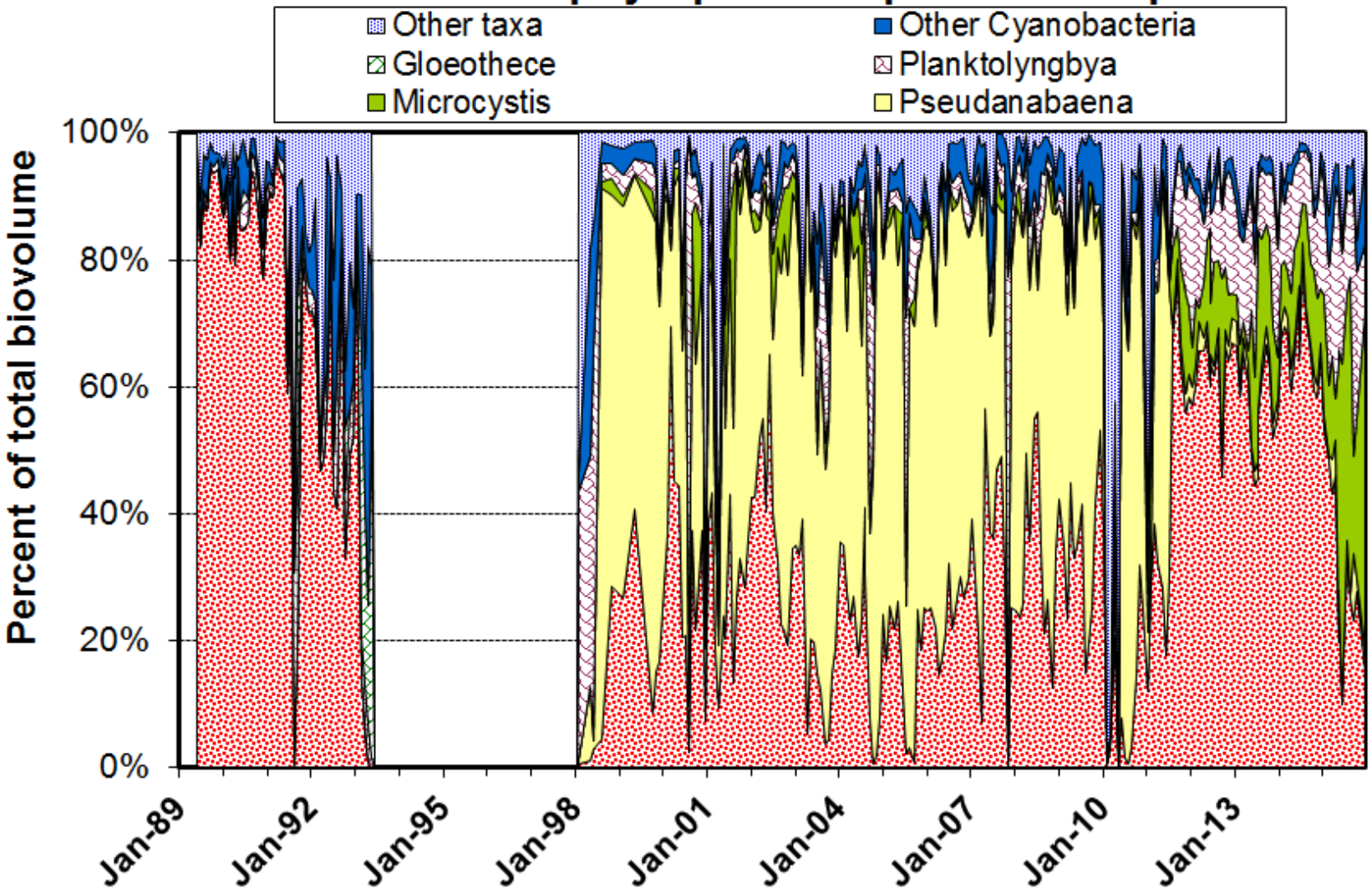

Lake Apopka phytoplankton percent composition
Percent of total biovolume
100%
80%
60%
40%
20%
0%
1989
1992
1995
1998
2001
2004
2007
2010
2013
Other taxa
Other Cyanobacteria
Chroococcus
Aphanocapsa
Planktolyngbya
Microcystis
Cylindrospermopsis

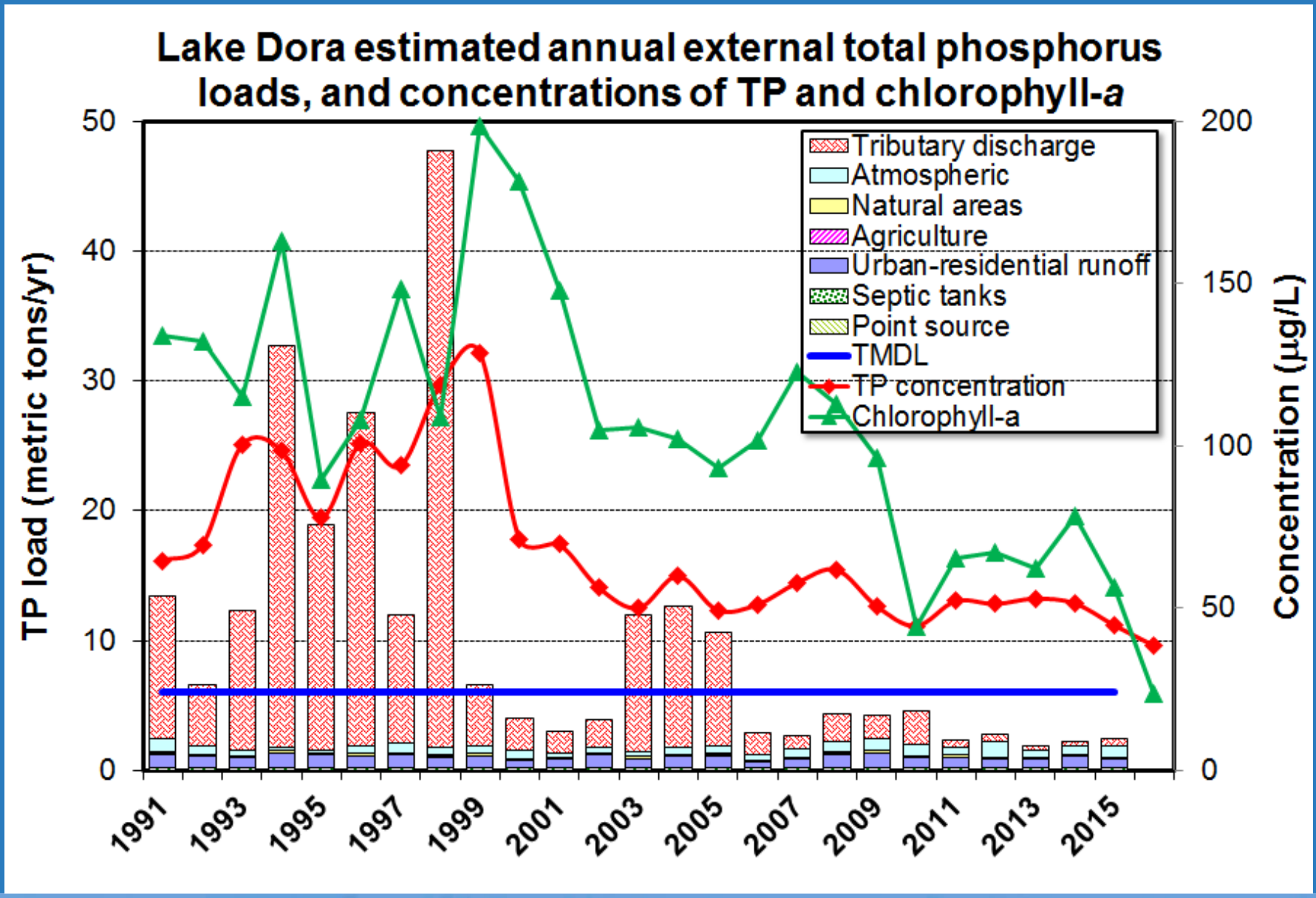
Lake Beauclair estimated annual external total phosphorus loads, and concentrations of TP and chlorophyll-*a*



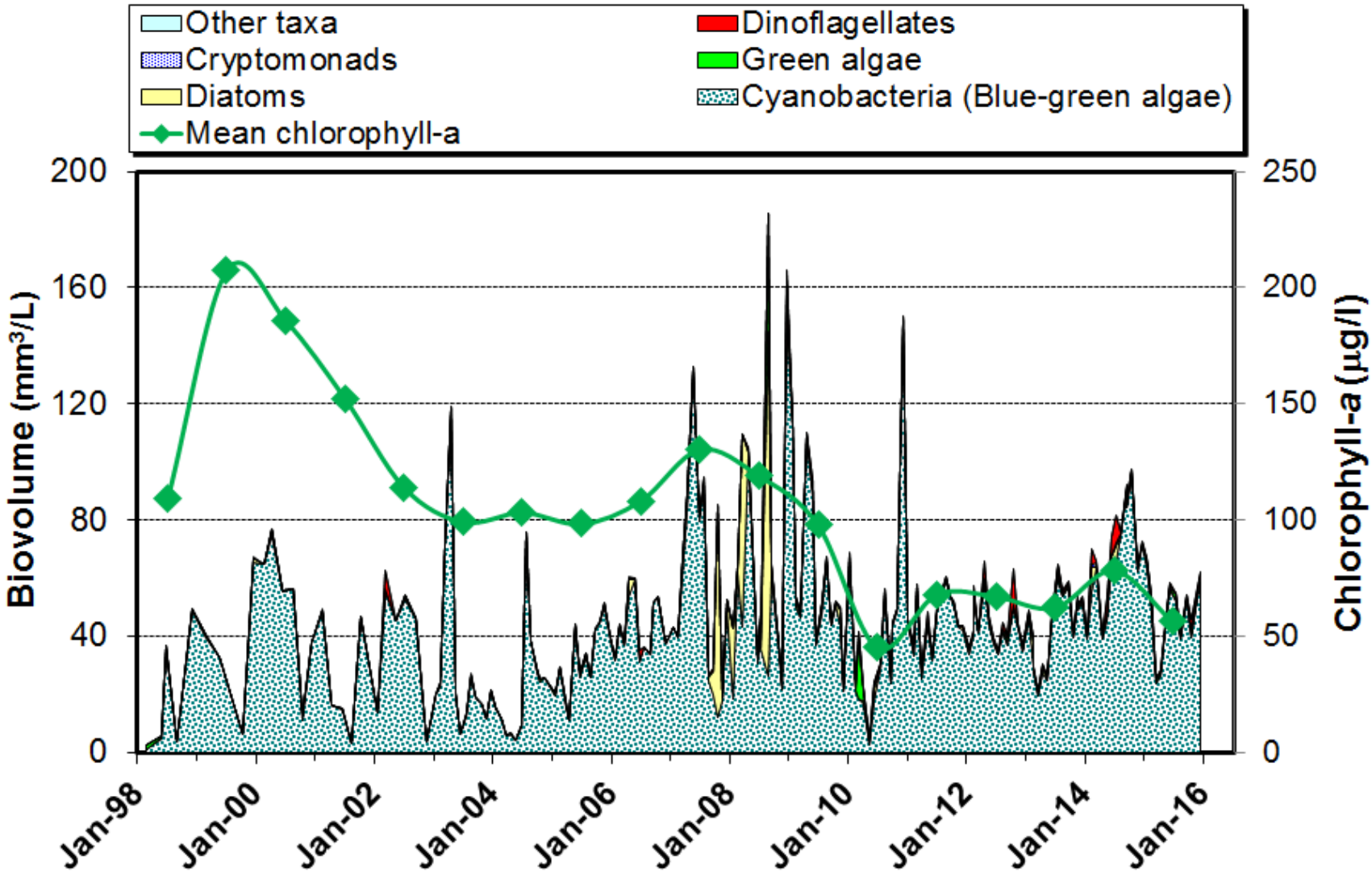

Lake Beauclair phytoplankton biovolume
Other taxa
Cryptomonads
Diatoms
Mean chlorophyll-a
Dinoflagellates
Green algae
Cyanobacteria (Blue-green algae)
Biovolume (mm 3/L)
Corrected chlorophyll-a (µg/L)
300
200
100
0
250
200
150
100
50
0
Jan-89
Jan-93
Jan-97
Jan-01
Jan-05
Jan-09
Jan-13

