BC Hydro

**Columbia River Project Water Use Plan**

**Kinbasket Fish and Wildlife Information Management Plan**

**Kinbasket and Revelstoke Reservoirs Ecological Productivity Monitoring**

**Implementation Year 10**

**Reference: CLBMON-3 and CLBMON-56**

# Kinbasket and Revelstoke Reservoirs Ecological Productivity Monitoring –*Year 10 and Year 6 (2017)*

**Study Period: 2017**

**K. Bray**
**BC Hydro**

August 31, 2019

# Kinbasket and Revelstoke Reservoirs Ecological Productivity Monitoring
# Year 10 (2017) Progress Report

Frenchman's Cap, Revelstoke Reservoir, October 2017


*Prepared by:*
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Revelstoke, B.C.

This is a progress report for a long term monitoring program and, as such, contains preliminary data. Conclusions are subject to change and any use or citation of this report or the information herein should note this status.

Suggested Citation for Progress Report:

Bray, K. 2019. Kinbasket and Revelstoke Reservoirs Ecological Productivity Monitoring. Progress Report Year 10 (2017). BC Hydro, Environment. Study No. CLBMON-3 and CLBMON-56.

Suggested citation for individual reports contained within:

Pieters, R., P. Buskas, and G. Lawrence. 2019. Hydrology of Kinbasket and Revelstoke Reservoirs, 2017. Prepared for BC Hydro, Water Licence Requirements. 58 pp. + apps. Appendix 1 *in* Bray, K. 2019. Kinbasket and Revelstoke Reservoirs Ecological Productivity Monitoring. Progress Report Year 10 (2017). BC Hydro, Environment. Study No. CLBMON-3 and CLBMON-56.

## *Acknowledgements*

The successful implementation of such a large and complex project is due to the continuing efforts of many people and they are gratefully acknowledged for their valuable contributions and support.

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## APPENDICES

# 1.0 Introduction

This report summarises the Year 10 (2017) implementation of CLBMON-3 Kinbasket and Revelstoke Reservoirs Ecological Productivity Monitoring project ("the study"). This report contains preliminary data and conclusions are subject to change. Any citations of this report or the data contained herein must note this status.

The Columbia River Water Use Plan (WUP) (BC Hydro 2007a) was concluded in 2004 following four years of public consultation (BC Hydro 2005). Water Use Plans were developed for each of BC Hydro's facilities to achieve optimal balance among operations and environmental and social values.

A lack of basic ecological data and information on Kinbasket and Revelstoke Reservoirs impeded informed decisions for any operational changes in the upper Columbia River system. The WUP Consultative Committee acknowledged the importance of understanding reservoir limnology and the influence of current operations on ecosystem processes for planning future water management activities. Therefore, a monitoring program was recommended to provide long-term data on reservoir limnology and the productivity of pelagic communities. This study is conducted in conjunction with CLBMON-2 Kinbasket and Revelstoke Reservoirs Kokanee Population Monitoring and is scheduled for implementation over twelve years (2008-2019).

As a result of the Environmental Assessment for the addition of two turbines at the Mica Generating Station (Units 5 and 6), the Terms of Reference for this study was amended to include a component for addressing the potential influence of the new units on reservoir productivity. This component, CLBMON-56, is an eight year study focussing on fine scale measurement of temperature in Kinbasket and Revelstoke Reservoirs to further refine data on circulation, and thus, production. The fifth year of this study was implemented in 2016 and annual results are included together with CLBMON-3 annual report (Appendix 8).

## 1.1 Management Questions

A Terms of Reference (TOR) (BC Hydro 2007b) for this study and revised in 2011 to include an addendum for Mica 5/6 (BC Hydro 2011b) outlines the rationale, approach, and primary management questions to be addressed. The TOR also provides a framework for implementation. The study is to focus on:

i) Reservoir trophic web mechanisms and dynamics;

ii) Obtaining measurements of aquatic productivity that can be used as parameters for system modeling; and

iii) Determining key indicators of change in pelagic production that would ultimately affect food availability and, thus, growth of kokanee.

