Cyanobacteria in the Lower Columbia River

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S. Dyer


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The Columbia River

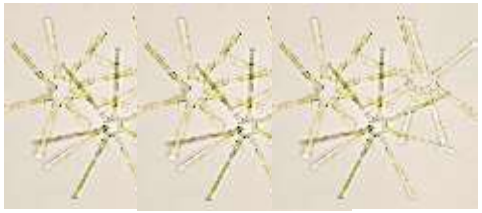
Lower Columbia

- Culturally important
- Key transportation conduit
- Critical habitat for salmonids
- River of national significance (EPA)
- Generator of hydroelectric power

Competing issues: endangered species, flood control, navigation, traditional fishing grounds, Hanford nuclear reactor

Ecosystem Monitoring Program seeks to inform wetland restoration activities by providing fundamental ecological knowledge about salmonid habitats and food webs

Invertebrates



Vascular plants

Aquatic, terrestrial

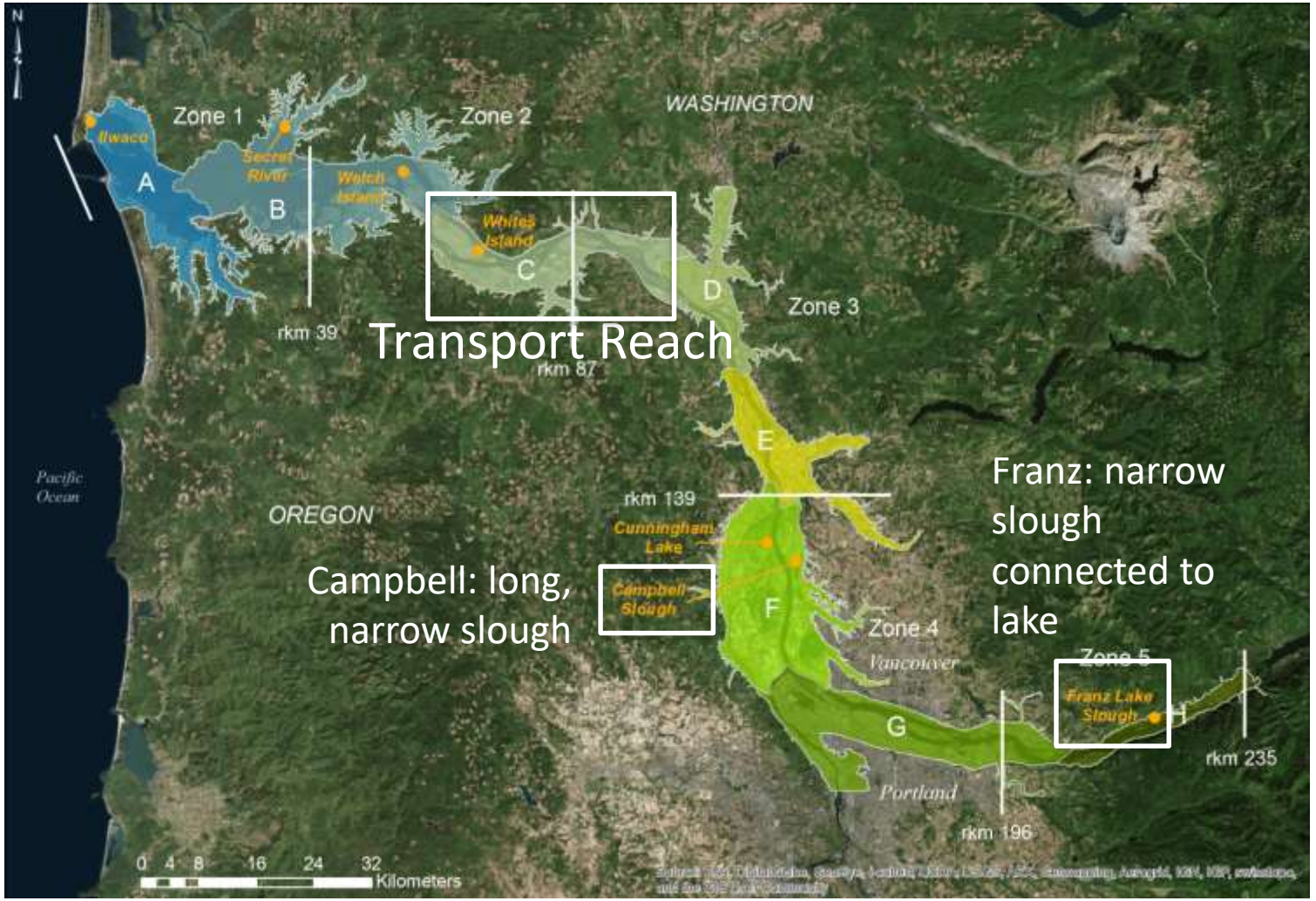
Freshwater & marine

Phytoplankton & macroalgae

Fluvial, benthic

Freshwater & marine

Columbia River: Ecosystem Monitoring Program (~2011 – present)

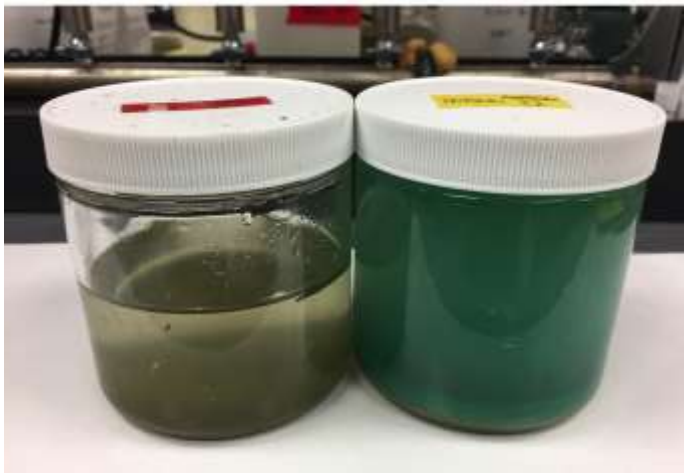


Campbell: long, narrow slough

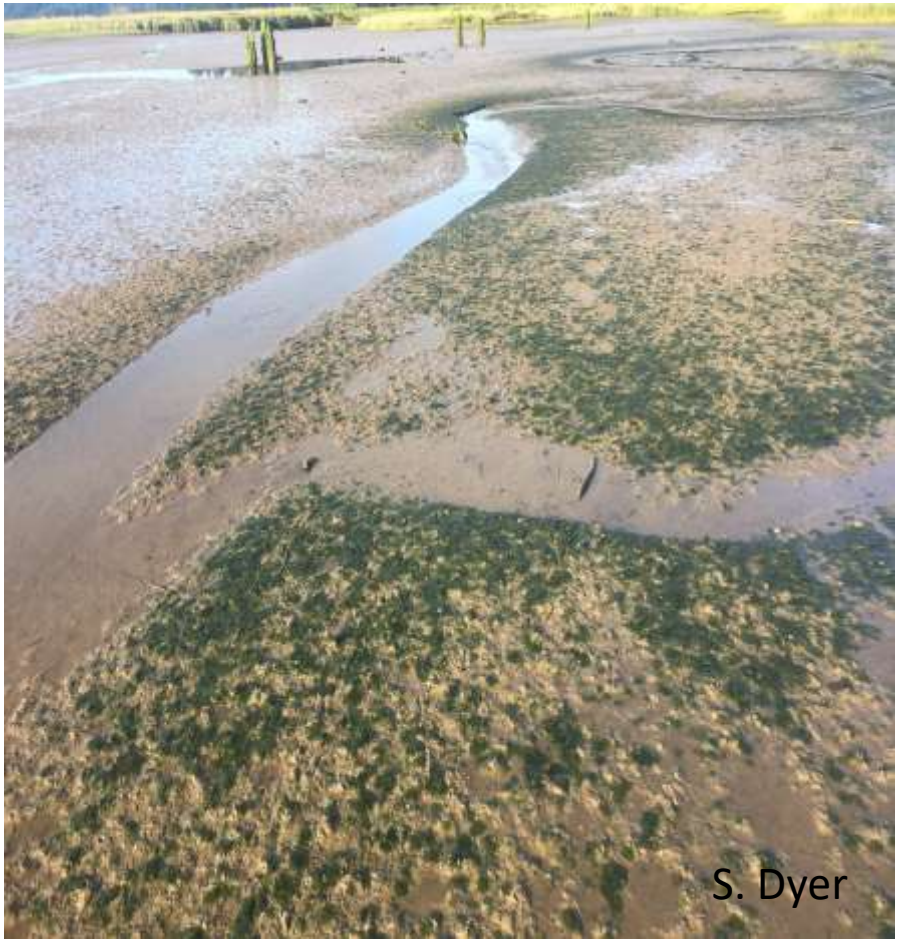
Franz: narrow slough connected to lake

Increasing tidal influence

Cyanobacteria blooms in the Columbia River have been repeatedly detected during the Ecosystem Monitoring Program