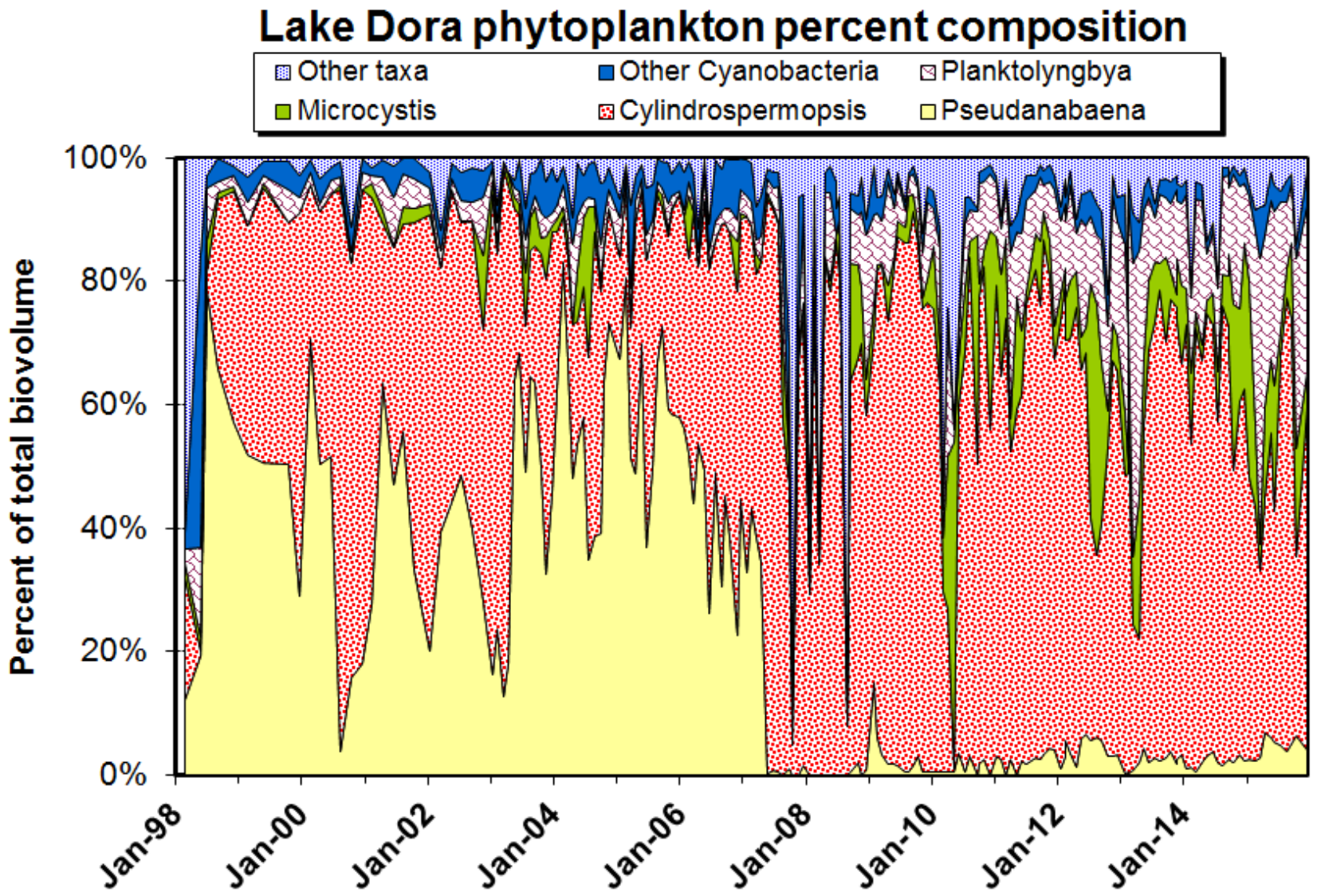
Lake Beauclair phytoplankton percent composition



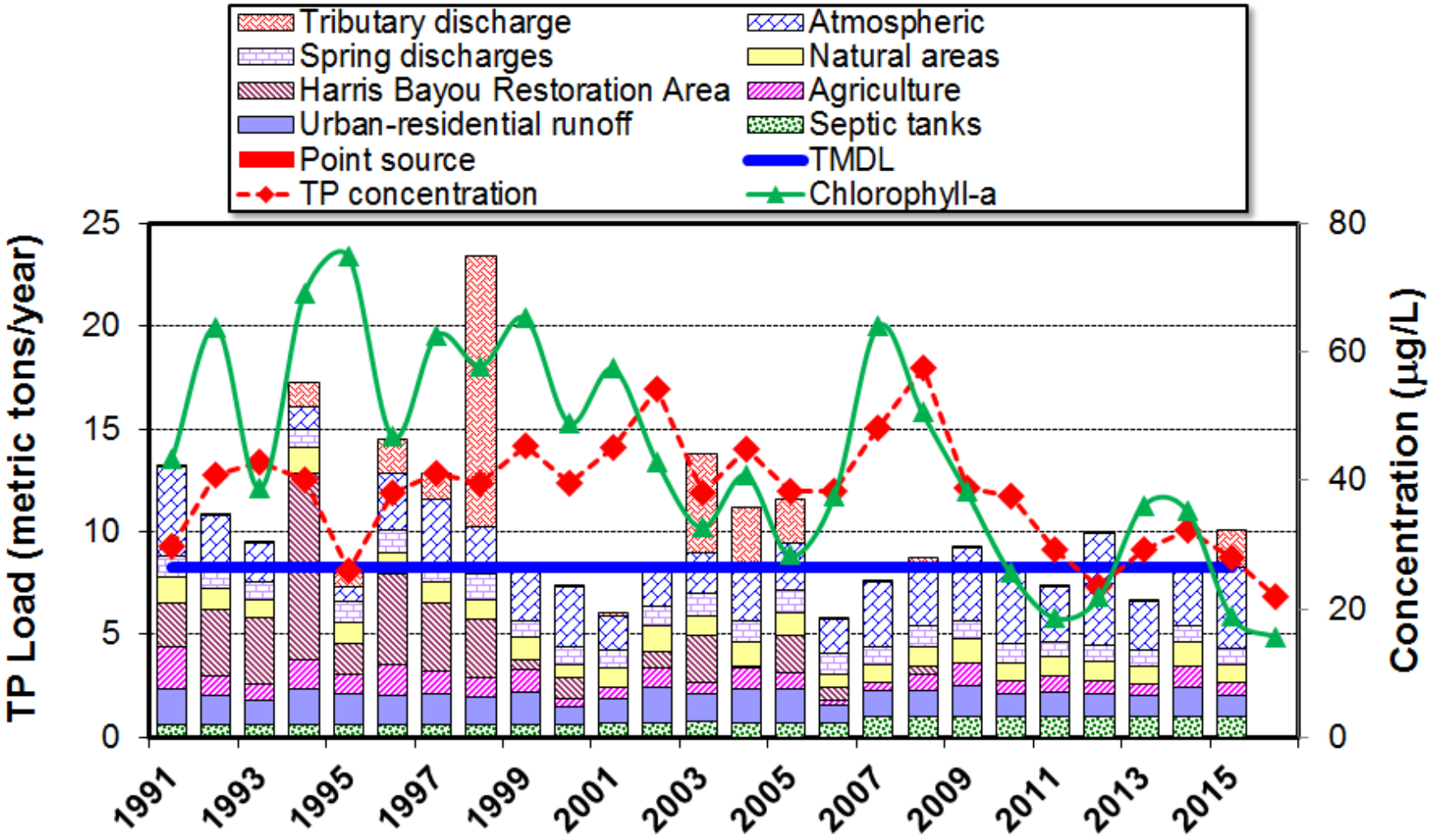

Lake Dora estimated annual external total phosphorus loads, and concentrations of TP and chlorophyll-a
TP load (metric tons/yr)
Concentration (µg/L)
0
10
20
30
40
50
0
50
100
150
200
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Tributary discharge
Atmospheric
Natural areas
Agriculture
Urban-residential runoff
Septic tanks
Point source
TMDL
TP concentration
Chlorophyll-a

Lake Dora west or composite phytoplankton biovolume

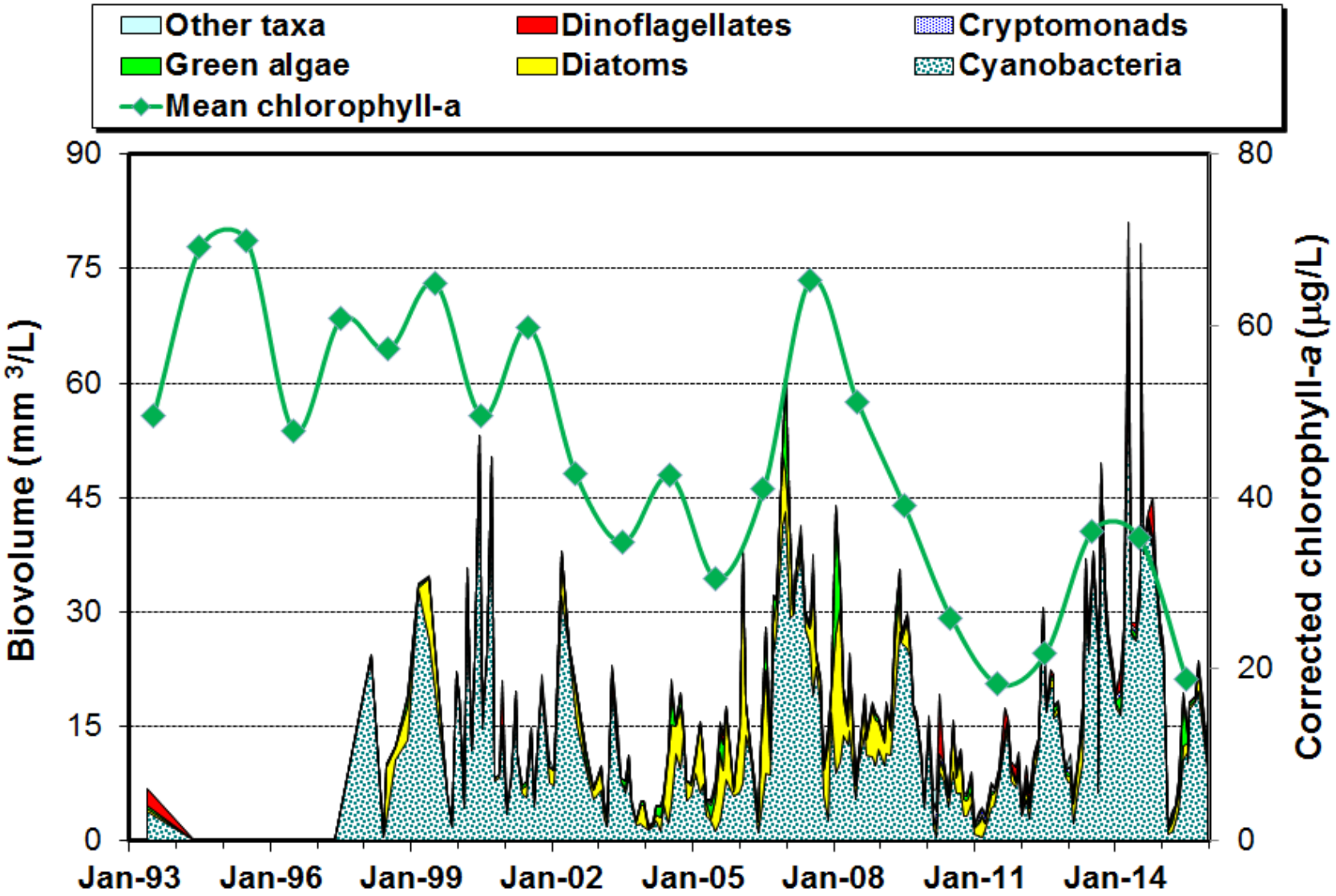


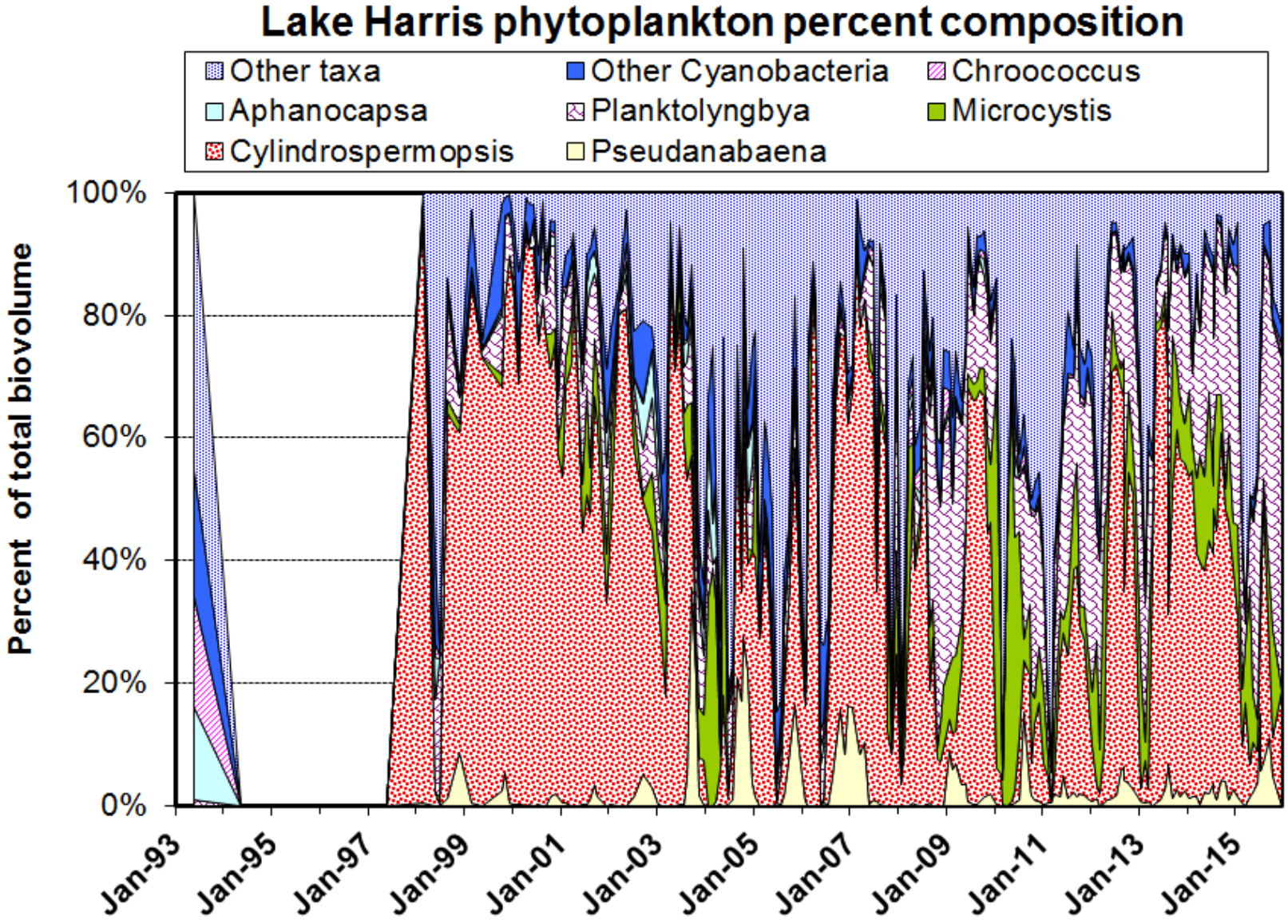

Lake Dora phytoplankton percent composition
Other taxa
Other Cyanobacteria
Planktolyngbya
Microcystis
Cylindrospermopsis
Pseudanabaena
Percent of total biovolume
100%
80%
60%
40%
20%
0%
Jan-98
Jan-00
Jan-02
Jan-04
Jan-06
Jan-08
Jan-10
Jan-12
Jan-14