The management questions to be addressed by this study are as follows:

i) What are the long-terms trends in nutrient availability and how are lower trophic levels affected by these trends?
ii) What are the interactions between nutrient availability, productivity at lower trophic levels and reservoir operations?

iii) Is pelagic productivity, as measured by primary production, changing significantly over the course of the monitoring period?
iv) If changes in pelagic productivity are detected, are the changes affecting kokanee populations?
v) Is there a link between reservoir operation and pelagic productivity? What are the best predictive tools for forecasting reservoir productivity?
vi) How do pelagic productivity trends in Kinbasket and Revelstoke reservoirs compare with similar large reservoir/lake systems (e.g., Arrow Lakes Reservoir, Kootenay Lake, Okanagan Lake, and Williston Reservoir)?
vii) Does the addition of Mica Units 5 and 6 influence pelagic productivity? (added in 2011)
viii) Are there operational changes that could be implemented to improve pelagic productivity in Kinbasket Reservoir?

## 1.2 Objectives

The study objectives are to conduct reservoir pelagic productivity monitoring and establish long term sampling sites and consistent methodologies and analyses for comparison with other Columbia reservoir monitoring programs (e.g. Arrow Lakes Reservoir, Kootenay Lake).

# 2.0 Study Implementation

The study team met on March 28-29, 2017, to discuss progress on the management questions, evaluate the sampling program to date, and set the 2017 (Year 10) work plan. The monitoring program is implemented in a phased approach in conjunction with the Kinbasket-Revelstoke Reservoirs Kokanee Population Monitoring program (CLBMON-2). Sampling is planned on a 4-year cycle and reviewed annually, thereby taking advantage of information gained in each sampling period to define the data needs for future years. Each phase will conclude with a synthesis report; an annual progress report is prepared in intervening years. Two synthesis reports covering 2008-2011 and 2008-2016 are complete (Bray et al. 2013; 2018); a final synthesis report will be prepared following the last year of field data collection.

Implementation of this study continues to follow the approach of using a combination of in house and external resources. Overall project management and field work is conducted using in house BC Hydro resources and external expertise is secured to provide field sampling, analyses, and reporting for specific components.

This tenth annual report presents a study overview followed by individual progress reports for the physical processes and biological components of the 2017 sampling year as per previous progress reports (Bray 2018, 2017, 2016a, 2016b, 2014, 2013, 2012; BC Hydro 2011a; BC Hydro 2010). Also included is the sixth annual report for CLBMON-56 (Appendix 8). More specific information pertaining to individual year monitoring results is contained in these reports.

In Year 10 (2017) regular reservoir monthly sampling began in April and concluded in October at four stations in Kinbasket Reservoir and three stations in Revelstoke Reservoir (Figure 1). Stations were sampled at Kinbasket Reservoir forebay elevations between 729 m and 752 m; full pool is 754.4m and minimum level is 707.1 m (Figure 2). Sampling protocols remained largely unchanged from the previous year (Table 1). All stations were sampled all months in 2017 with the exception of KIN Wood in October due to high winds and unsafe conditions.