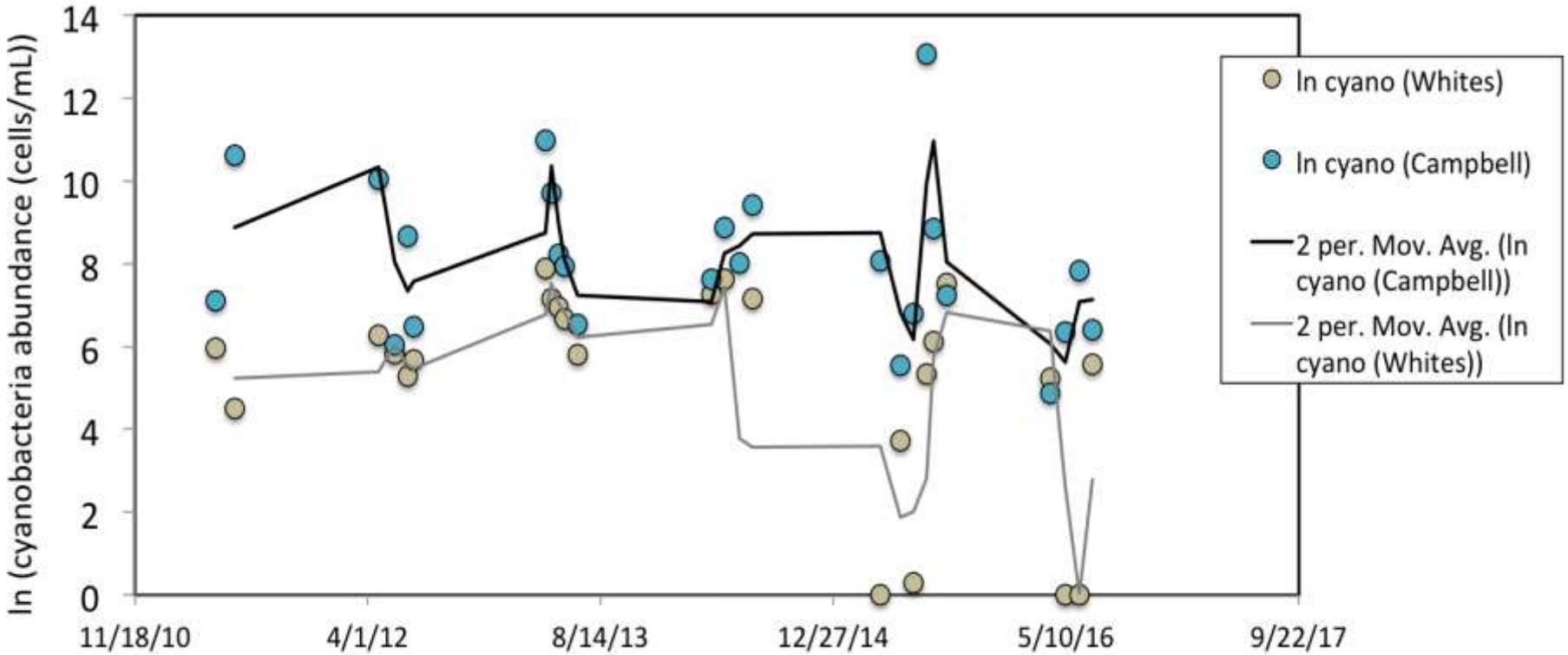
- **Where, when, who, and why do cyanobacteria blooms develop in the Columbia River?**
- **Do the blooms pose a problem to the public and to wildlife?**
- **If so, what can we do about it?**



Nature of observations

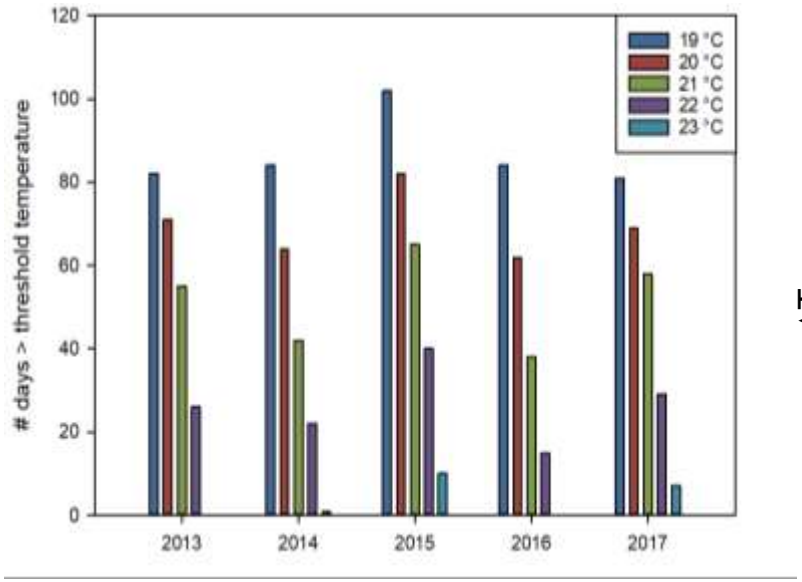
- Grab samples (2011 – present)
  - 4–6 sites
- Net tows (2011 – present)
  - 4–6 sites
- In situ sensors ~specific to cyanobacteria (2015 – present)
  - 2 sites

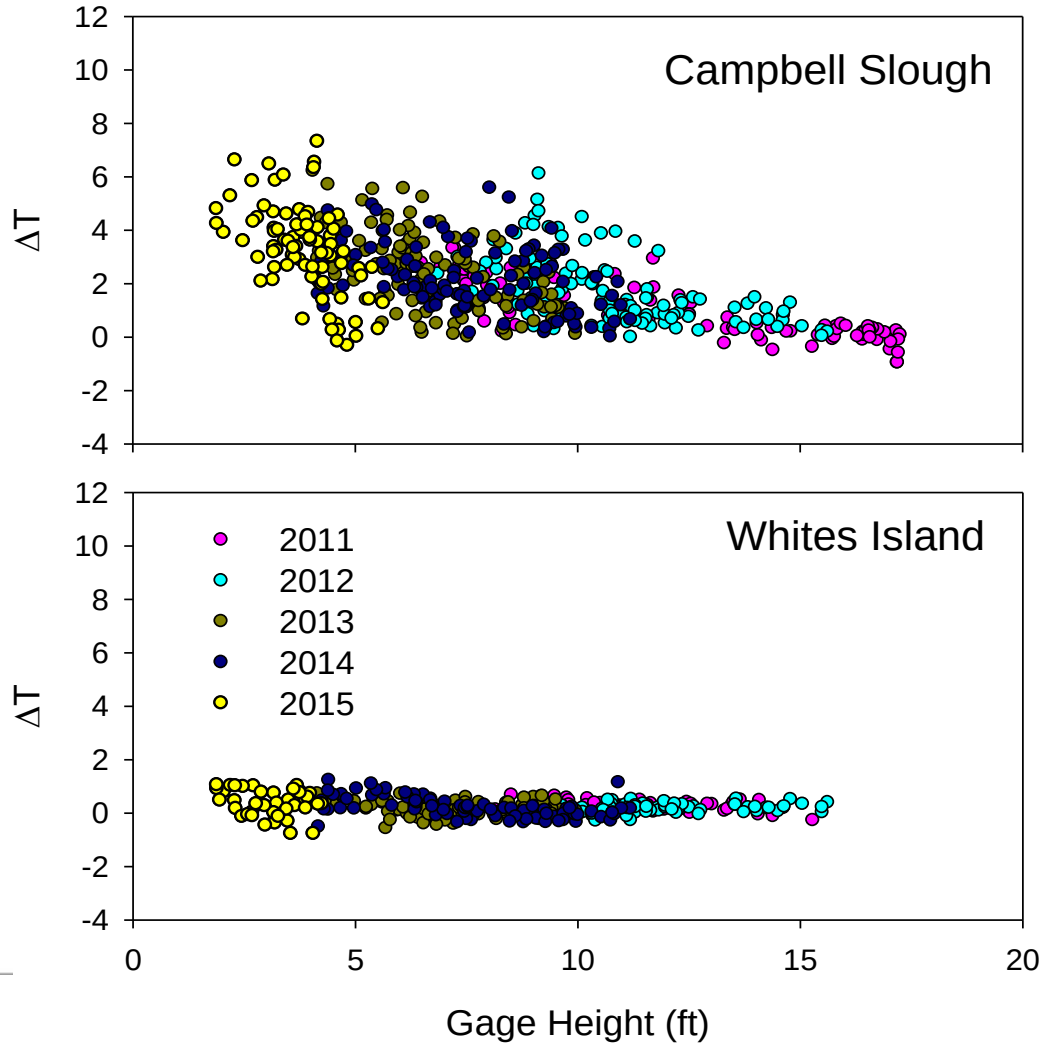
Total cyanobacteria densities tend to be higher at Campbell Slough than Whites Island