Lake Harris estimated annual external total phosphorus loads, and concentrations of TP and chlorophyll-*a*

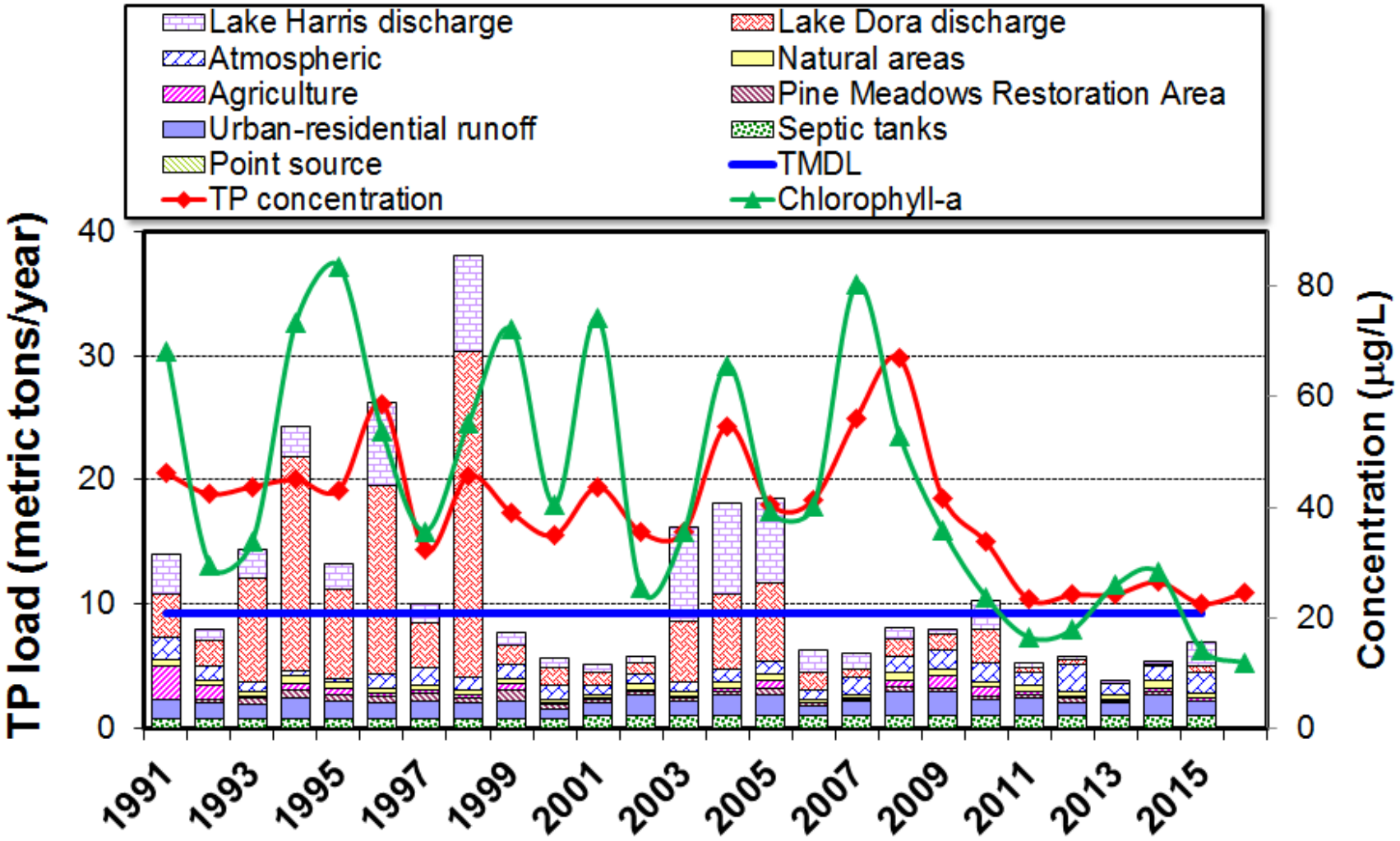


Lake Harris phytoplankton biovolume

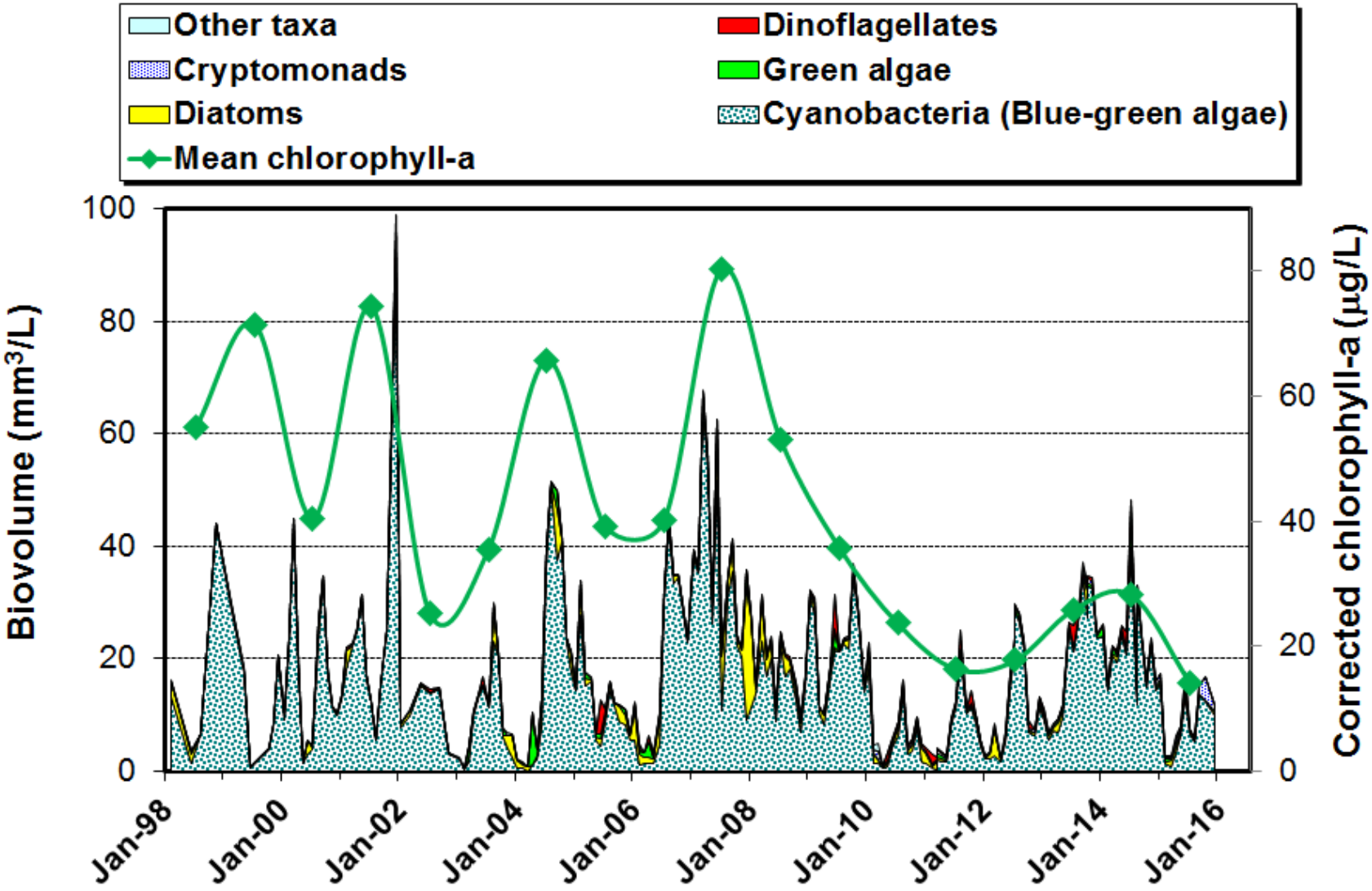



Lake Harris phytoplankton percent composition
Other taxa
Other Cyanobacteria
Chroococcus
Aphanocapsa
Planktolyngbya
Microcystis
Cylindrospermopsis
Pseudanabaena
Percent of total biovolume
100%
80%
60%
40%
20%
0%
Jan-93
Jan-95
Jan-97
Jan-99
Jan-01
Jan-03
Jan-05
Jan-07
Jan-09
Jan-11
Jan-13
Jan-15

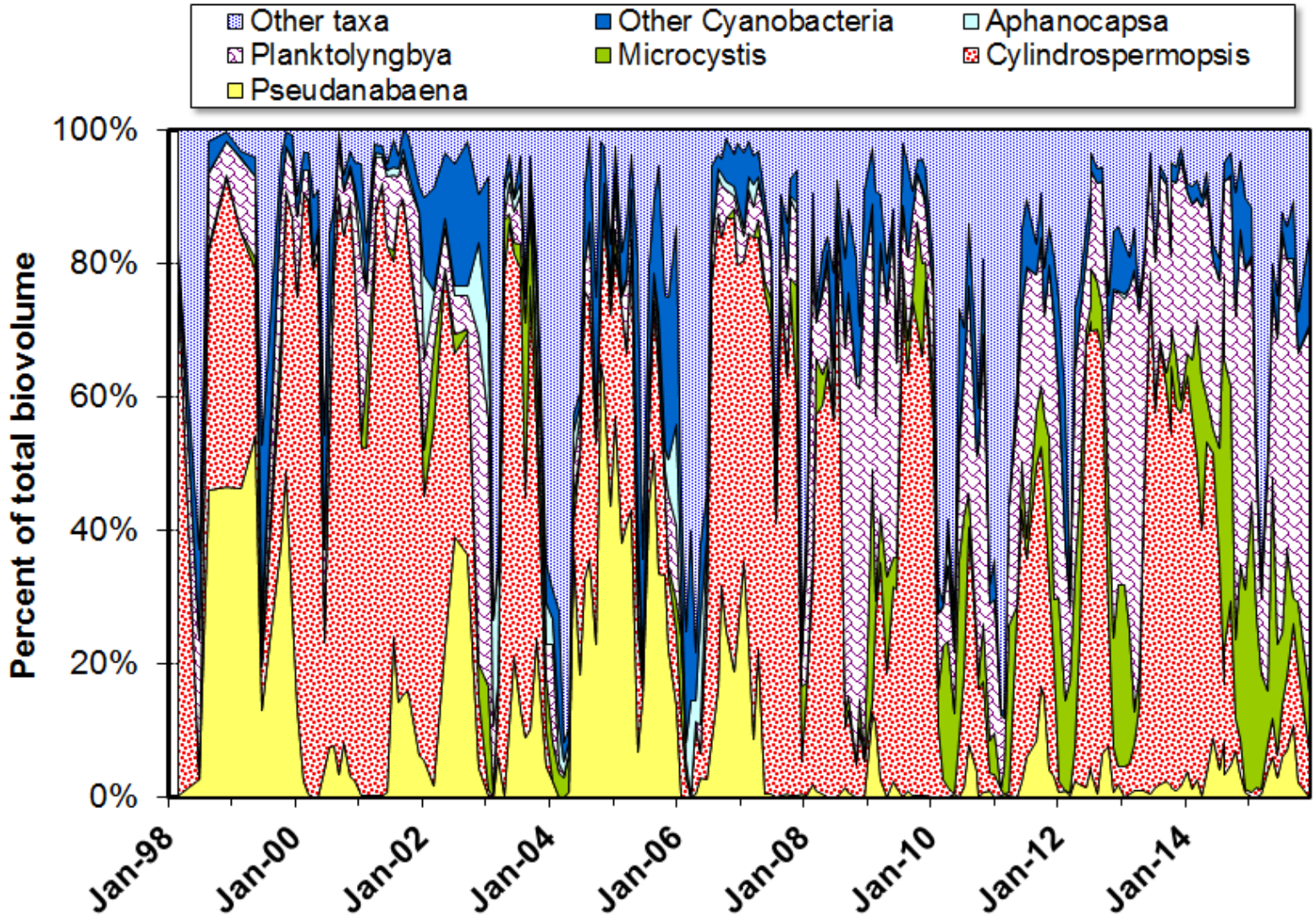
Lake Eustis estimated annual external total phosphorus loads, and concentrations of TP and chlorophyll-*a*