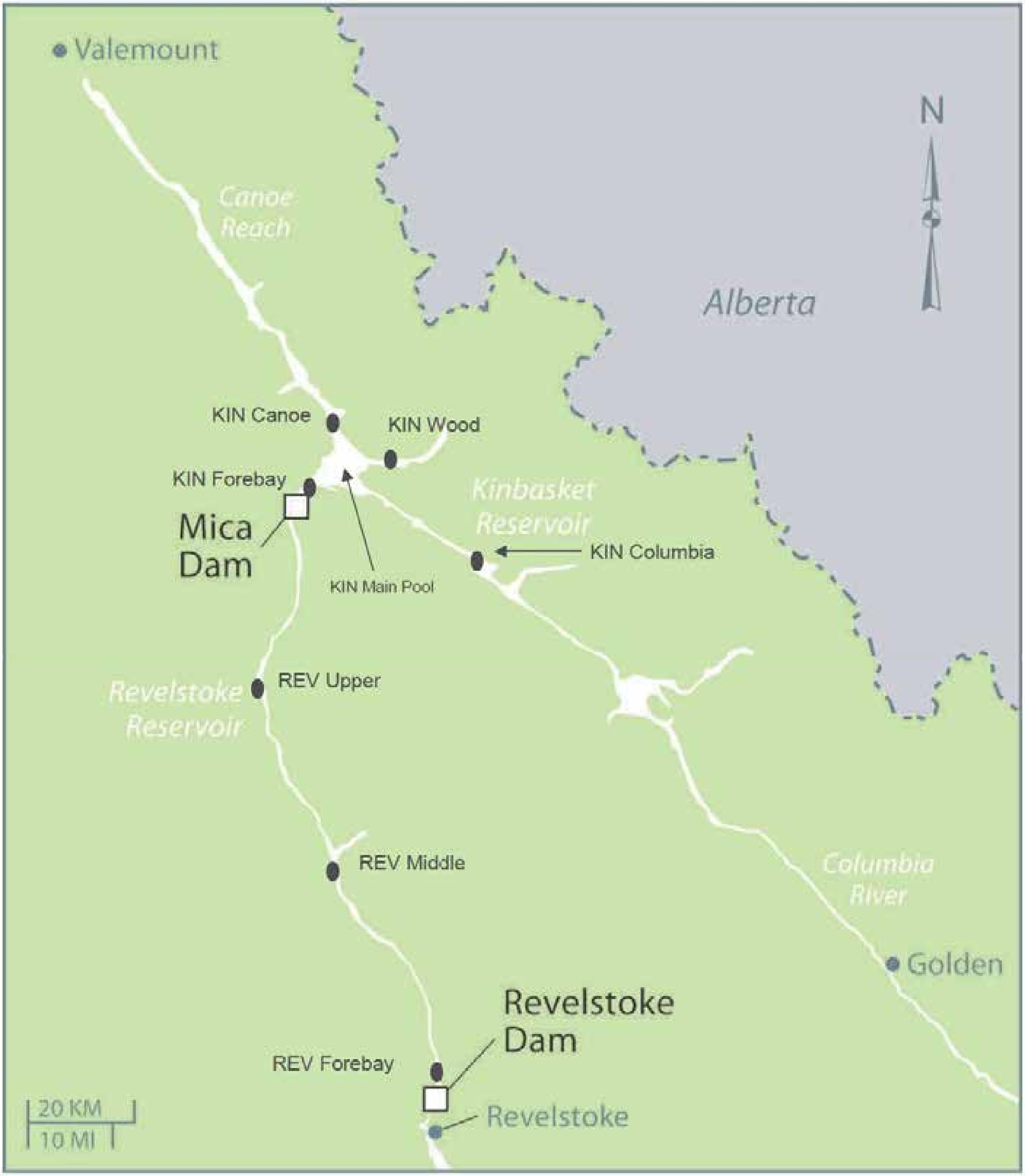


Figure 1. Location of regular sampling stations on Kinbasket and Revelstoke Reservoirs.