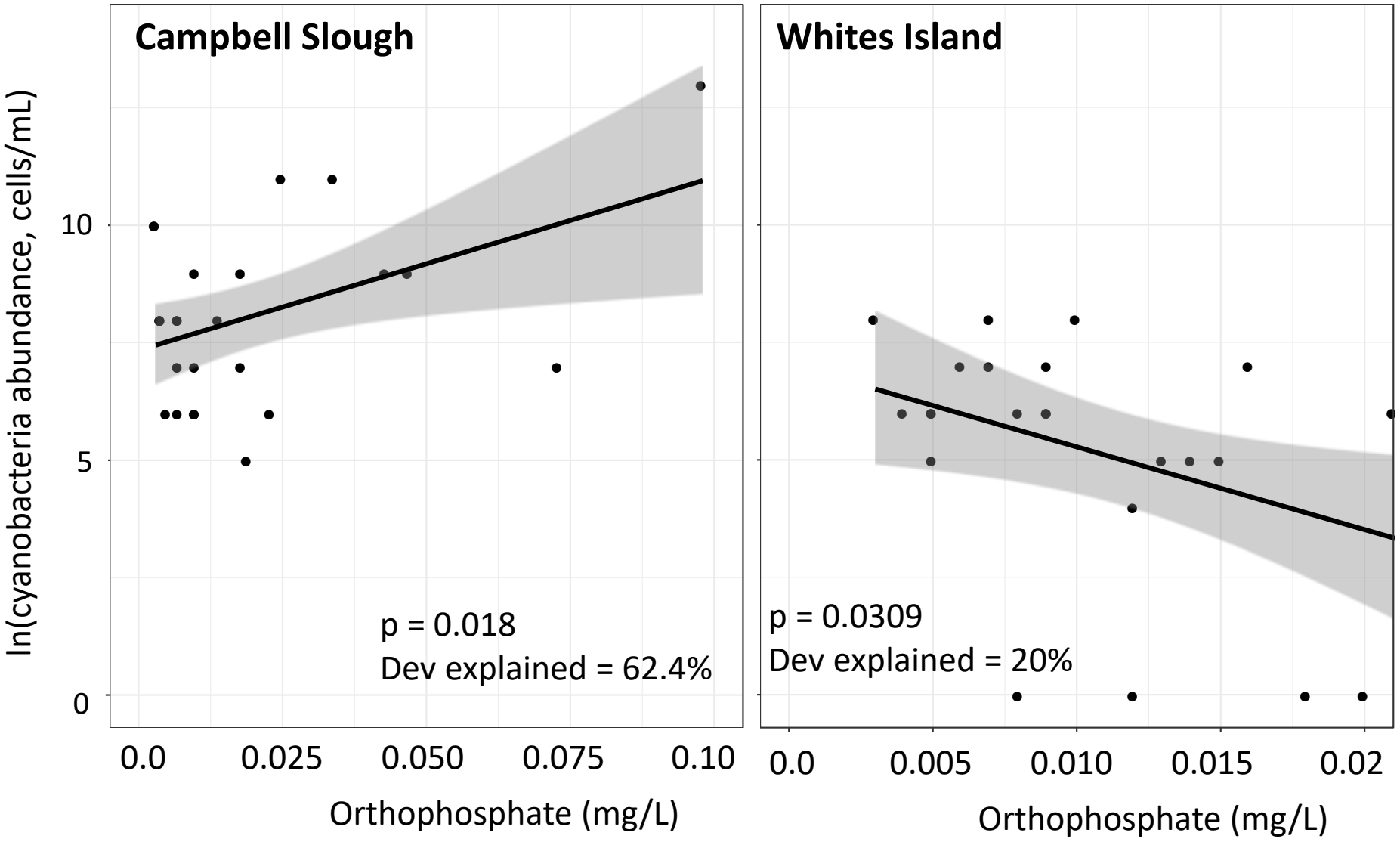
As water levels drop, Campbell Slough diverges from mainstem conditions more than Whites Island

ΔT is the difference in temperature between the off-channel site and the mainstem, as measured by continuous, in situ sensors