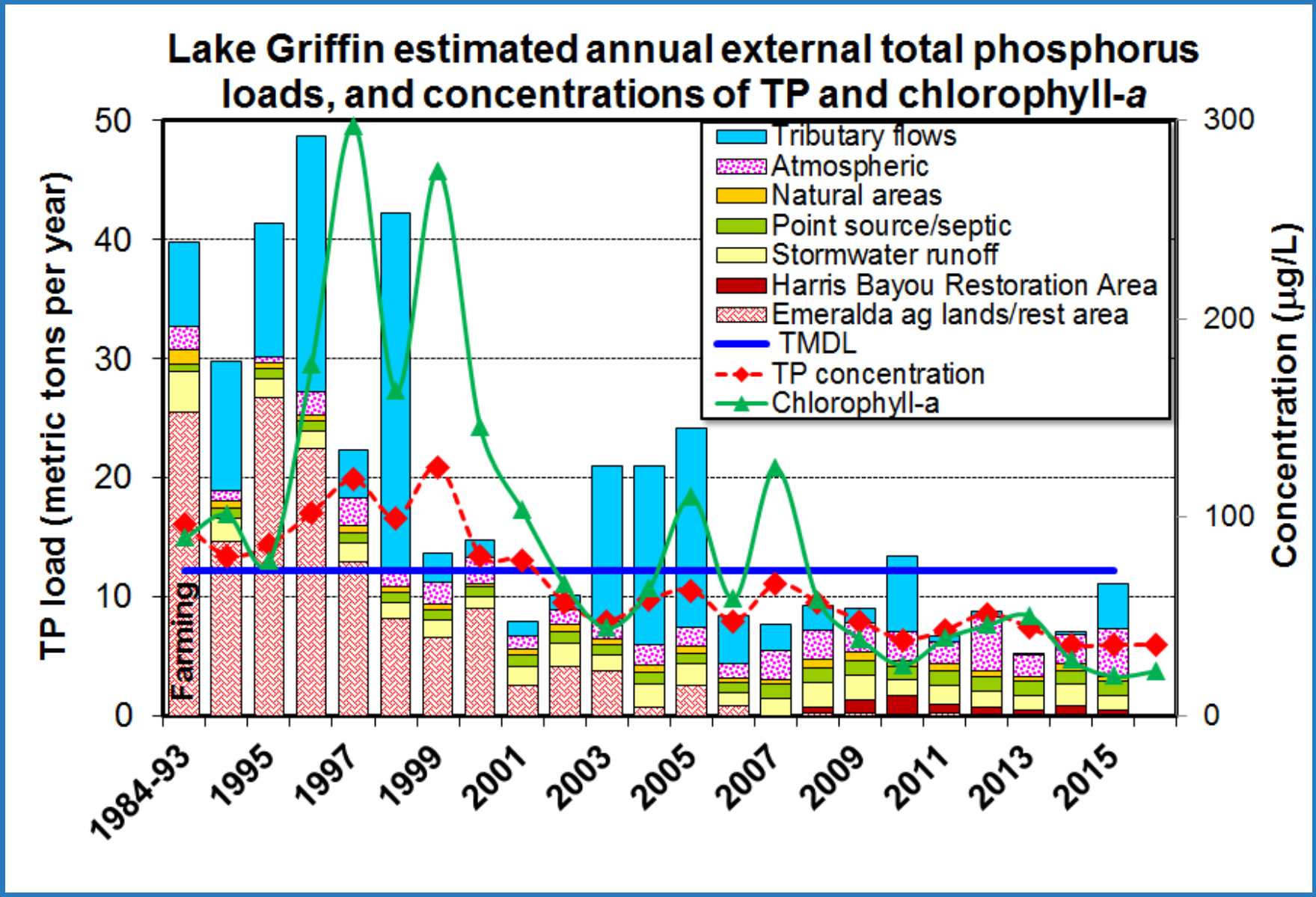


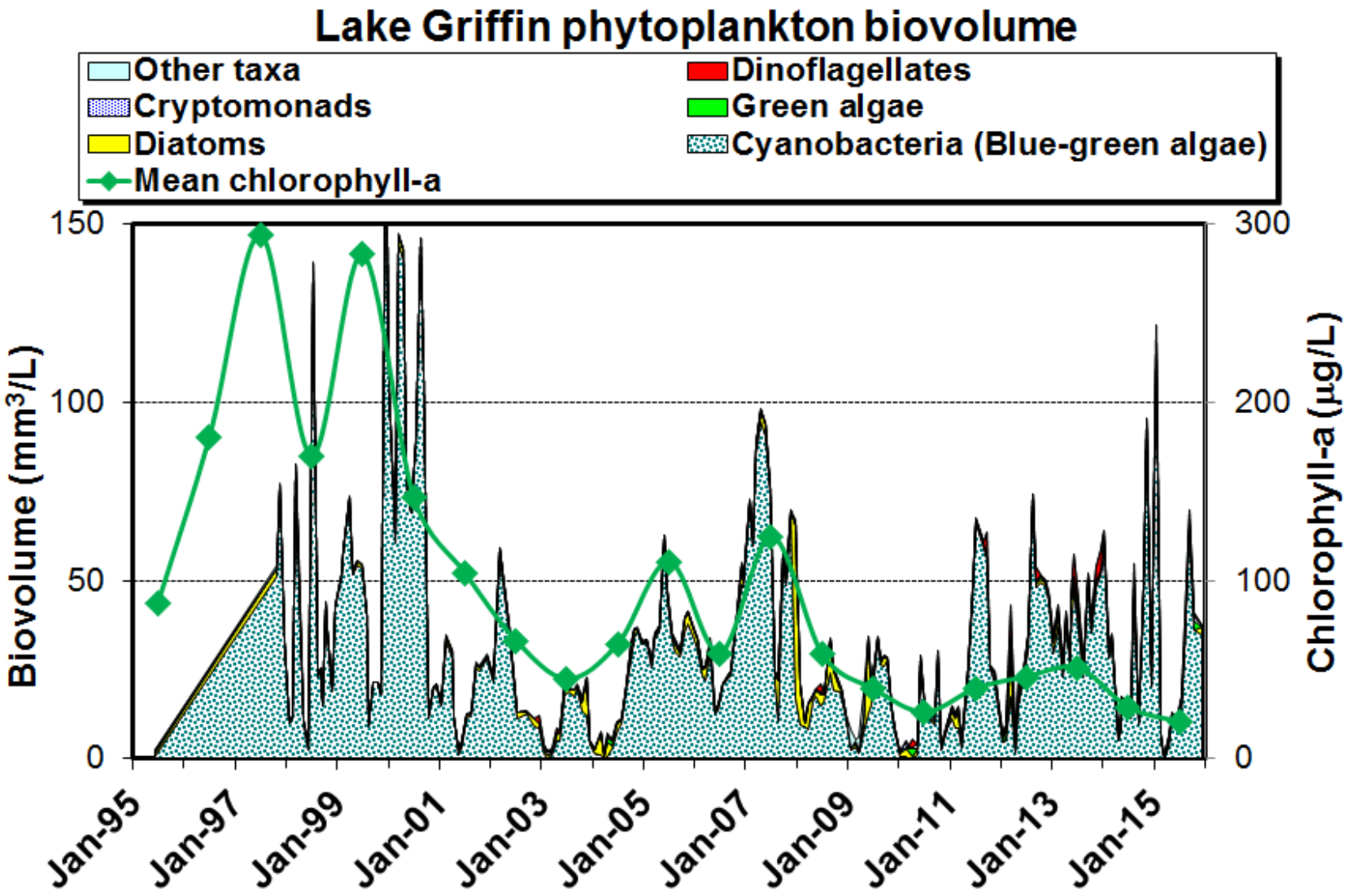
Lake Eustis phytoplankton biovolume

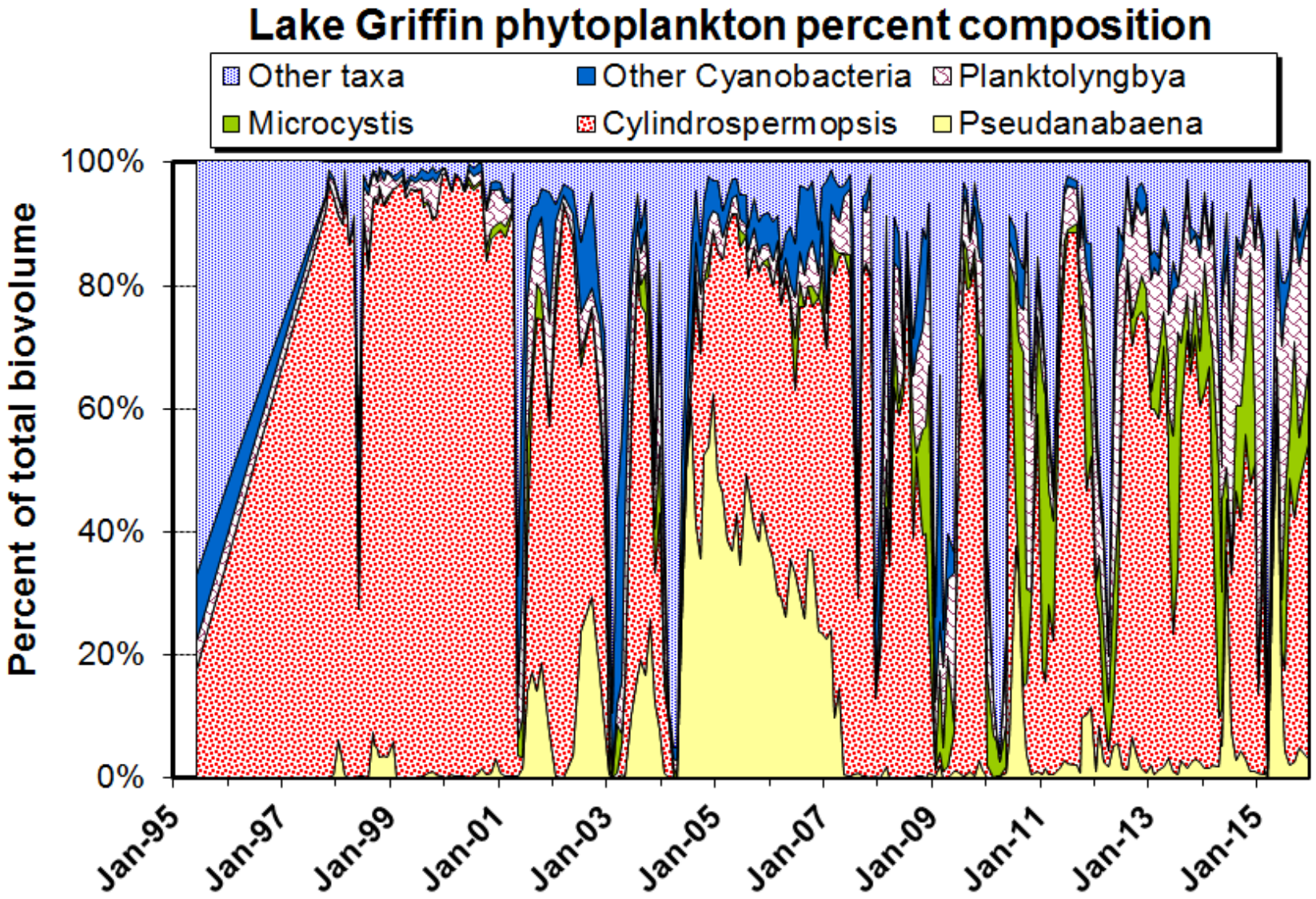


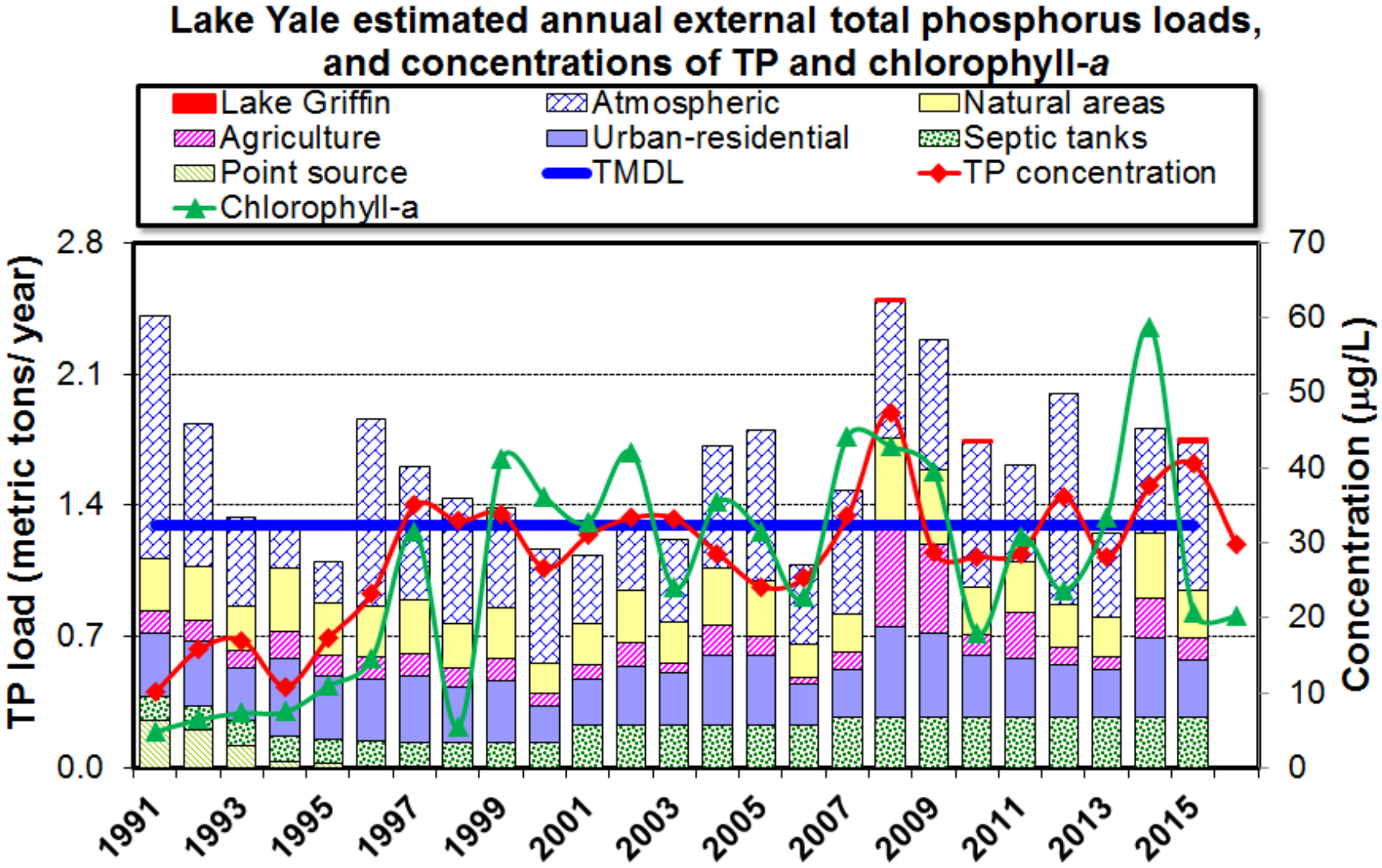
Lake Eustis phytoplankton percent composition