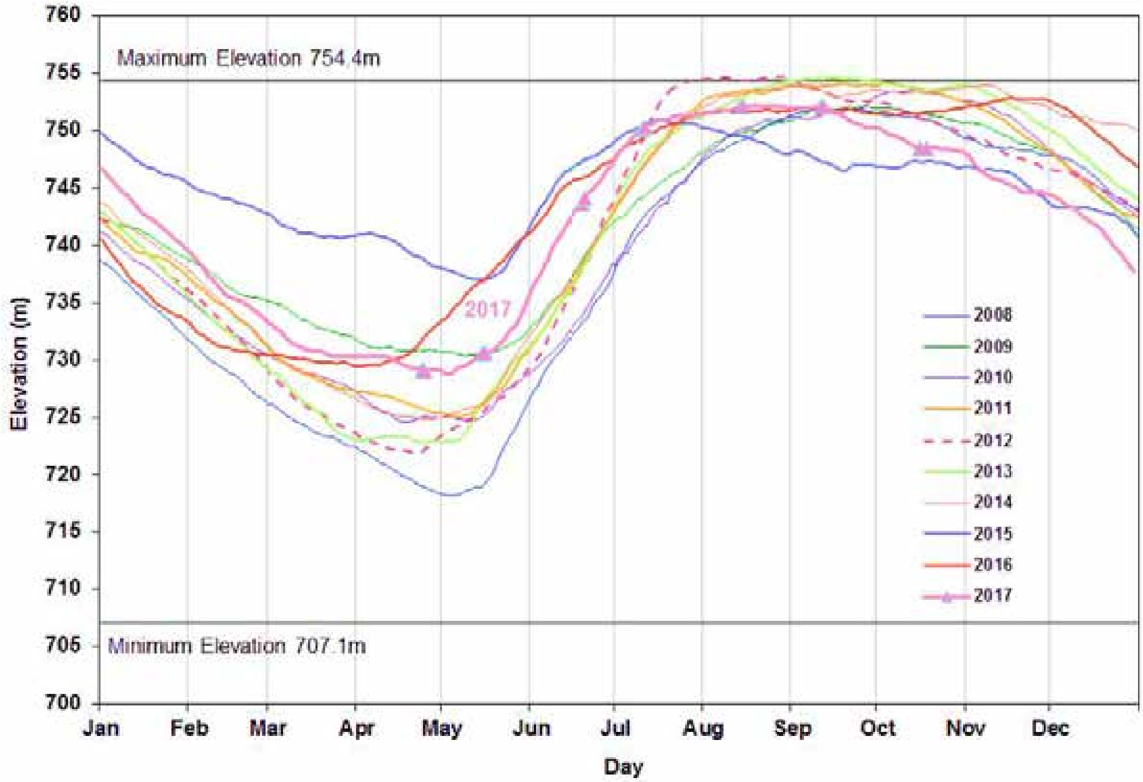


Figure 2. Kinbasket Reservoir elevation and sampling dates, 2017. Elevations for 2008-2016 are shown for comparison.

Table 1. Summary of Kinbasket and Revelstoke Reservoirs field sampling program 2017.

| Parameter (Analyses) | Sampling Frequency | Method | Details | Stations (Figure 1) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | KIN Forebay | KIN Canoe | KIN Wood Arm | KIN Col Reach | KIN Main Pool | REV Upper | REV Middle | REV Forebay | Tribs |
| **Weather Station** (temp, ppt, BP, RH, PAR, wind) | Hourly/daily | Fixed Data logger | | Mica dam | | | | | | | Rev Dam crest | |
| **Profile** (DO, temp, cond, chl a, PAR, turbidity) +Secchi | **Apr-Oct** Monthly (7) | Seabird +Secchi | 0 to 60m+ (to within 5 m of bottom) | √ | √ | √ | √ | √ | √ | √ | √ | |
| **Water Chem - Reservoir** TP, SRP, TDP, cond, $NO_2$+$NO_3$, TN, alk, pH, turb, SRS, chl a) | **Apr-Oct** Monthly (7) | Bottle | 2,5,10,15,20, 40, 60, 80m and 5m off bottom<br>SRS in Aug only, 2-20m discrete depths. Chl a composite 2-20m | √ | √ | √ | √ | | √ | √ | √ | |
| **Water Chem - Tributary** TP, SRP, TDP, cond, $NO_2$+$NO_3$, TN, pH, alk, turb, temp) | 5 reference tribs* once in Mar/Apr/Jul/Aug/S/O/N/D; twice in May/Jun | Bucket | Surface grab | | | | | | | | | √ |
| **Temperature - Tributaries** | Hourly | Data logger/WSC gauge | Ref tribs* + Bush R, Camp Ck, Col R at Fairmont | | | | | | | | | √ |
| **Temperature - Reservoir** | Continuous | Data logger | Moored arrays, surface to bottom | √ | | | | | √ | √ | √ | |
| **Phytoplankton** | **Apr-Oct** Monthly (7) | Bottle | 2, 5, 10, 15, 25 m | √ | √ | √ | √ | | √ | √ | √ | |
| **Bacteria** | **Apr-Oct** Monthly (7) | Bottle | Two composites of 2,5,10m and 15,20,25m | √ | √ | √ | √ | | √ | √ | √ | |
| **Zooplankton** | **Apr-Oct** Monthly (7) | Wisconsin net, 2 hauls | 0-30m | √ | √ | √ | √ | | √ | √ | √ | |
| $C^{14}$ | **June-Sep** Monthly (4) | 3 size fractions | 0,1,2,5,10,12,15m | √** | | | | | | √ | √ | |

* Columbia River at Donald, Beaver River, Mica outflow, Goldstream River, Revelstoke outflow