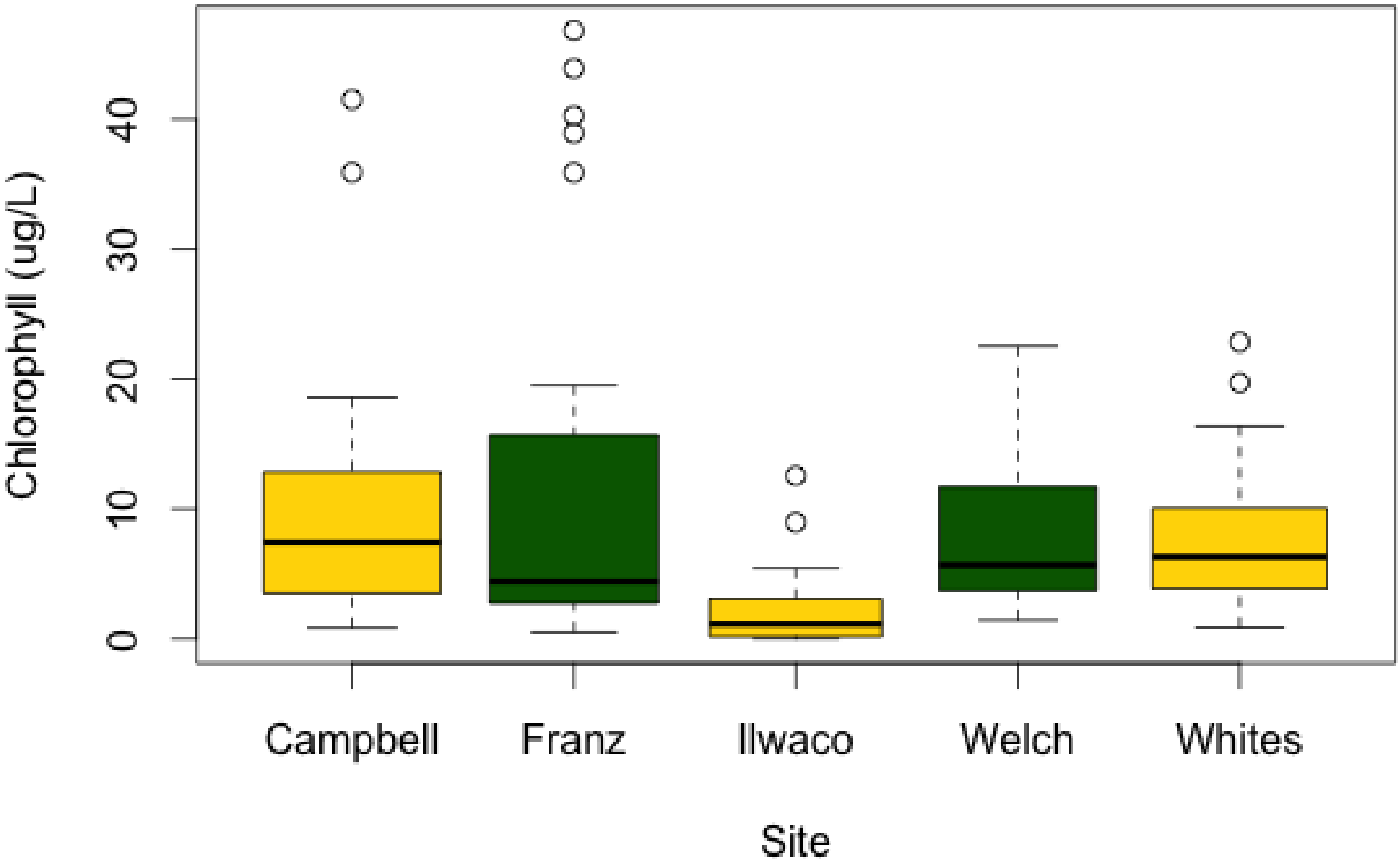


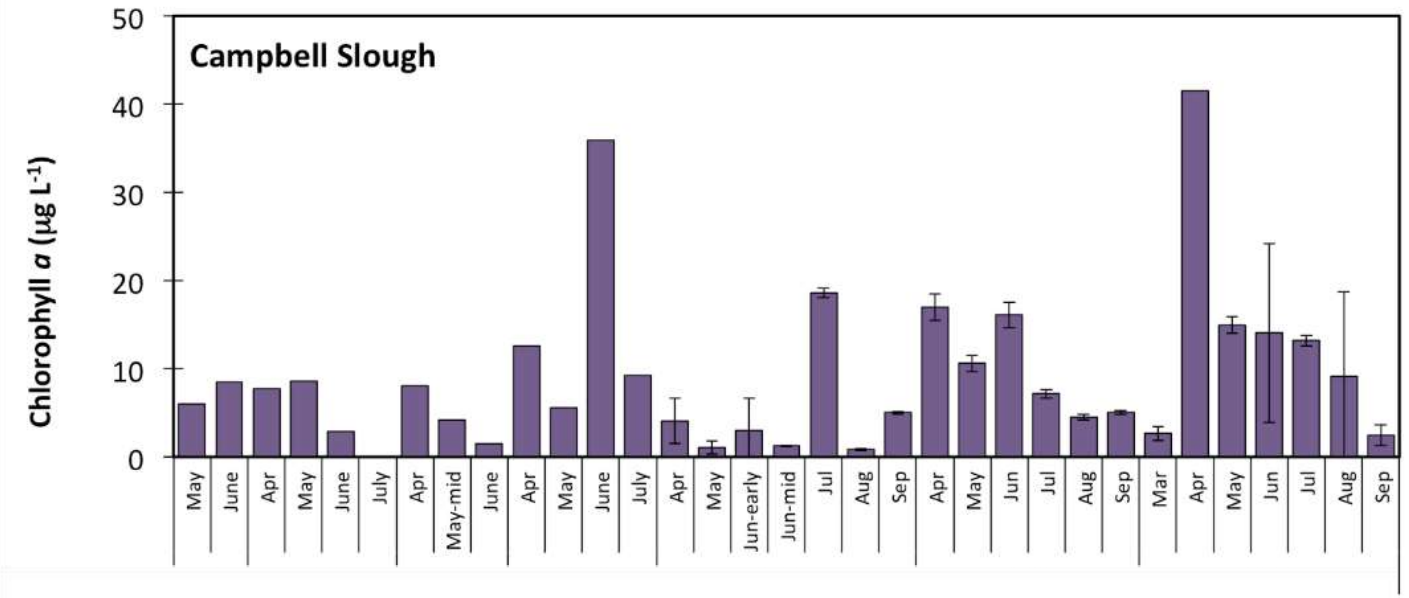


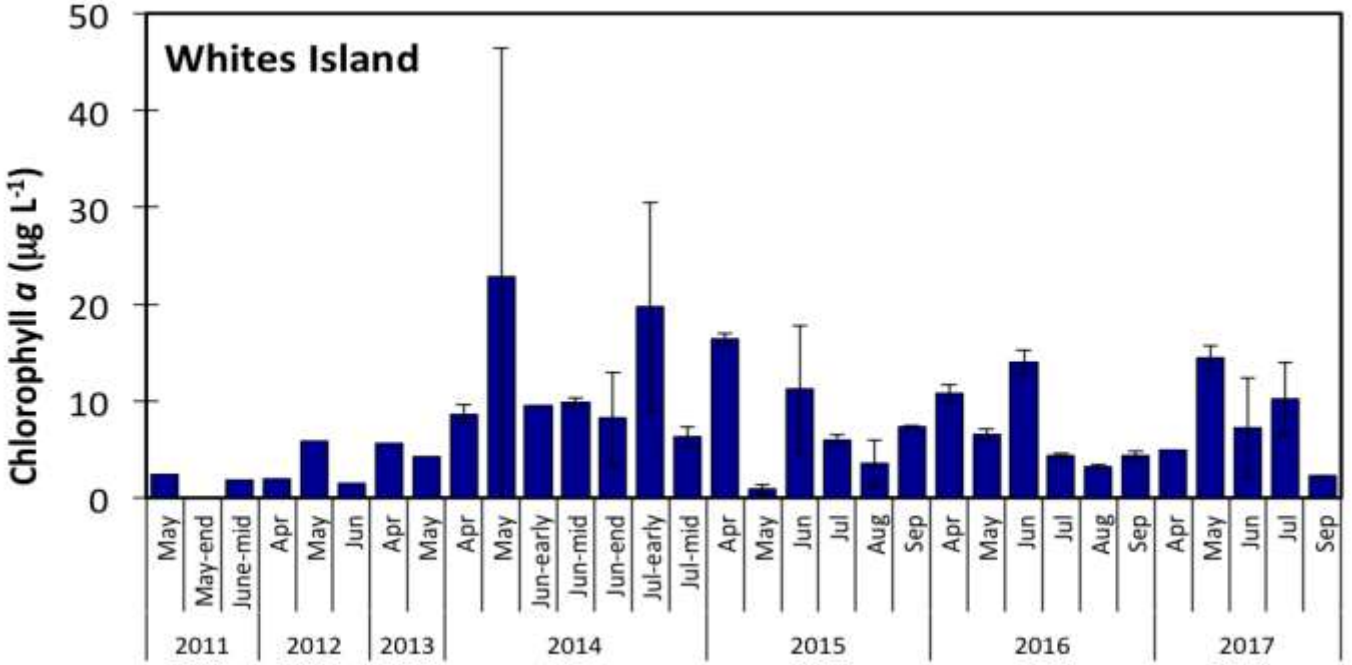
Phosphate concentrations predict cyanobacteria abundance