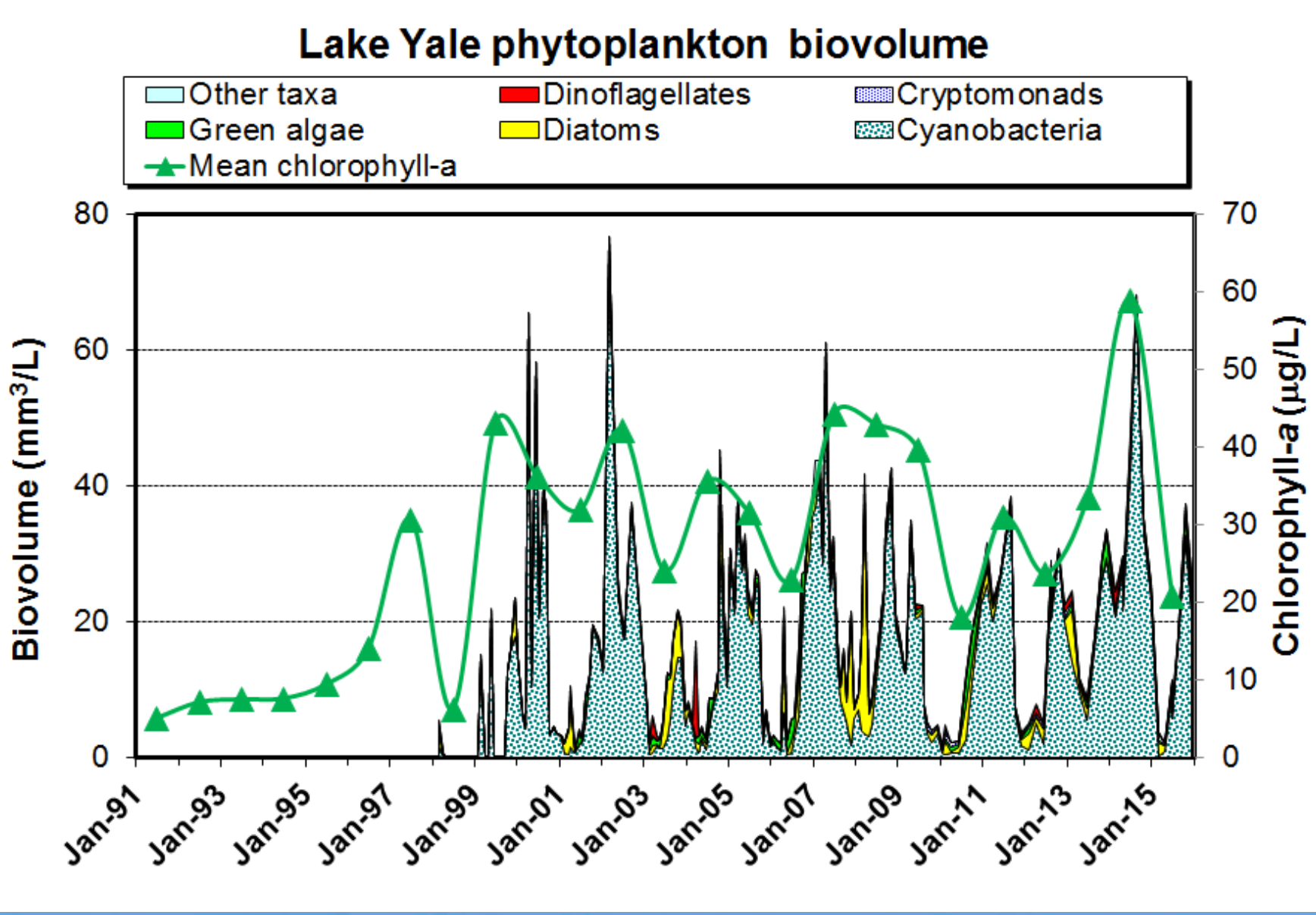


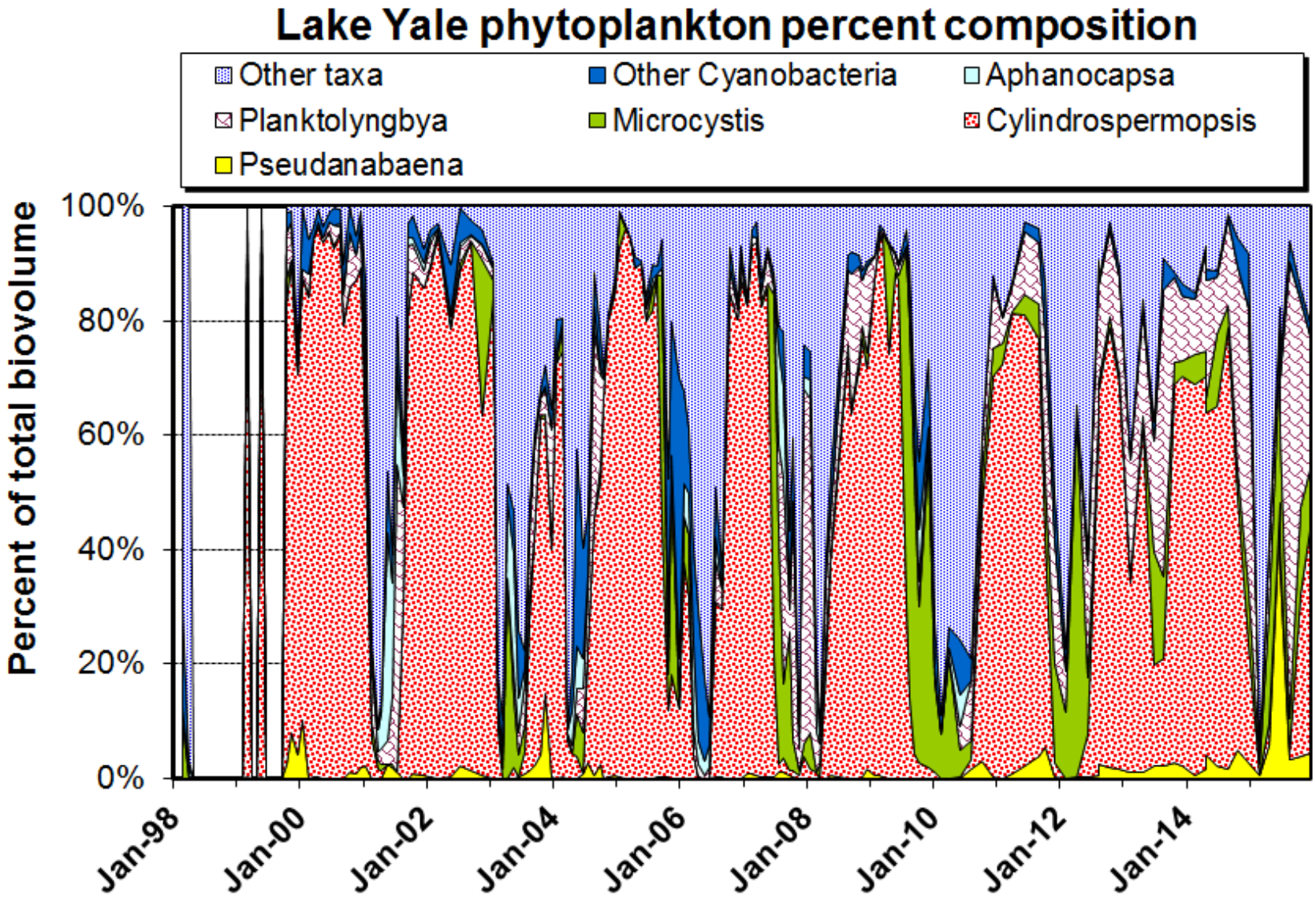

Lake Griffin estimated annual external total phosphorus loads, and concentrations of TP and chlorophyll-a
TP load (metric tons per year)
Concentration (µg/L)
0
10
20
30
40
50
0
100
200
300
1984-93
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Farming
Tributary flows
Atmospheric
Natural areas
Point source/septic
Stormwater runoff
Harris Bayou Restoration Area
Emeralda ag lands/rest area
TMDL
TP concentration
Chlorophyll-a


Lake Griffin phytoplankton biovolume
Other taxa
Cryptomonads
Diatoms
Mean chlorophyll-a
Dinoflagellates
Green algae
Cyanobacteria (Blue-green algae)
Biovolume (mm³/L)
Chlorophyll-a (µg/L)
150
100
50
0
300
200
100
0
Jan-95
Jan-97
Jan-99
Jan-01
Jan-03
Jan-05
Jan-07
Jan-09
Jan-11
Jan-13
Jan-15

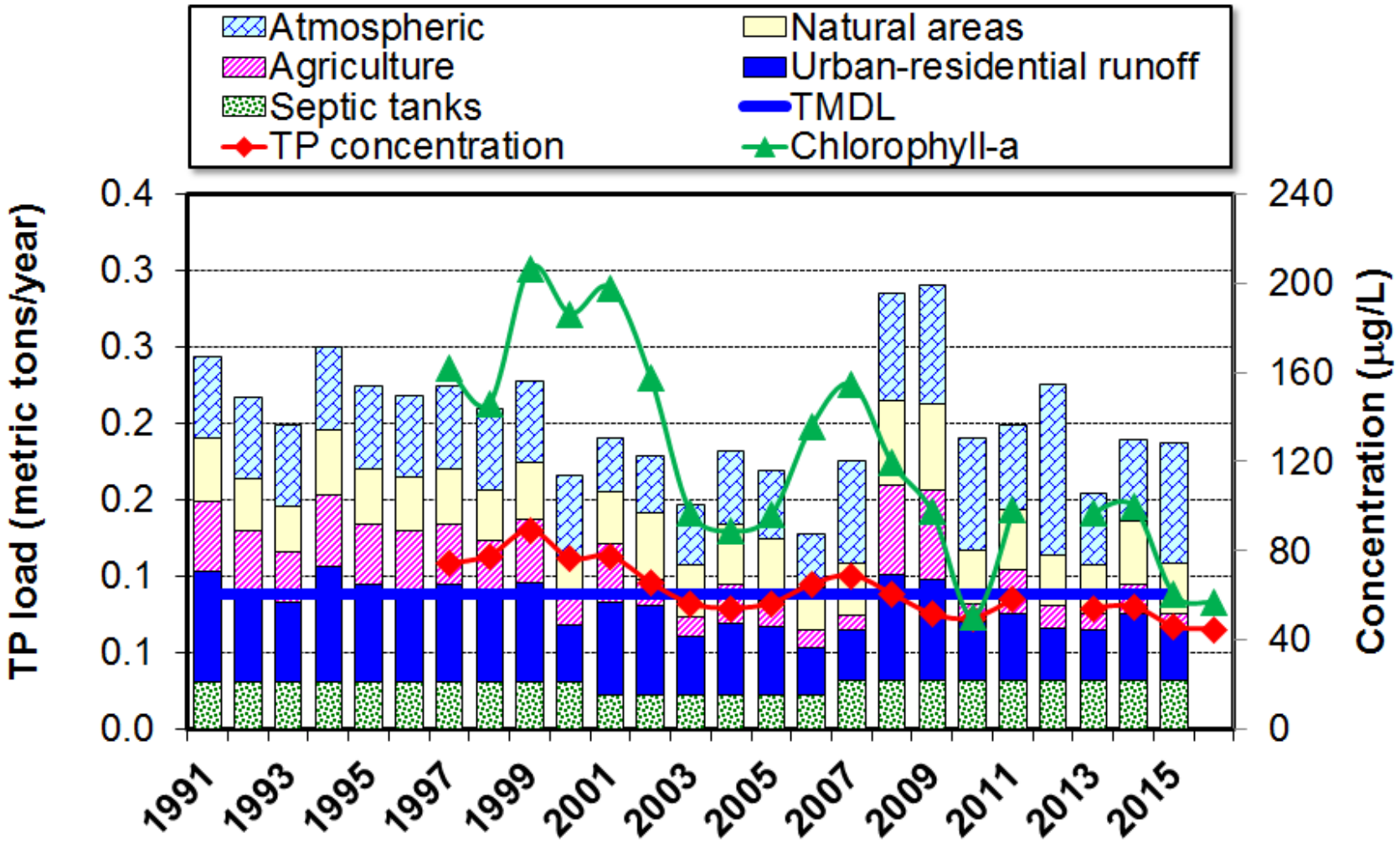

Lake Griffin phytoplankton percent composition
Other taxa
Other Cyanobacteria
Planktolyngbya
Microcystis
Cylindrospermopsis
Pseudanabaena
Percent of total biovolume
100%
80%
60%
40%
20%
0%
Jan-95
Jan-97
Jan-99
Jan-01
Jan-03
Jan-05
Jan-07
Jan-09
Jan-11
Jan-13
Jan-15


Lake Yale estimated annual external total phosphorus loads, and concentrations of TP and chlorophyll-a
Lake Griffin
Atmospheric
Natural areas
Agriculture
Urban-residential
Septic tanks
Point source
TMDL
TP concentration
Chlorophyll-a
TP load (metric tons/ year)
Concentration (µg/L)
2.8
2.1
1.4
0.7
0.0
70
60
50
40
30
20
10
0
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015