**Note that station for PP is farther out towards the main pool than the regular sampling station in the forebay.

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# Appendix 1

## Hydrology of Kinbasket and Revelstoke Reservoirs, 2017

Roger Pieters, P. Buskas, and Greg Lawrence
University of British Columbia

# Hydrology of Kinbasket and Revelstoke Reservoirs, 2017

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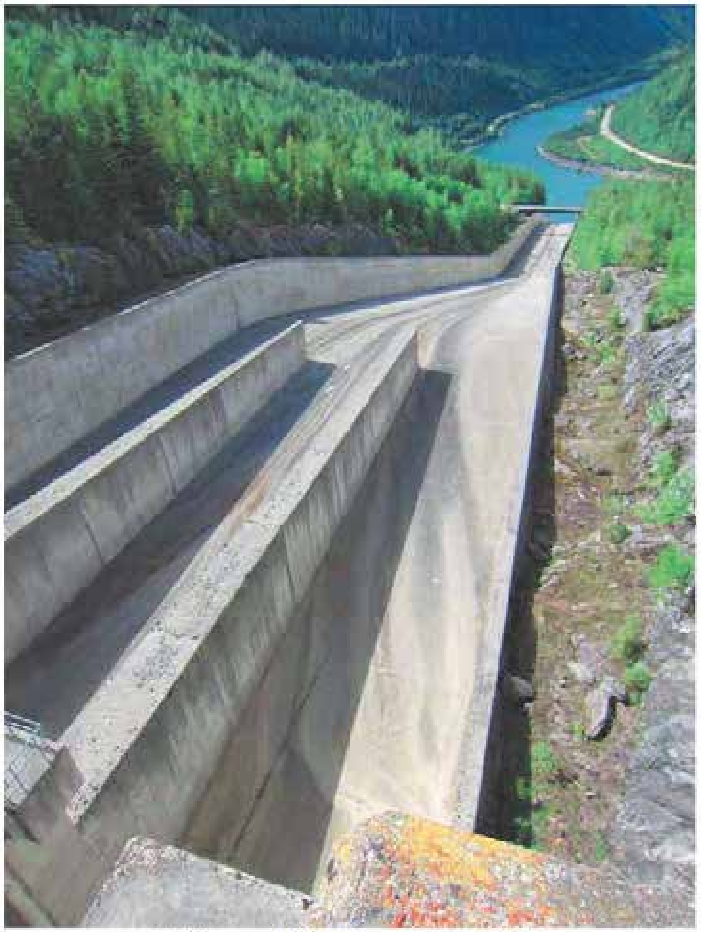

Spillway at Mica Dam, 1 June 2018

Prepared for

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March 11, 2019

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## List of Figures

## 1. Introduction

The hydrology of Kinbasket and Revelstoke Reservoirs is described in this report, with a focus on flow in 2017. This report updates Pieters et al. (2018) and provides context for the ongoing BC Hydro project entitled "Kinbasket and Revelstoke Ecological Productivity Monitoring (CLBMON-3 and CLBMON-56)".

The upper Columbia River is defined in Figure 1.1 as the flow of the Columbia River near the Canada-US border, excluding the Pend Oreille River which joins the Columbia just above the border. Also excluded are the Kettle, Okanagan and Similkameen Rivers which join the Columbia in Washington State. As shown in Table 1.1, the upper Columbia accounts for only 13% of the total area drained by the Columbia River, but contributes 27% of the total flow in the Columbia River. Kinbasket and Revelstoke Reservoirs account for 4% of the area of the Columbia, and contribute 11% of the flow.

**Table 1.1** Drainage area, mean flow and yield of selected regions of the Columbia River

| | **Drainage area ($km^2$)** | **Flow ($m^3/s$)** | **Yield* (m/yr)** |
|---|---|---|---|
| Kinbasket and Revelstoke Reservoirs (WSC 08ND011 1955-1986) | 26,400 | 796 | 0.95 |
| Upper Columbia, Figure 1.1 (WSC 08NE058 minus 08NE010) | 89,700 | 2,047 | 0.72 |
| Columbia River (Kammerer, 1990) | 668,000 | 7,500 | 0.35 |

*Annual water yield gives the total volume of river water leaving a catchment. Rather than express the volume in $m^3$, the yield is commonly given as the average depth of water spread over the entire catchment area, here given in m. The yield can be thought of as the average precipitation minus evapotranspiration over the catchment.