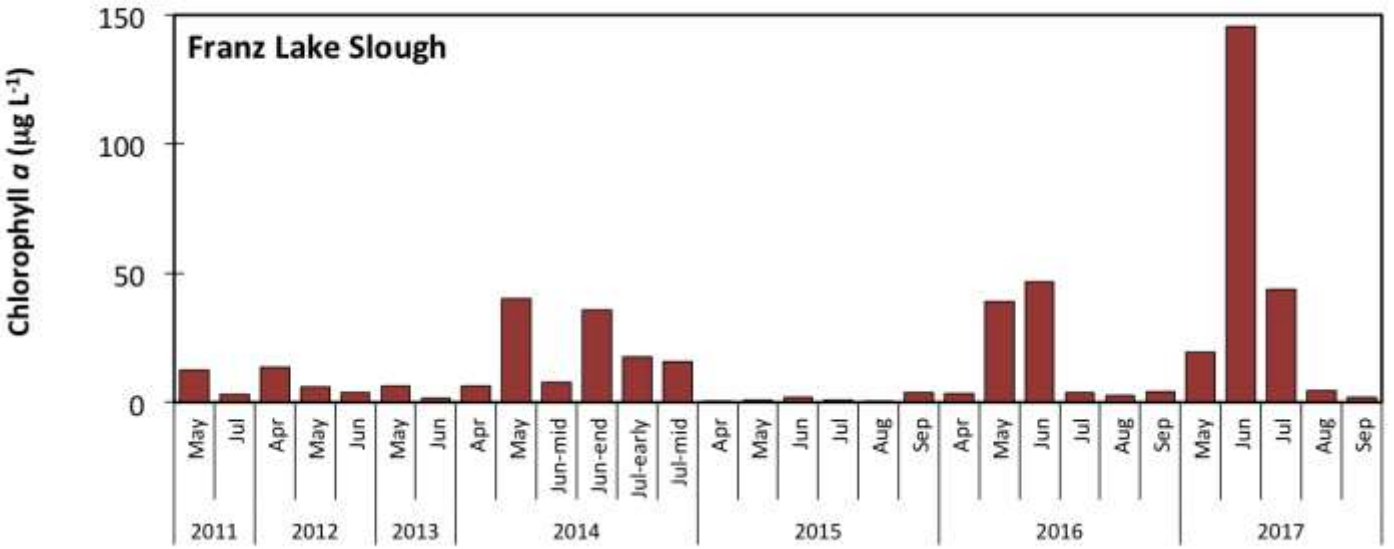


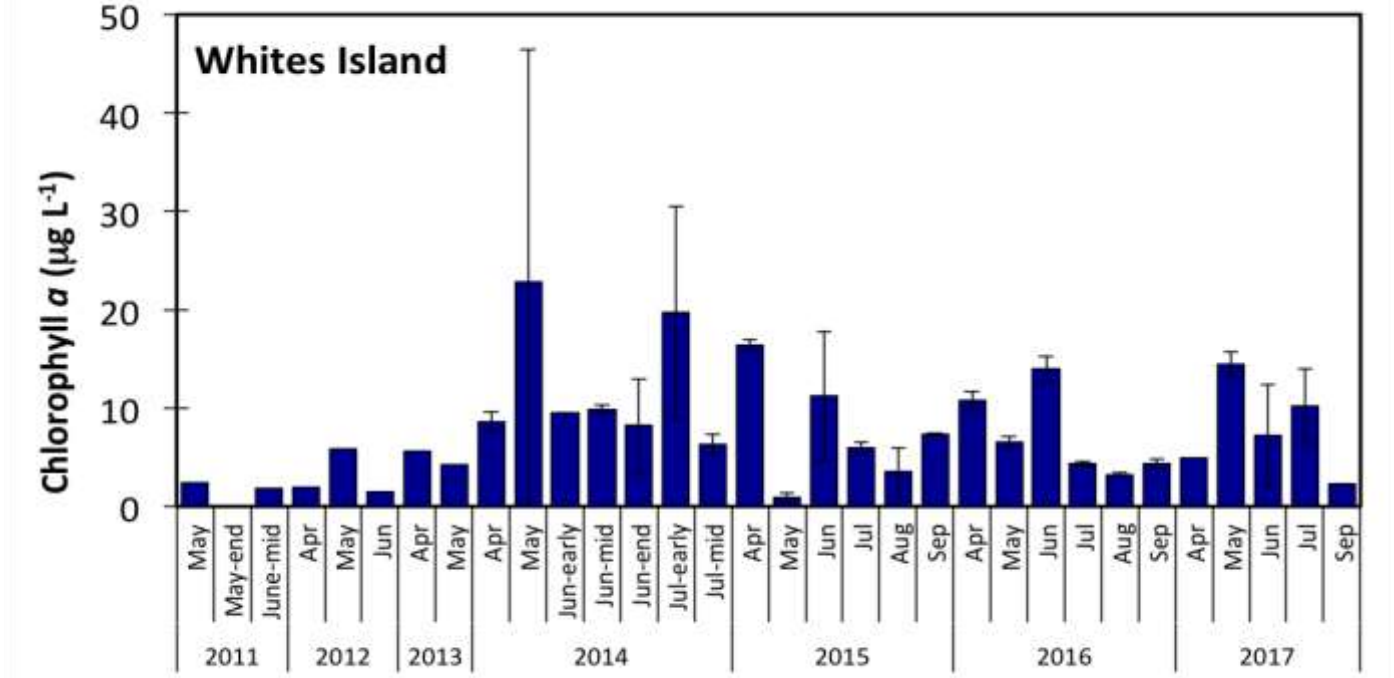
Bulk chlorophyll concentrations are higher at Campbell Slough and Franz Lake Slough than other sites



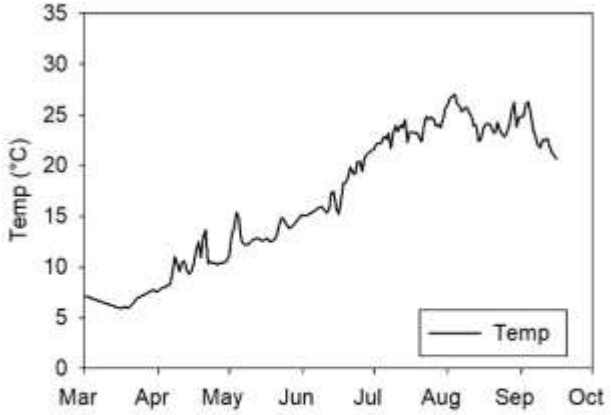

Campbell Slough
Chlorophyll a (µg L-1)
50
40
30
20
10
0
May
June
Apr
May
June
July
Apr
May-mid
June
Apr
May
June
July
Apr
May
Jun-early
Jun-mid
Jul
Aug
Sep
Apr
May
Jun
Jul
Aug
Sep
Mar
Apr
May
Jun
Jul
Aug
Sep

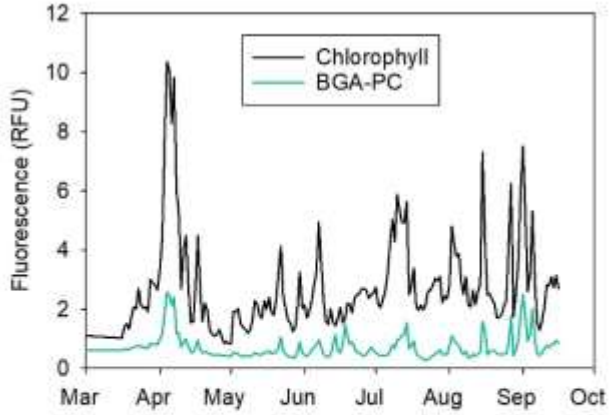

Whites Island
Chlorophyll a (µg L-1)
50
40
30
20
10
0
May
May-end
June-mid
Apr
May
Jun
Apr
May
Apr
May
Jun-early
Jun-mid
Jun-end
Jul-early
Jul-mid
Apr
May
Jun
Jul
Aug
Sep
Apr
May
Jun
Jul
Aug
Sep
Apr
May
Jun
Jul
Sep
2011
2012
2013
2014
2015
2016
2017

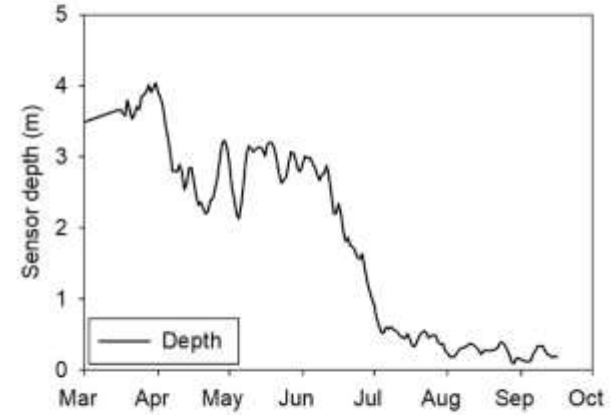

Franz Lake Slough
Chlorophyll a (µg L-1)
150
100
50
0
May
Jul
Apr
May
Jun
May
Jun
Apr
May
Jun-mid
Jun-end
Jul-early
Jul-mid
Apr
May
Jun
Jul
Aug
Sep
Apr
May
Jun
Jul
Aug
Sep
May
Jun
Jul
Aug
Sep
2011
2012
2013
2014
2015
2016
2017

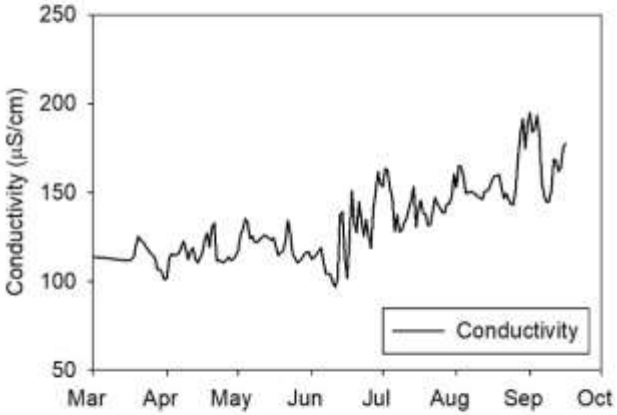

Whites Island
Chlorophyll a (µg L-1)
50
40
30
20
10
0
May
May-end
June-mid
Apr
May
Jun
Apr
May
Apr
May
Jun-early
Jun-mid
Jun-end
Jul-early
Jul-mid
Apr
May
Jun
Jul
Aug
Sep
Apr
May
Jun
Jul
Aug
Sep
Apr
May
Jun
Jul
Sep
2011
2012
2013
2014
2015
2016
2017

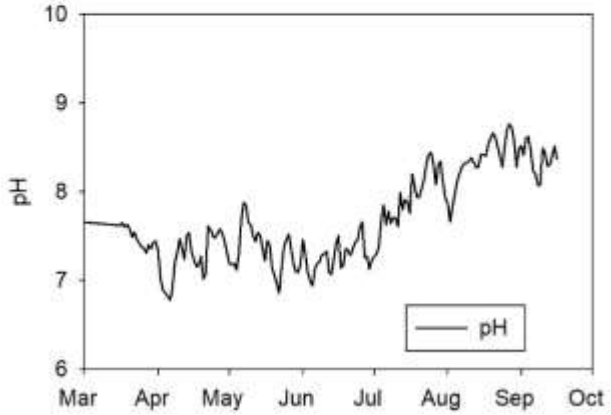
Campbell

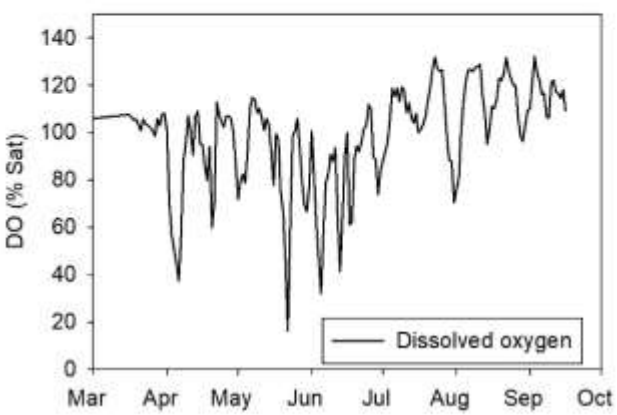

Temp (°C)
35
30
25
20
15
10
5
0
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Temp