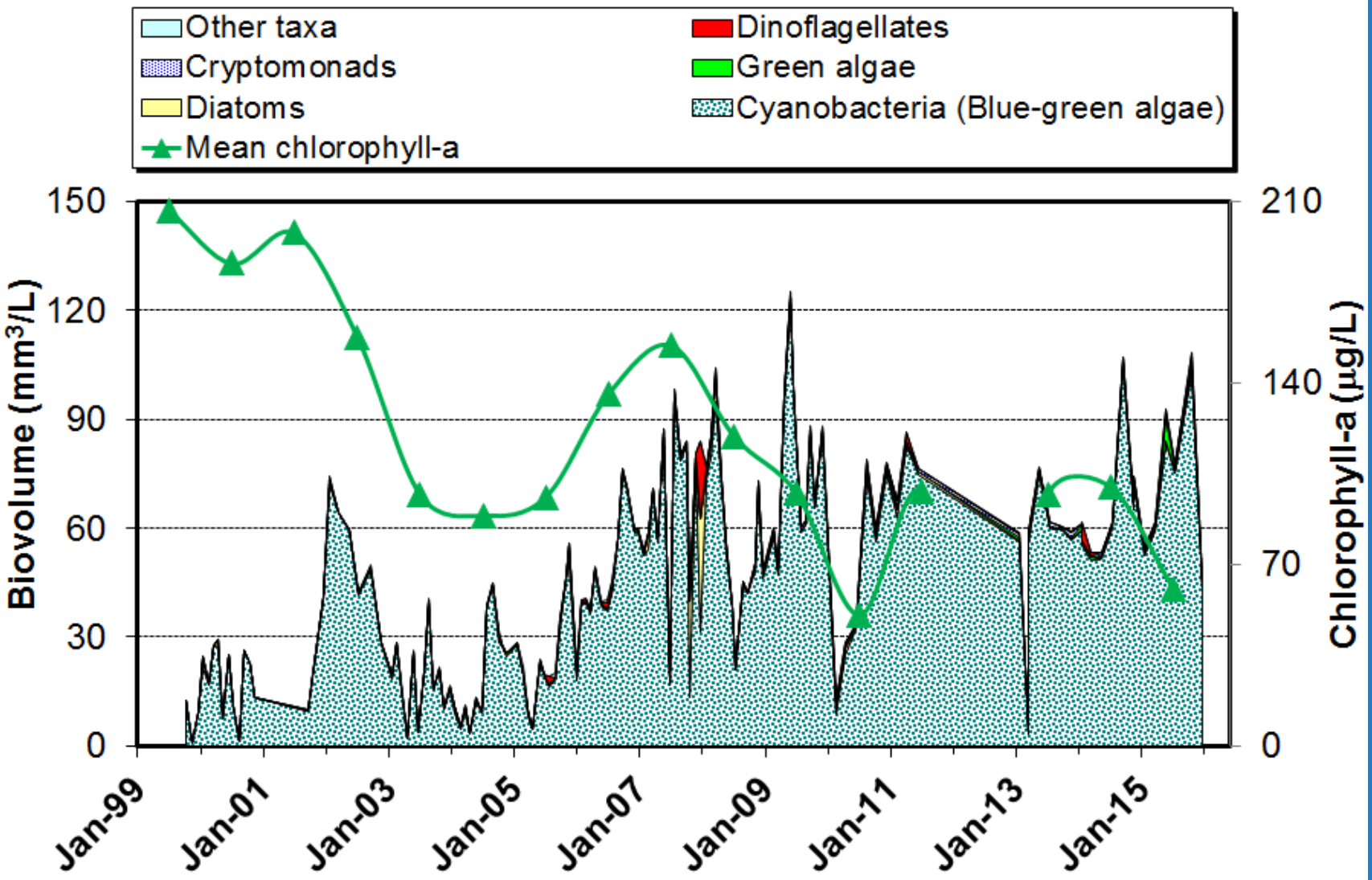

Lake Yale phytoplankton biovolume
Other taxa
Dinoflagellates
Cryptomonads
Green algae
Diatoms
Cyanobacteria
Mean chlorophyll-a
Biovolume (mm³/L)
Chlorophyll-a (µg/L)
0
20
40
60
80
0
10
20
30
40
50
60
70
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Jan-01
Jan-03
Jan-05
Jan-07
Jan-09
Jan-11
Jan-13
Jan-15


Lake Yale phytoplankton percent composition
Other taxa
Other Cyanobacteria
Aphanocapsa
Planktolyngbya
Microcystis
Cylindrospermopsis
Pseudanabaena
Percent of total biovolume
100%
80%
60%
40%
20%
0%
Jan-98
Jan-00
Jan-02
Jan-04
Jan-06
Jan-08
Jan-10
Jan-12
Jan-14

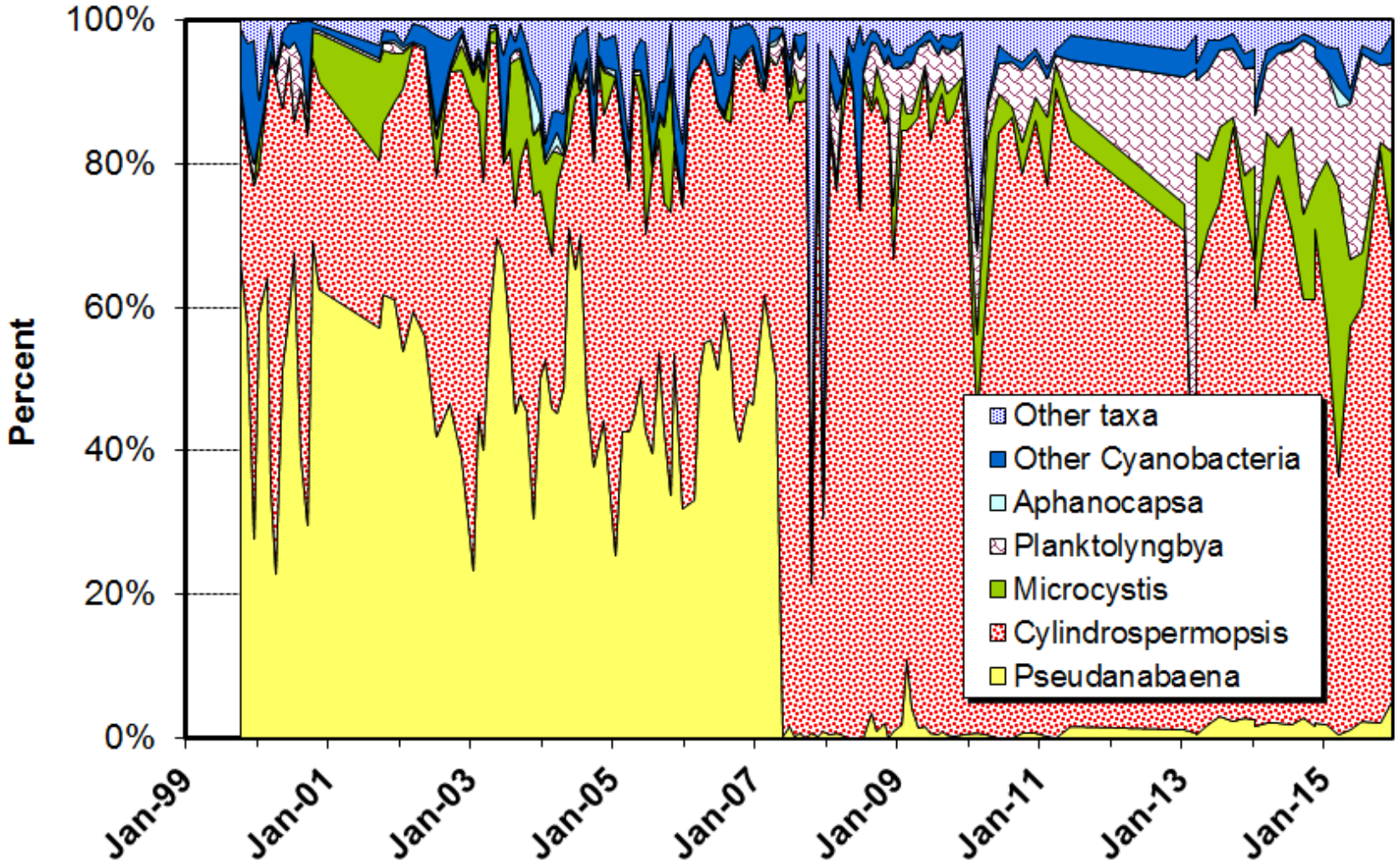
Lake Carlton estimated annual external total phosphorus loads, and concentrations of TP and chlorophyll-a