The headwater of the Columbia River begins in wetlands adjoining Columbia Lake (Figure 1.1). The Columbia River flows north-west through Windermere Lake and into Kinbasket Reservoir. Just before Mica Dam the Columbia River turns almost 180 degrees and flows south, through Mica Dam and along Revelstoke Reservoir, and then into the Arrow Lakes Reservoir.

Basic characteristics of Kinbasket and Revelstoke Reservoirs are compared to other major lakes and reservoirs from the Upper Columbia in Table 1.2. Kinbasket and Revelstoke Reservoirs are shown in greater detail in Figures 1.2 and 1.3, respectively. The approximate lengths of the reservoirs and their reaches are given in Table 1.3.

## 2. Annual Water Balance

### *Kinbasket Reservoir*

Kinbasket Reservoir is shown in Figure 1.2. To the southeast, the Columbia River enters the Columbia Reach of Kinbasket Reservoir about 15 km downstream of Donald Station.

To the northwest, the Canoe River enters the Canoe Reach near the town of Valemount. These two long, narrow reaches join near Mica Dam.

**Table 1.2** Characteristics of major lakes and reservoirs of the Upper Columbia

| | Dam | Dam Completed (year) | Dam Height (m) | Max. Depth (m) | Max. Area ($km^2$) | Mean Outflow ($m^3/s$) |
|---|---|---|---|---|---|---|
| Kinbasket | Mica | 1973 | 244 | *~185* | 425 | 590 |
| Revelstoke | Revelstoke | 1984 | 175 | *~125* | 115 | 750 |
| Arrow | Keenleyside | 1968 | 52 | 290/190 | 520 | 1,080 |
| Koocanusa | Libby | 1973 | 95 | 107 | 186 | 350 |
| Duncan | Duncan | 1967 | 39 | 147 | 75 | 90 |
| Kootenay | Cora Linn | 1931 | 38 | 154 | 390 | 780 |

| | Drawdown (m) | Drawdown Area ($km^2$) | Drawdown Area (% full) |
|---|---|---|---|
| Kinbasket | 47 | 220 | 50% |
| Revelstoke | 1.5 | 2.4 | 2% |
| Arrow | 20 | 159 | 30% |
| Koocanusa | 52 | | |
| Duncan | 28 | | |
| Kootenay | 3 | | |

The water balance for Kinbasket Reservoir is given in Table 2.1. Also given is the annual water yield from the drainage. The yield is the average annual outflow divided by the drainage area. The local inflow to Kinbasket Reservoir has about twice the yield as the Columbia River above Donald, indicating increased precipitation in the local drainage to Kinbasket Reservoir.

**Table 1.3** Length of reservoirs

| **Reservoir** | **Length (km)** |
|---|---|
| Kinbasket Reservoir | 190 |
| Columbia Reach | 100 |
| Canoe Reach | 90 |
| Revelstoke Reservoir | 130 |
| Upper Revelstoke | 80 |
| Lower Revelstoke | 50 |
| Arrow Lakes Reservoir | 210 |
| Revelstoke Reach | 40 |
| Upper Arrow | 60 |
| Narrows | 30 |
| Lower Arrow | 80 |
| Kootenay Lake | 110 |

Local inflow to Kinbasket dominates the water balance, contributing 66% of the inflow. In contrast, the Canoe River, while having a high yield, contributes only 3% due to its relatively small drainage.

**Table 2.1** Annual water balance for Kinbasket Reservoir

| | | Area ($km^2$) | Flow ($m^3/s$) | Yield (m/yr) |
|---|---|---|---|---|
| Qin | Columbia R. at Donald Station | 9,710 (45%) | 172 (30%) | 0.56 |
| Qin | Canoe River near Valemount | 368 (2%) | 19* (3%) | 1.6* |
| Qloc | Local Flow into Kinbasket | 11,422 (53%) | 376 (66%) | 1.0 |
| Qout | Columbia River at Nagle Creek (Mica Dam Outflow) | 21,500 | 567 | 0.83 |

*Estimated from partial data for 1966-1967.