Fluorescence (RFU)
12
10
8
6
4
2
0
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Chlorophyll
BGA-PC

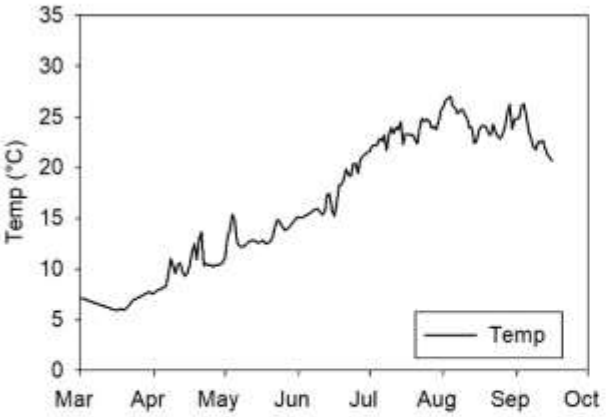

Sensor depth (m)
5
4
3
2
1
0
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Depth

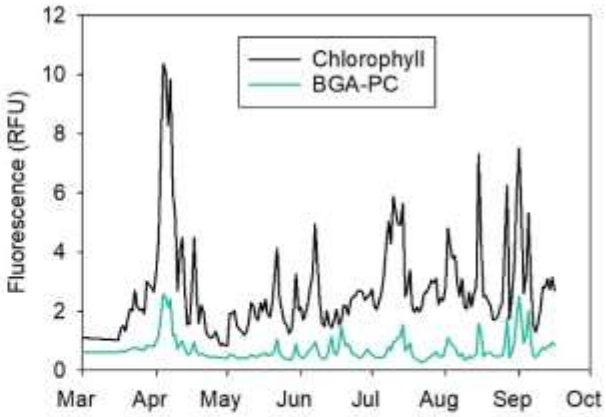

Conductivity (µS/cm)
250
200
150
100
50
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Conductivity

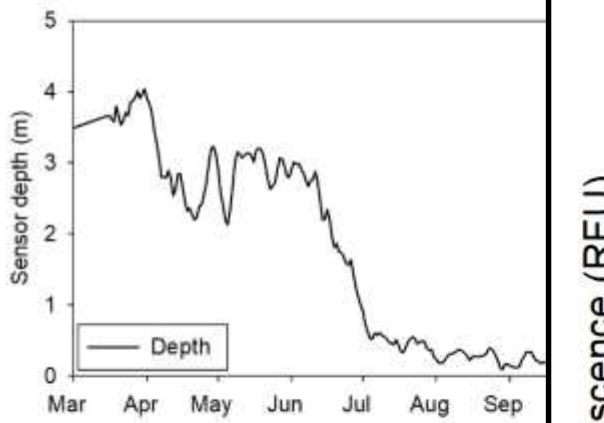

pH
10
9
8
7
6
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
pH

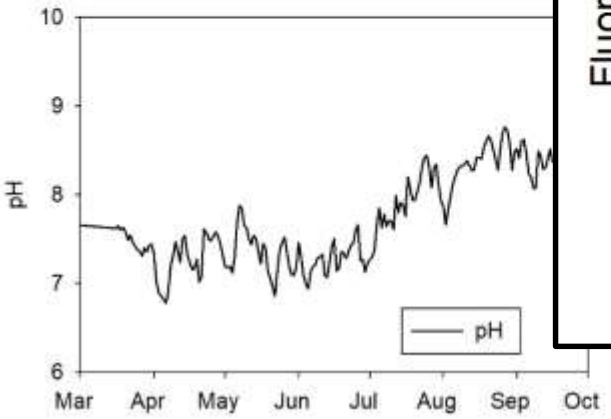

DO (% Sat)
140
120
100
80
60
40
20
0
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Dissolved oxygen

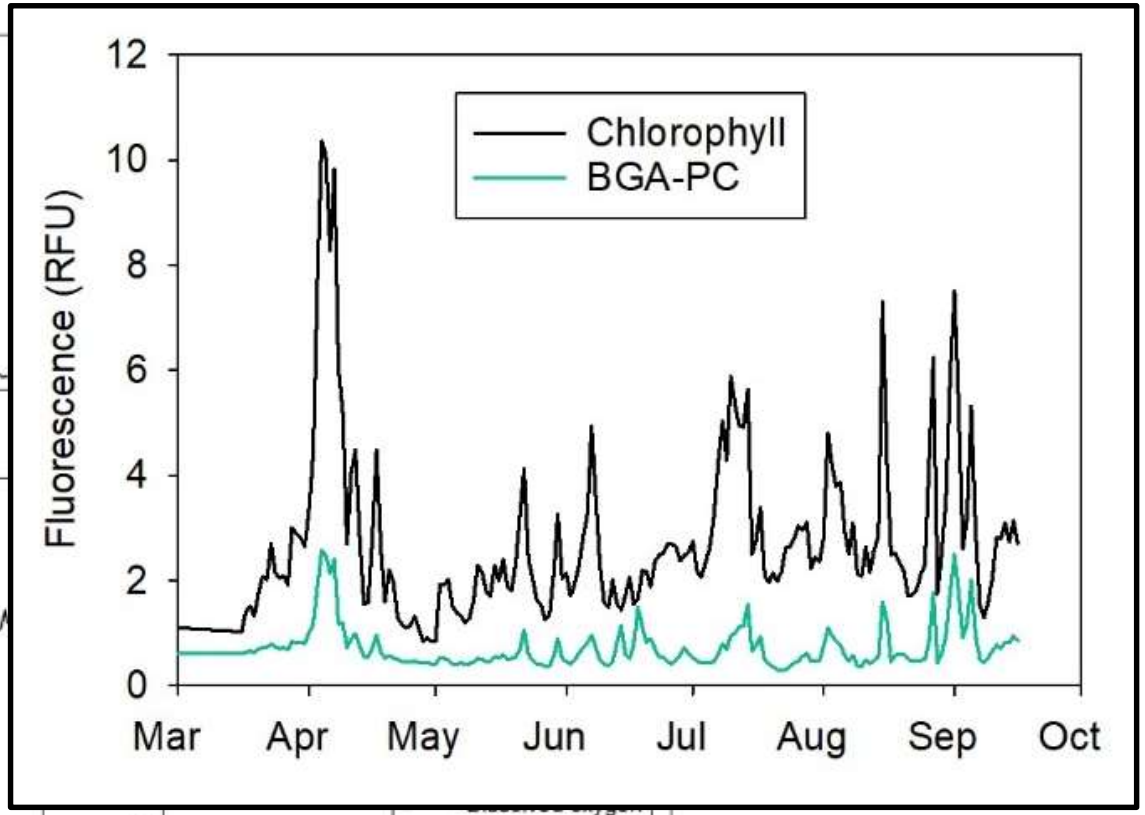
Campbell


Temp (°C)
Temp
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct


Fluorescence (RFU)
Chlorophyll
BGA-PC
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct


Sensor depth (m)
Depth
Mar
Apr
May
Jun
Jul
Aug
Sep


pH
pH
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct


Fluorescence (RFU)
Chlorophyll
BGA-PC
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct

Where, when, who, and <u>why</u> do cyanobacteria blooms develop in the Columbia River?