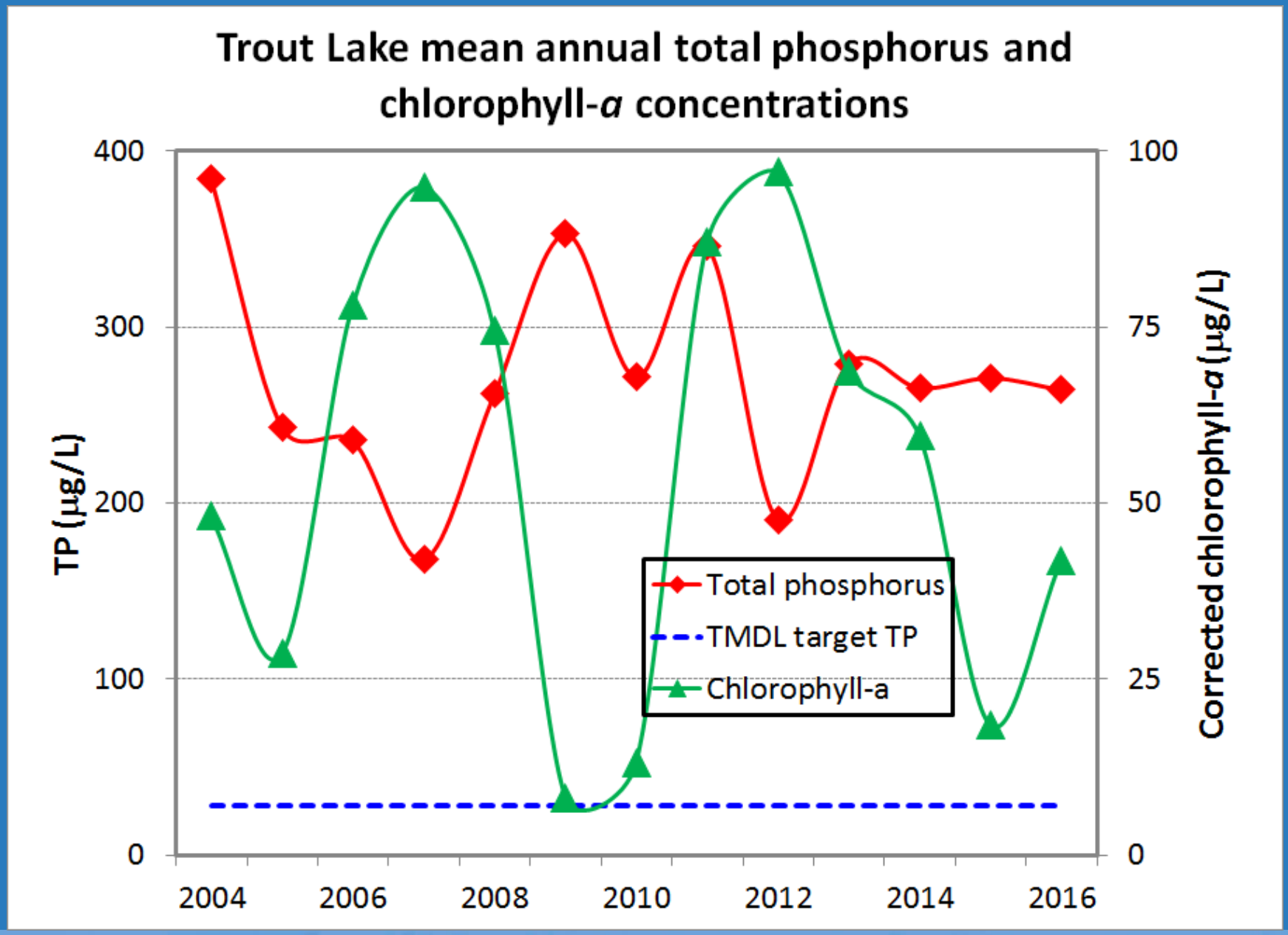


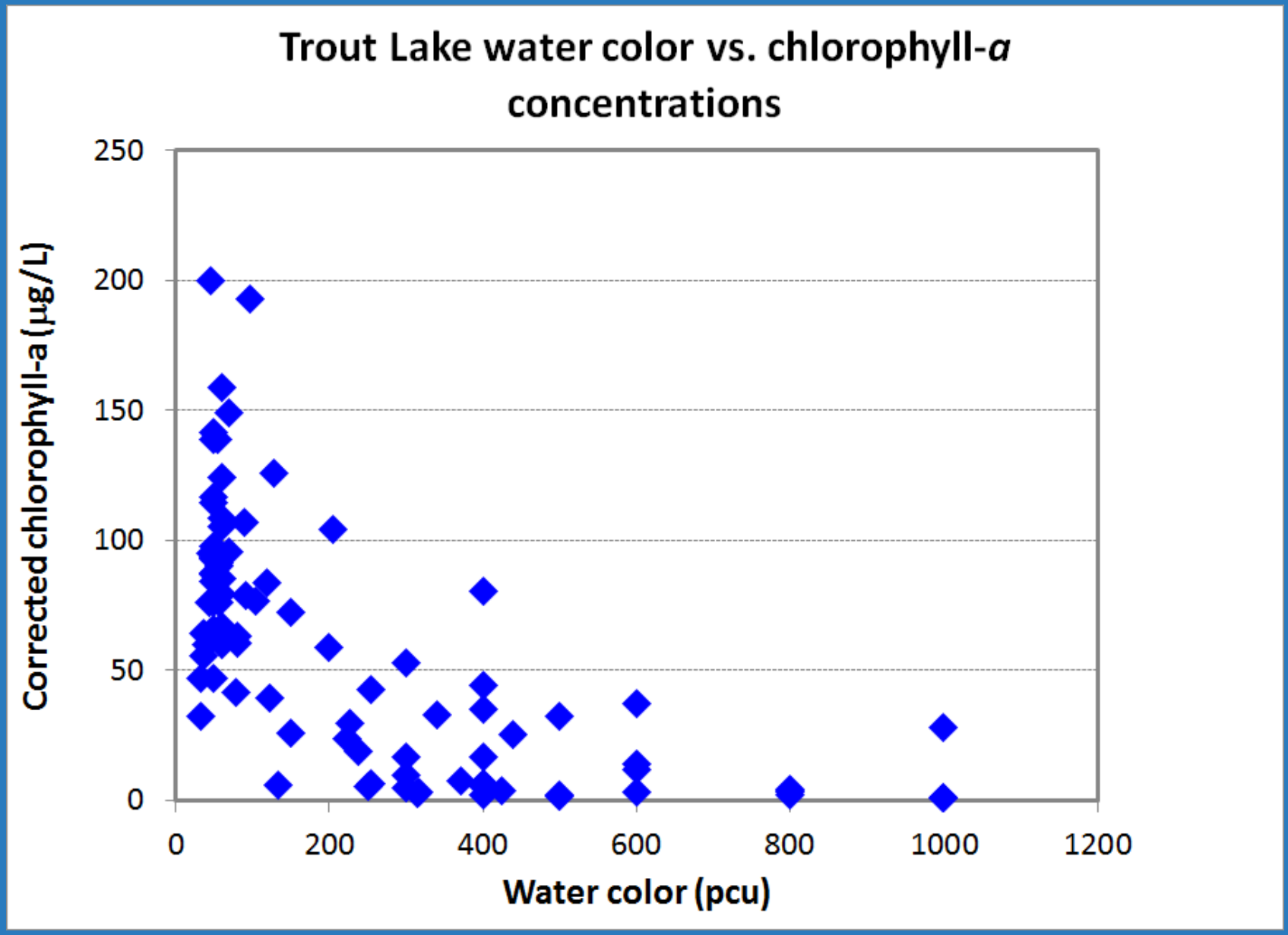
Lake Carlton phytoplankton biovolume



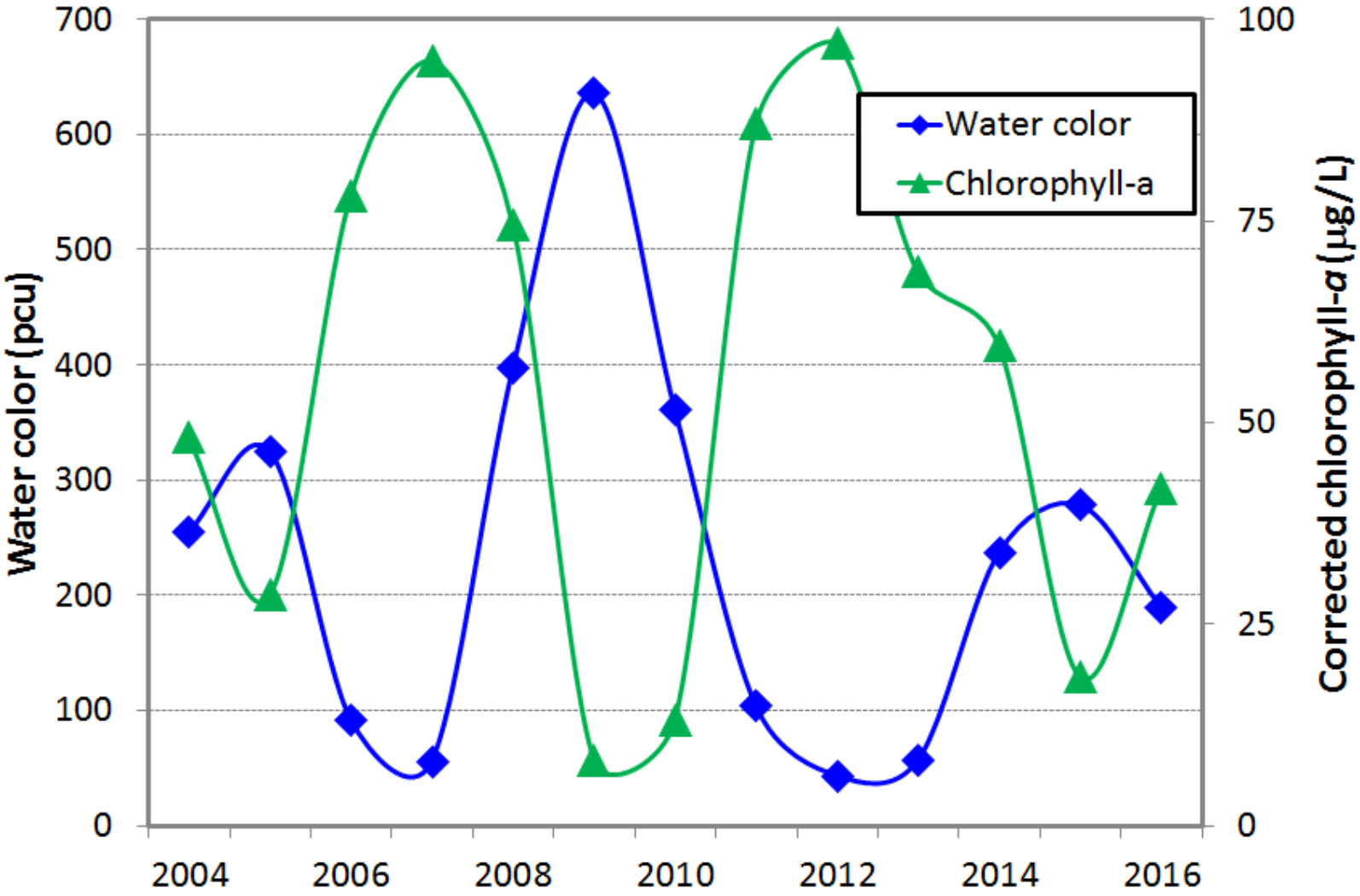
Lake Carlton phytoplankton percent composition



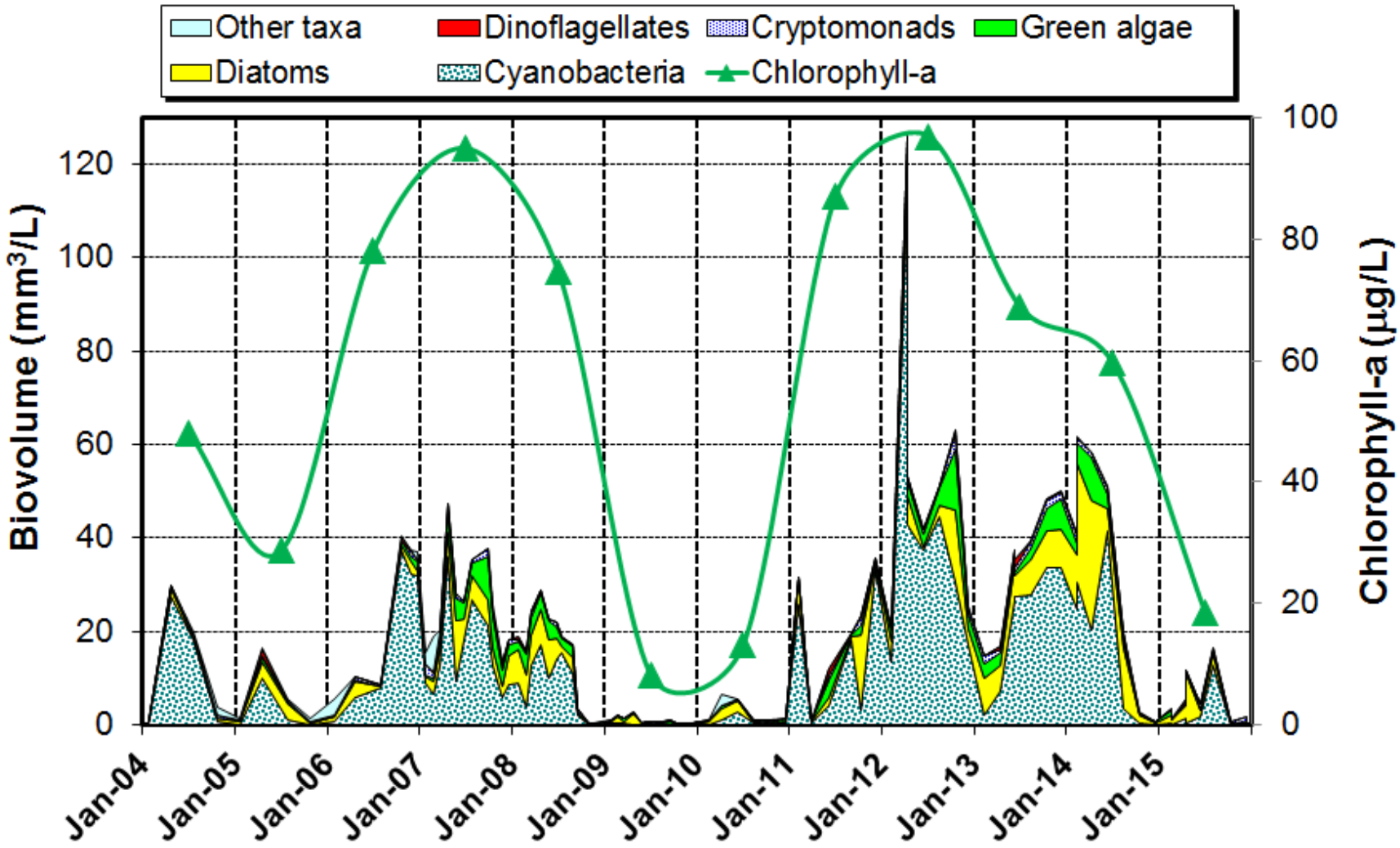

Trout Lake mean annual total phosphorus and chlorophyll-a concentrations
TP (µg/L)
Corrected chlorophyll-a (µg/L)
400
300
200
100
0
100
75
50
25
0
2004
2006
2008
2010
2012
2014
2016
Total phosphorus
TMDL target TP
Chlorophyll-a


Trout Lake water color vs. chlorophyll-a concentrations
Corrected chlorophyll-a (µg/L)
250
200
150
100
50
0
0
200
400
600
800
1000
1200
Water color (pcu)

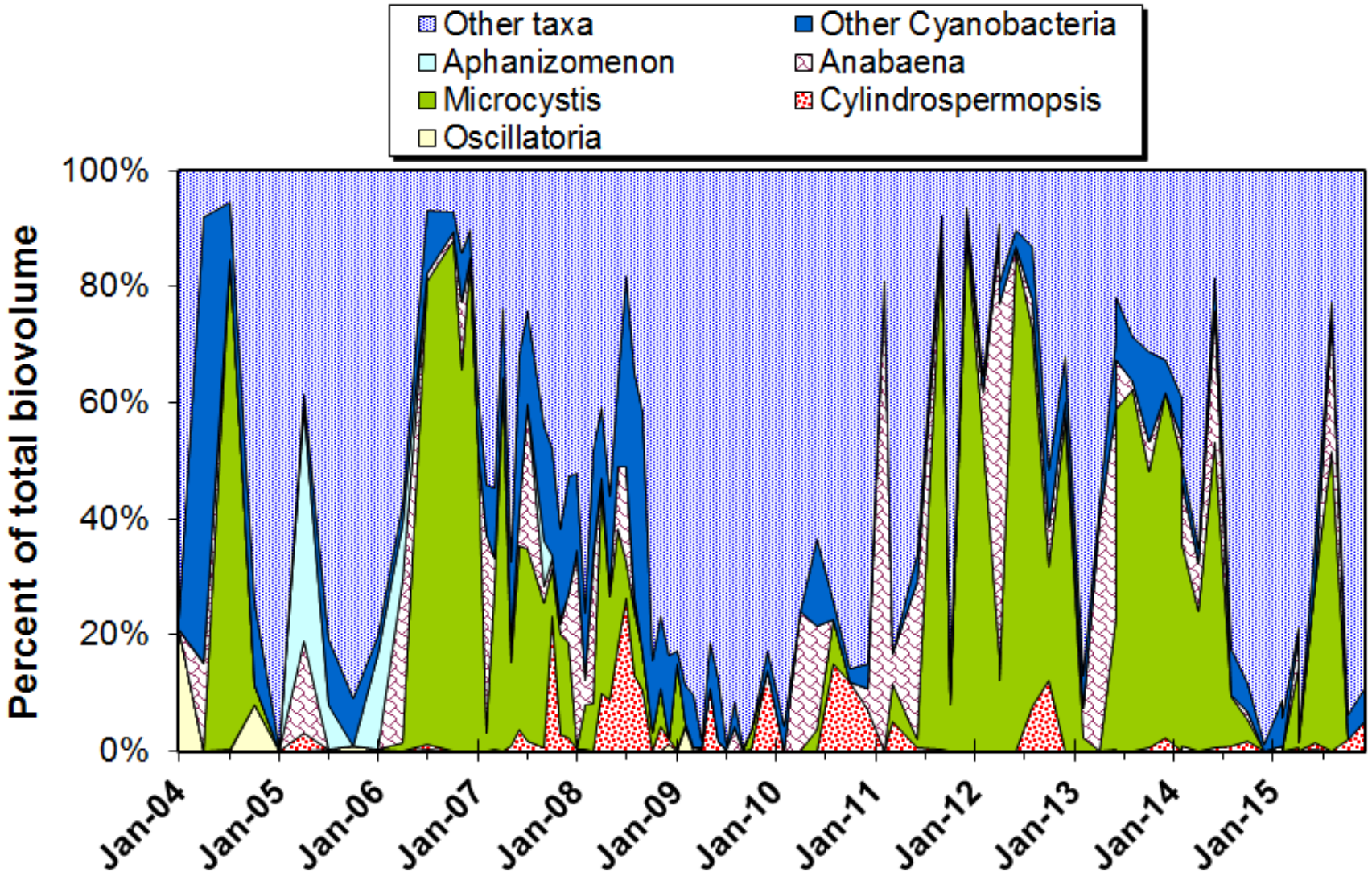
Trout Lake mean annual water color and chlorophyll-*a* concentrations