Prior to Mica Dam, most of Kinbasket Reservoir was a river, with the exception of Kinbasket Lake which was approximately 10 km long, located near Kinbasket Creek on the Columbia Reach. Water Survey of Canada (WSC) had gauges at several sites along what would become Kinbasket Reservoir, shown in Figure 1.2 (red squares). The data from these sites (Appendix 1) allow the division of Kinbasket Reservoir into the regions given in Table 2.2. The inflow of the Upper Columbia Reach is particularly large, matching the inflow of the Columbia River at Donald.

**Table 2.2** Drainage, flow and yield of regions in Kinbasket Reservoir

| | Canoe River | Canoe Reach | Wood Arm | Lower Columbia Reach[1] | Upper Columbia Reach[2] | Columbia River Above Donald |
|---|---|---|---|---|---|---|
| Drainage ($km^2$) | 368 | 2,922 | 956 | 3,250 | 4,290 | 9,710 |
| Inflow ($m^3/s$) | ~19 | 86 | 40 | 85 | 165 | 172 |
| Yield (m/yr) | ~1.6 | 0.93 | 1.3 | 0.82 | 1.2 | 0.56 |
| % of outflow | 3% | 15% | 7% | 15% | 29% | 30% |

[1] Between Mica Dam and the Columbia River at Surprise Rapids
[2] Between the Columbia River at Surprise Rapids and Columbia River at Donald

### *Revelstoke Reservoir*

Revelstoke Reservoir is shown in Figure 1.3. The entire length was formerly a river and the resulting reservoir is very narrow. The water balance for Revelstoke Reservoir is given in Table 2.3. For Revelstoke, the outflow from Mica Dam is the dominant inflow (71%) to the reservoir. While the local drainage area to Revelstoke Reservoir is relatively small, the higher yield of this drainage means that the local inflow still contributes 29% to the total outflow.

**Table 2.3** Annual water balance for Revelstoke Reservoir

| | Area ($km^2$) | Flow ($m^3/s$) | Yield (m/yr) |
|---|---|---|---|
| Columbia River at Nagle Creek (Mica Dam Outflow) | 21,500 (81%) | 567 (71%) | 0.83 |
| Local Flow into Revelstoke | 4,900 (19%) | 229 (29%) | 1.47 |
| Columbia River above Steamboat Rapids (Revelstoke Outflow) | 26,400 | 796 | 0.95 |

Unlike Kinbasket Reservoir, no WSC data were available for the Columbia River along what would become Revelstoke Reservoir. While WSC lists a station "Columbia River above Downie Creek" (08ND010), no data were available at this site. We divide Revelstoke Reservoir just above Downie Creek (Figure 1.3) into upper and lower reaches assuming the same yield to each, see Table 2.4. Note the drainage to the lower Revelstoke reach is relatively small.

**Table 2.4** Drainage, flow and yield of regions in Revelstoke Reservoir

| | Mica Outflow (Columbia above Nagle) | Upper Revelstoke Reach[1] | Lower Revelstoke Reach |
|---|---|---|---|
| Drainage ($km^2$) | 21,500 | *3,300* | *1,600* |
| Inflow ($m^3/s$) | 567 | *155* | *75* |
| Yield (m/yr) | 0.83 | *1.5* | *1.5* |
| Of outflow (%) | 71% | *19%* | *9%* |

[1] The boundary between upper and lower was chosen above Downie Creek.
Values in italics are approximate.

## 3. Columbia River at Donald

### *Data*

Daily flow data were available for 1944-2017 from WSC station 08NB005, entitled "Columbia River at Donald". This station is located roughly 15 km upstream of Kinbasket Reservoir.

### *Results*

Figure 3.1a shows the daily flows for 1944-2017. The mean daily hydrograph shown in Figure 3.1b peaks from early June to mid-July at roughly 550 $m^3/s$, tapering through the summer and fall to a base flow in the winter of approximately 35 $m^3/s$. The mean annual flow for 1944-2017 was 171 $m^3/s$.

The daily flows are shown in Figure 3.2 for years 2001-2017, which include the years with hydroacoustic surveys of kokanee abundance (2003-2017). Also shown for comparison in each panel is the daily mean flow for 1944-2017. The flows generally followed the mean. Exceptions include the following:

- in late fall of 2003 the flow rose to about 4 times the seasonal average;
- in 2006 and 2007 the flows in the late spring were above average;
- in 2004, 2009 and 2010 the summer flows were below average;
- in late September 2010, around the time of kokanee counts, there was a relatively large peak in flow likely the result of a rainfall event (Figure 3.2.2b);
- in 2012, flow from June until mid-August was much higher than average (Figure 3.2.2d);
- in 2016 the freshet was early but the flow during summer (July to August) was below average (Figure 3.2.2.h); and
- in 2017 the flows in late spring were briefly above average (Figure 3.2.2i).