Conditions that favor cyanobacteria:

- High temperature
- Nutrients
- High light/stratification

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Observations:

- Bubbles/trapped air in scums ➔ buoyancy
- Cyanobacteria are FULL of proteinaceous gas vesicles ➔ amino acids
  - BMAA

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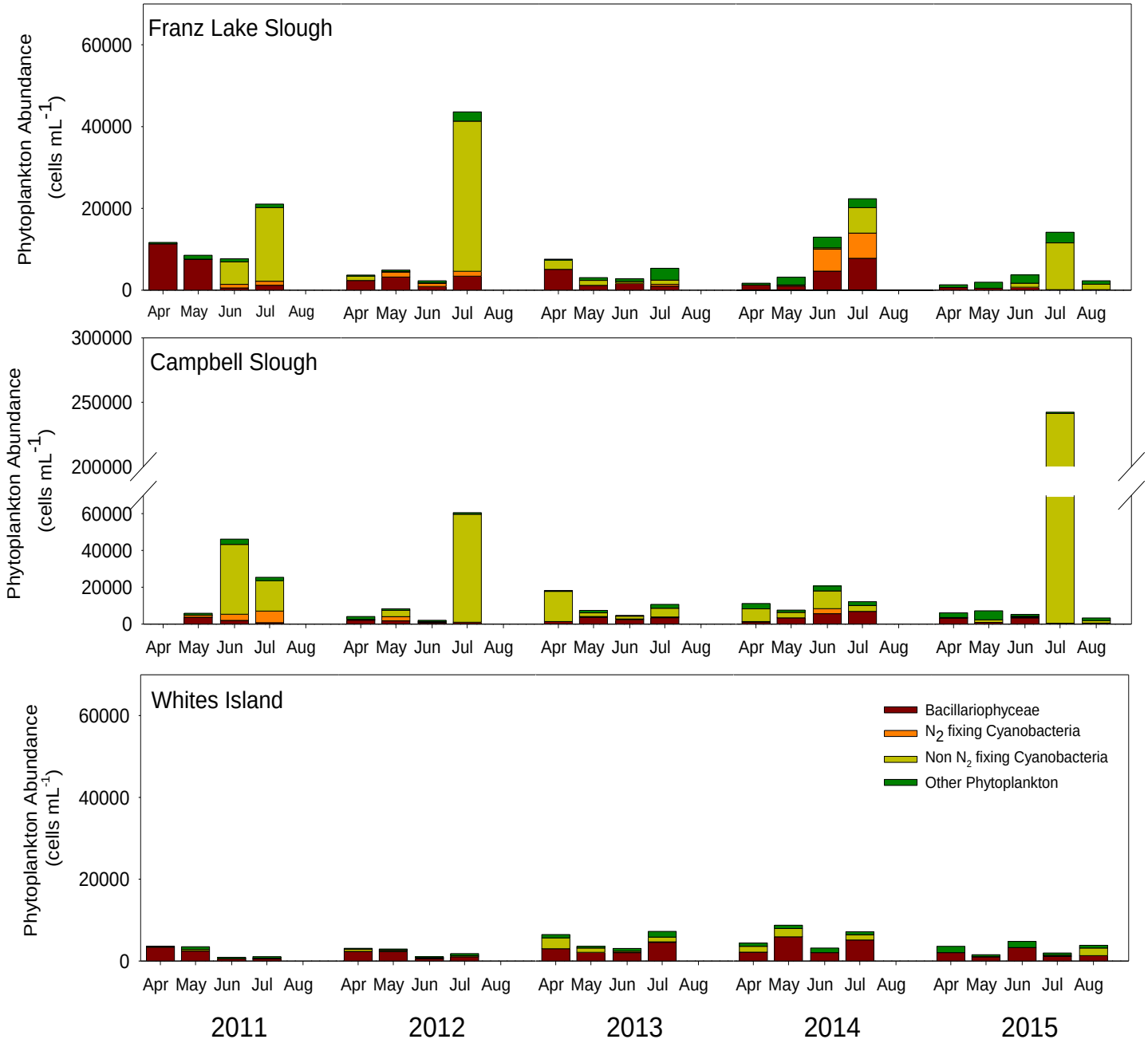
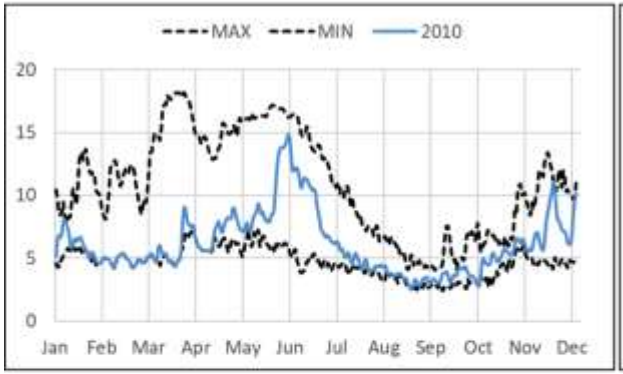
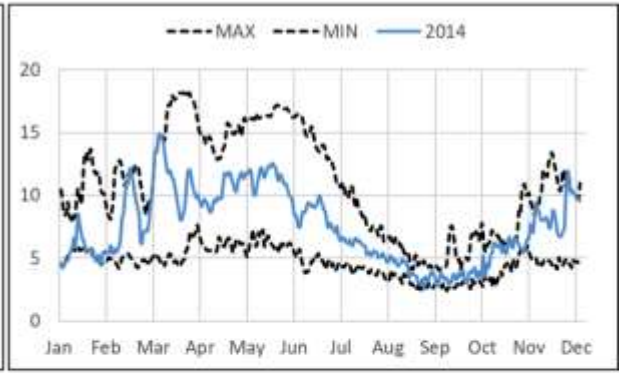
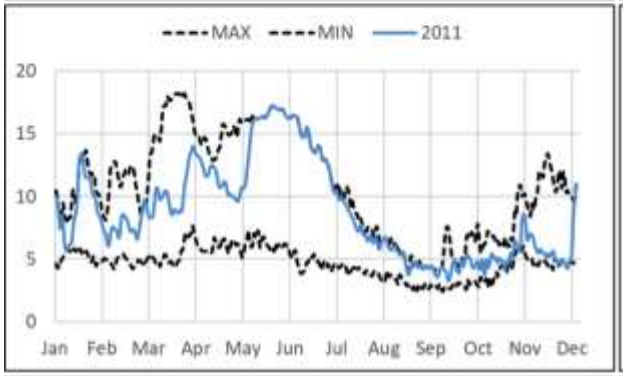
Challenges

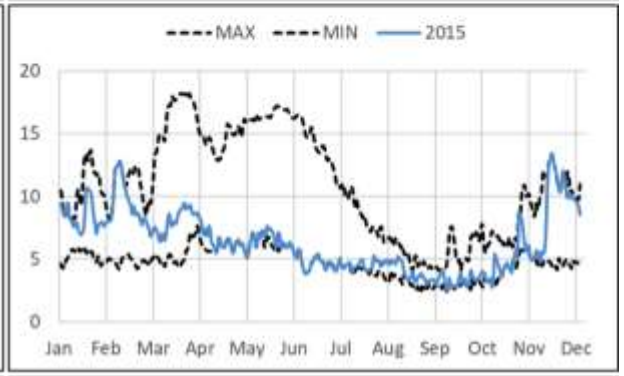
- Scope of lower Columbia River and Columbia River system is large
- Management of cyanobacteria may compete with:
  - hydropower interests
  - Salmon recovery (e.g., creation of floodplain habitats)
- Climate change

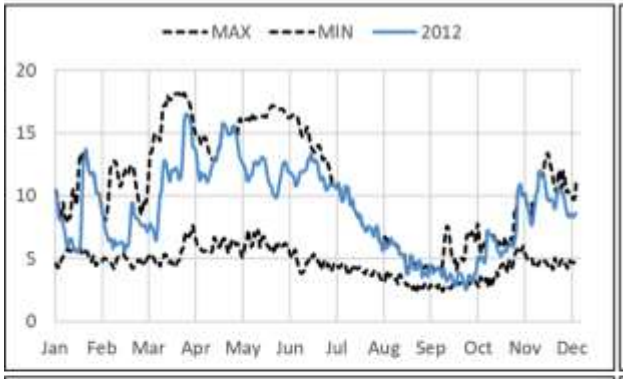

Franz Lake Slough
Campbell Slough
Whites Island
Phytoplankton Abundance (cells mL-1)
60000
40000
20000
0
300000
250000
200000
Apr May Jun Jul Aug
2011
2012
2013
2014
2015
Bacillariophyceae
N2 fixing Cyanobacteria
Non N2 fixing Cyanobacteria
Other Phytoplankton