Trout Lake phytoplankton biovolume



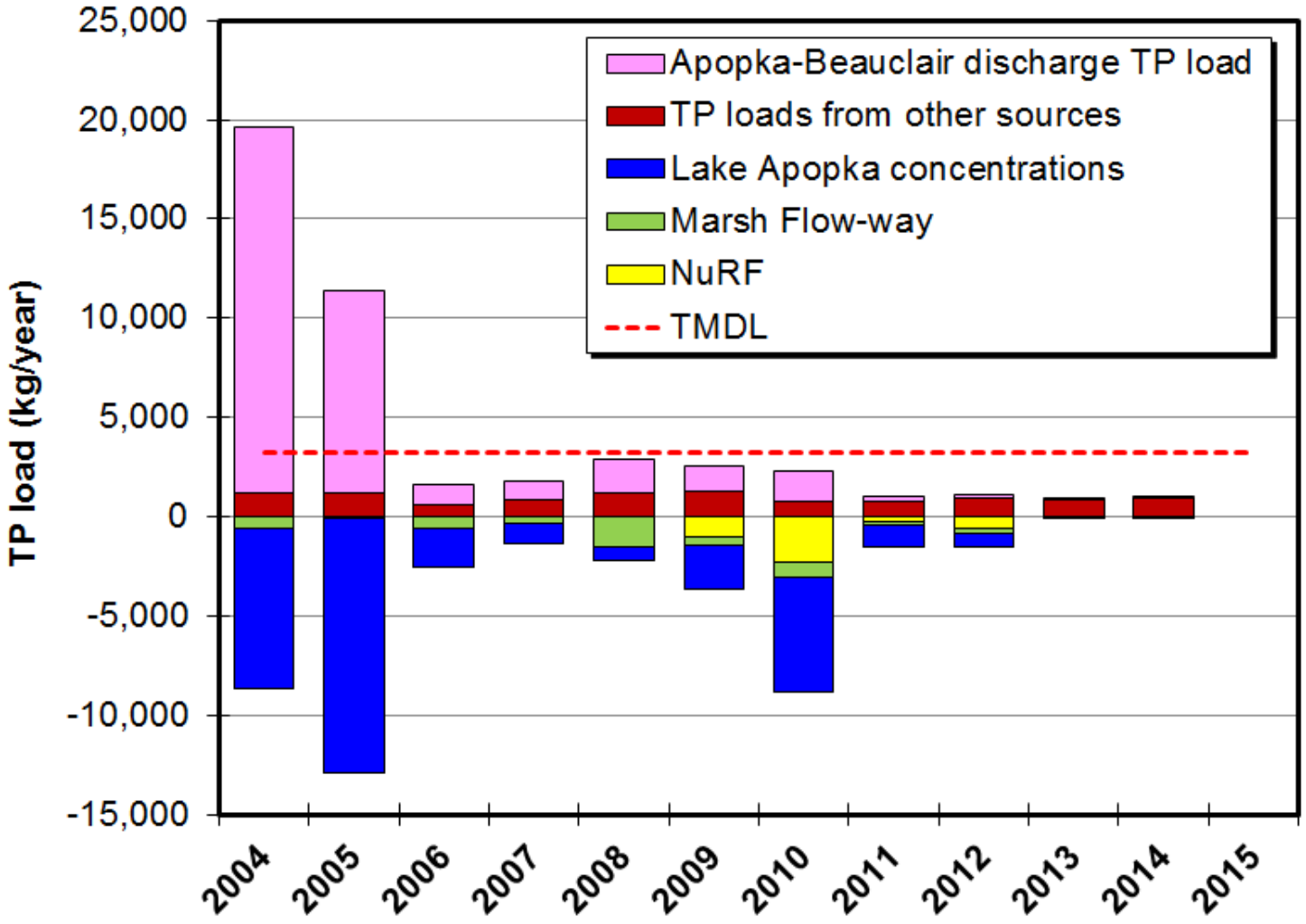
Trout Lake phytoplankton percent composition

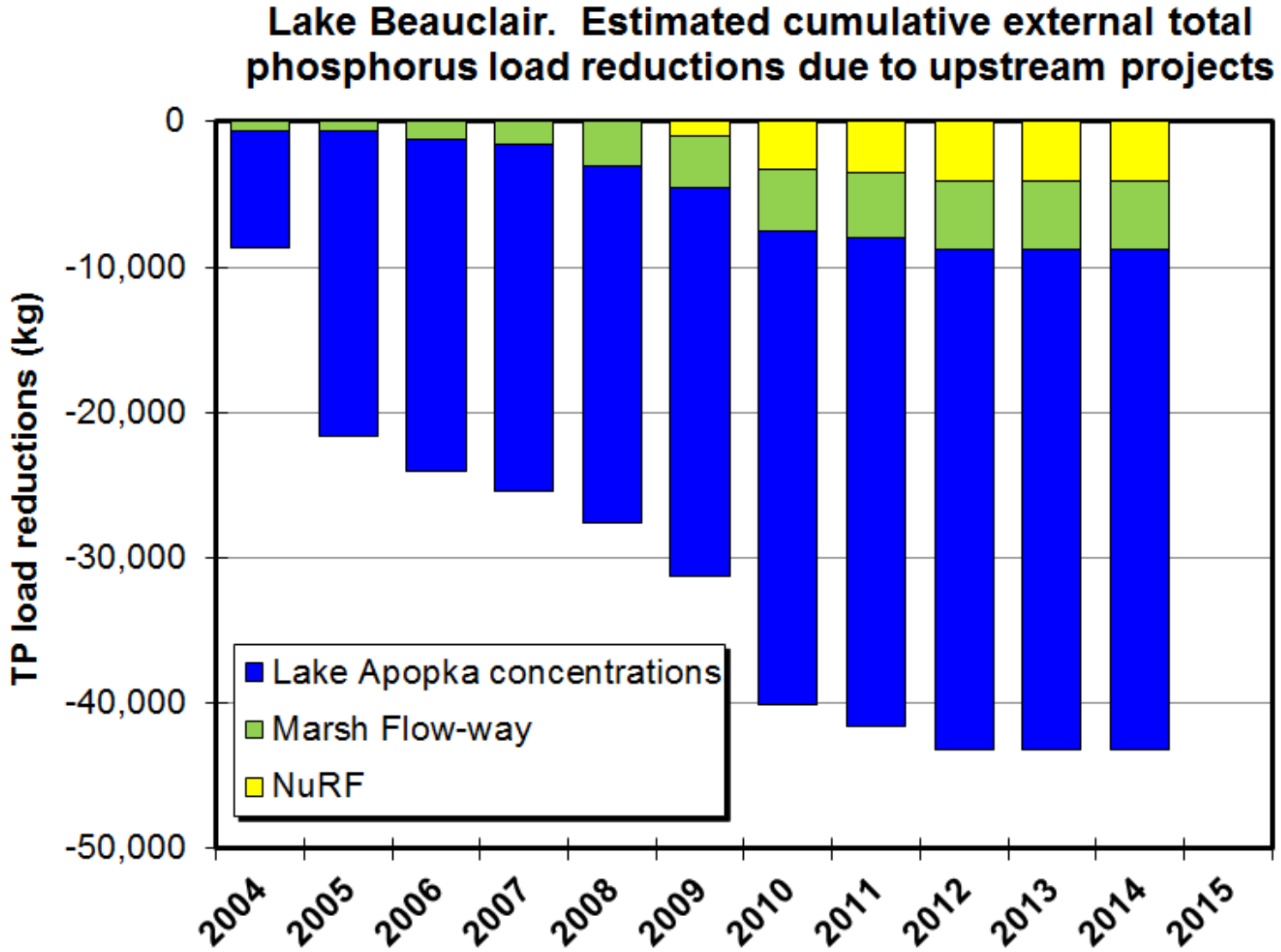


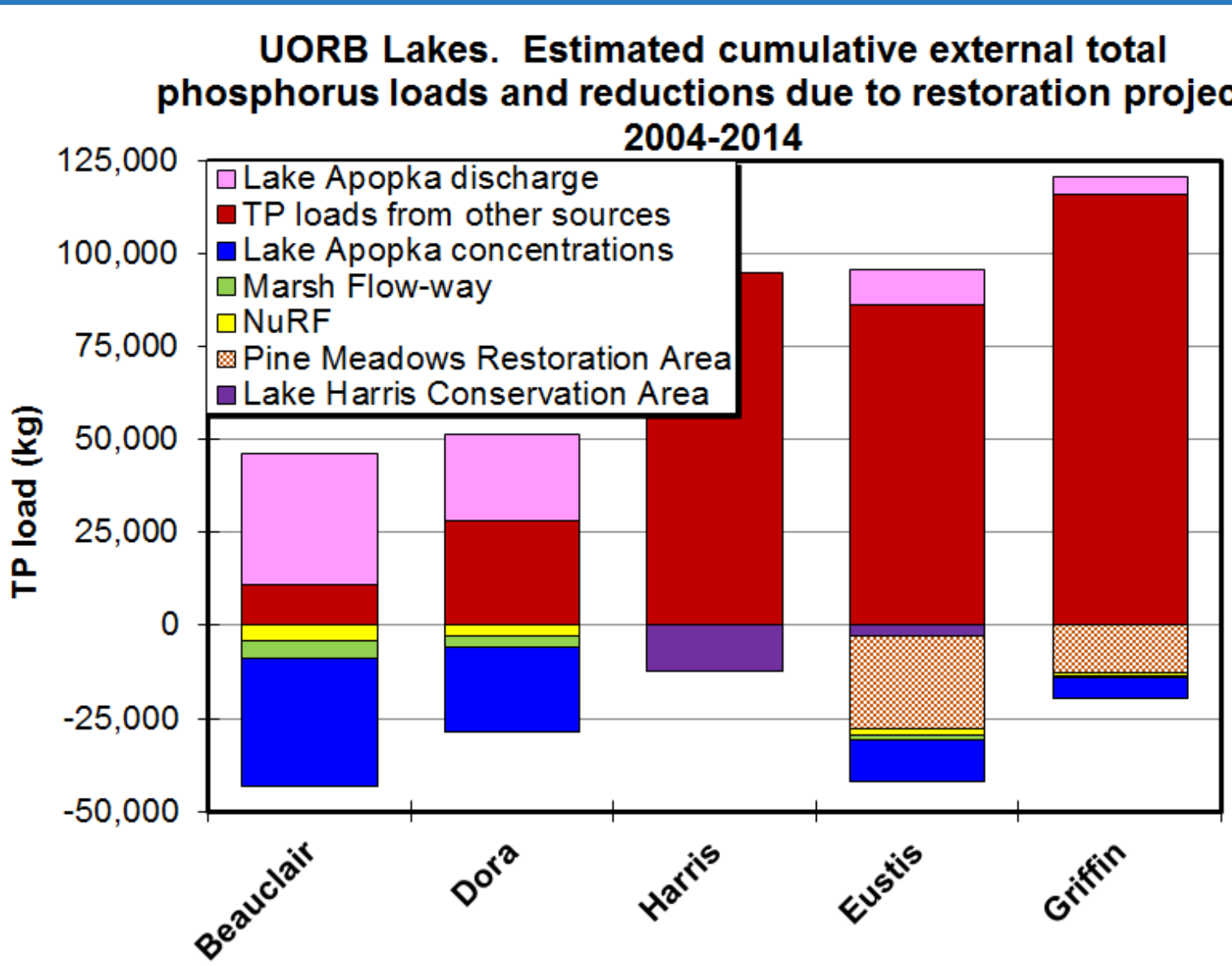
Effects of major projects on TP loading to downstream lakes

- Lake Apopka concentration changes since TMDL baseline period (1989-1994)
  - LANS restoration, Marsh flow-way, gizzard shad harvest, water level changes
- Marsh flow-way – 15% of total TP removals
- NuRF project
- Pine Meadows Restoration Area
- Lake Harris Conservation Area

Lake Beauclair. Estimated annual external total phosphorus loads and reductions due to upstream projects




Lake Beauclair. Estimated cumulative external total phosphorus load reductions due to upstream projects
TP load reductions (kg)
0
-10,000
-20,000
-30,000
-40,000
-50,000
Lake Apopka concentrations
Marsh Flow-way
NuRF
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015


UORB Lakes. Estimated cumulative external total phosphorus loads and reductions due to restoration projects 2004-2014
TP load (kg)
125,000
100,000
75,000
50,000
25,000
0
-25,000
-50,000
Lake Apopka discharge
TP loads from other sources
Lake Apopka concentrations
Marsh Flow-way
NuRF
Pine Meadows Restoration Area
Lake Harris Conservation Area
Beauclair
Dora
Harris
Eustis
Griffin

Summary (1)

- Generally best water quality in lakes Eustis, Harris, and Yale, and in recent years Griffin
- TP load decreases and substantial water quality improvements in lakes Apopka, Beauclair, Dora, and Griffin
  - Due primarily to SJRWMD and LCWA projects

Summary (2)

- Smaller load decreases and water quality improvements in lakes Harris, Eustis, and Carlton
  - May reflect reduced loading due to extended dry conditions, restoration activities, basin stormwater projects
- Water quality deterioration in Trout Lake and Lake Yale
  - No projects in Yale basin

Summary (3)

- Water quality substantially improved in 2015-16 in most of basin lakes, reaching or approaching TMDL TP target concentrations
- Phytoplankton tends to be dominated by *Cylindrospermopsis*, except for lakes Apopka (*Planktolyngbya*) and Trout (*Microcystis*)

More information

- Coveney, M.F. 2016. Water quality changes in Lake Apopka, Florida, and the St. Johns River Water Management District's restoration program. Technical Memorandum 56.
- Fulton, R.S. III. 2016. Nutrient loading and water quality trends in the Upper Ocklawaha basin lakes through 2014. Technical Memorandum 54-2.