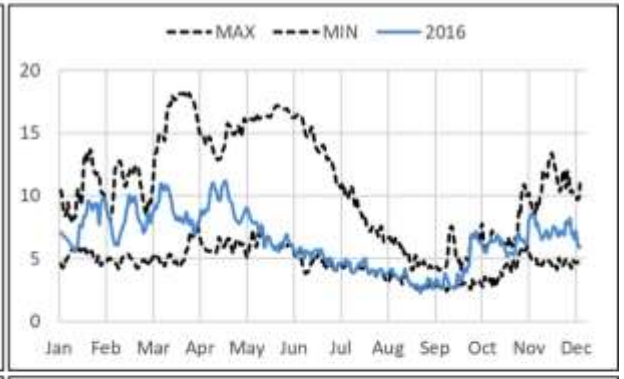

MAX
MIN
2010
20
15
10
5
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

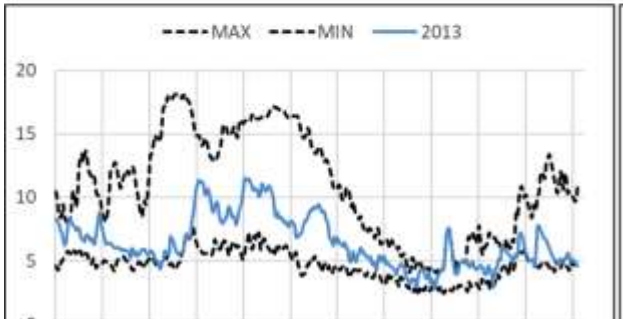

MAX
MIN
2014
20
15
10
5
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

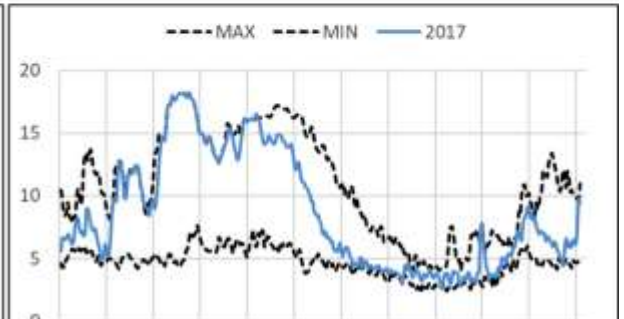

MAX
MIN
2011
20
15
10
5
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

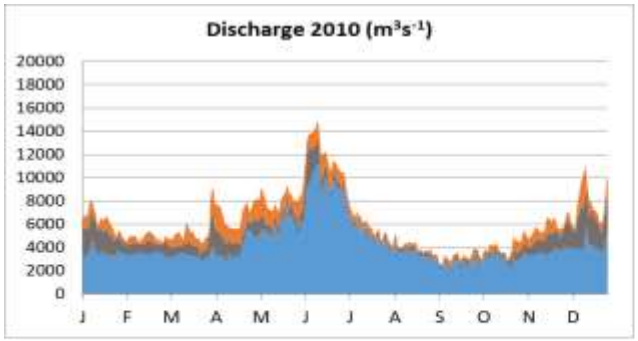

MAX
MIN
2015
20
15
10
5
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

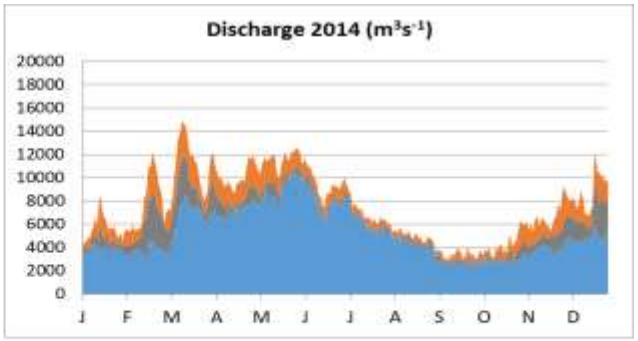

MAX
MIN
2012
20
15
10
5
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

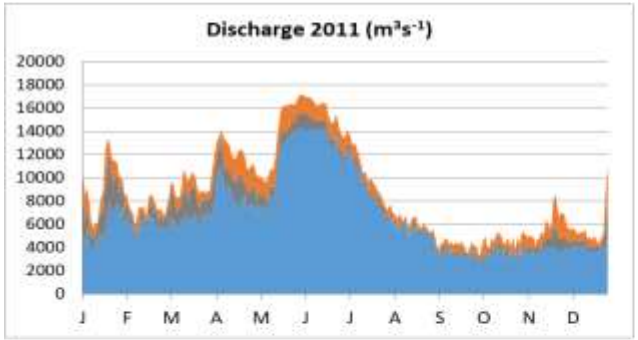

MAX
MIN
2016
20
15
10
5
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

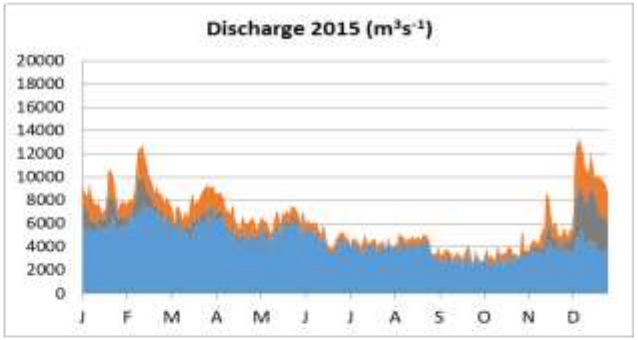

MAX
MIN
2013
20
15
10
5
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

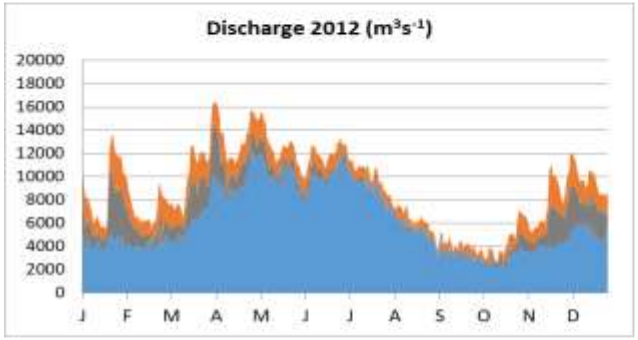

MAX
MIN
2017
20
15
10
5
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

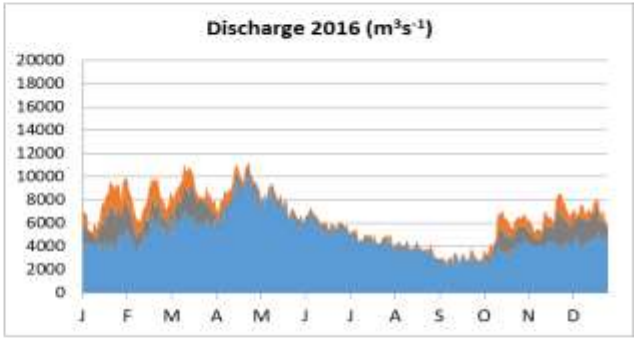

Discharge 2010 (m³s⁻¹)
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
J F M A M J J A S O N D

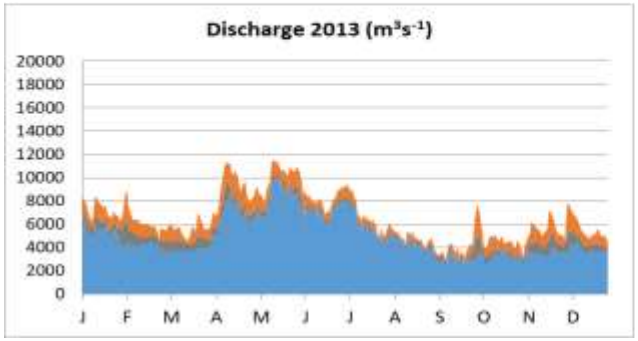

Discharge 2014 (m³s⁻¹)
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
J F M A M J J A S O N D

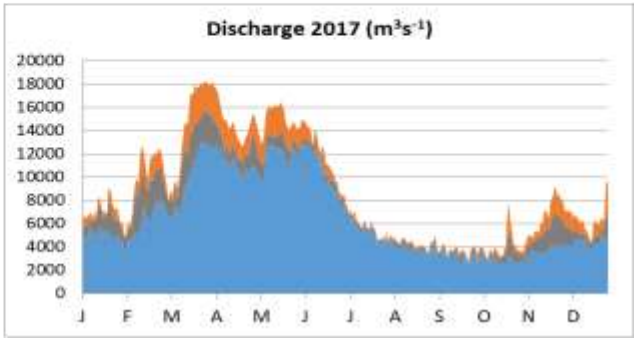

Discharge 2011 (m³s⁻¹)
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
J F M A M J J A S O N D


Discharge 2015 (m³s⁻¹)
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
J F M A M J J A S O N D


Discharge 2012 (m³s⁻¹)
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
J F M A M J J A S O N D


Discharge 2016 (m³s⁻¹)
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
J F M A M J J A S O N D


Discharge 2013 (m³s⁻¹)
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
J F M A M J J A S O N D


Discharge 2017 (m³s⁻¹)
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
J F M A M J J A S O N D

Cyanobacteria

Knowns

- Associated with warm temperatures
- Associated with high nutrient loading
- Pose problems in lakes and reservoirs

Less known