## 4. Columbia River at Mica Dam

### *Data*

Data were available for 1947-1983 from WSC station 08ND007, entitled "Columbia River above Nagle Creek". This station is located approximately 3 km downstream of Mica Dam. Data for the Mica Dam Outflow were available for 1971-2017 from BC Hydro. The WSC data from "Columbia River above Nagle Creek" were used for 1947-1975 and the BC Hydro data were used for 1976-2017.

### *Results*

Pre- and post-impoundment flows are shown in Figure 4.1a. The change in flow after completion of Mica Dam in 1973 is evident. Before impoundment, the hydrograph had a large single peak of roughly 1600 $m^3/s$ from early June to mid-July (Figure 4.1b). The flow gradually declined in the summer and fall until it reached a low base flow in the winter of approximately 120 $m^3/s$. After Mica Dam was completed, the spring peak flow was reduced and replaced with a more variable flow throughout the year (Figure 4.1c). During snowmelt in spring, the outflow from the reservoir was generally low, and most of the freshet inflow was stored in the reservoir. However, once the reservoir has almost filled, outflow was increased, thereby releasing the tail of the freshet and resulting in an increase in flow during the late summer. A second broad peak occurred during the winter as water was released for hydroelectric generation.

The discharge from Mica Dam for 2001-2017 is shown in Figure 4.2. While the flow over the years shown has generally followed the mean, the flow from mid-May to mid-July was often below average with long stretches close to zero. Most notable, 2012 had very high flow in July and August. In 2015 the flow was unusual, with significantly higher flows throughout much of the productive season from April to mid-May, and mid-June to mid-September. In 2017, the spring flow had higher values than recent years which had very low flow from April to early June. Note, in some years, outflow was also below average through late summer and early fall, e.g. 2008, 2009, 2010 and 2013.

## 5. Columbia River at Revelstoke Dam

### *Data*

Daily flow data from two WSC stations were used for the Columbia River near Revelstoke Dam. For 1955-1985, data were available from WSC station 08ND011, entitled "Columbia River above Steamboat Rapids". This station is located roughly 1.5 km downstream of Revelstoke Dam. For 1986-2017, data were available from WSC station 08ND025, entitled "Revelstoke Project Outflow".

### *Results*

The daily discharge for 1955-2017 is shown in Figure 5.1a. The change in flow due to the completion of the upstream Mica Dam in 1973 is evident. There is no obvious change in the daily flow upon the completion of Revelstoke Dam in 1984 as it is operated run-of-the-river. The mean daily pre-impoundment hydrograph given by the data from the Columbia River above Steamboat Rapids is shown in Figure 5.1b. The post-impoundment hydrograph given by the data from the Revelstoke Project Outflow is shown in Figure 5.1c.

Similar to that seen for the pre-impoundment flow at Mica Dam, the pre-impoundment outflow at Revelstoke showed a spring peak of about 2800 $m^3/s$ which declined through the summer and fall until it reached a winter base flow of under 300 $m^3/s$ (Figure 5.1b). Post-impoundment outflow is distributed more evenly throughout the year with minor peaks in the summer and winter (Figure 5.1c).

The Revelstoke discharge for 2001-2017 is shown in Figure 5.2, and generally follows the mean post-impoundment hydrograph. Two particular exceptions were July to September 2010 when outflow was below average, and mid-July to mid-August 2012 when outflow was far greater than average, including spill. Like the outflow from Kinbasket Reservoir, the outflow from Revelstoke was significantly higher from May to September 2015. In 2017, the outflow from Revelstoke was closer to average. In 2017, the non-power outflow (spill) from Revelstoke was zero except for small values in April,May, and June.

## 6. Local Metered Inflow

### *Data*

Of the rivers and streams in the Kinbasket and Revelstoke drainage, few have been gauged by Water Survey Canada. Those that have been gauged are listed in Appendix 1. Beaver River, Gold River, and Goldstream River are all currently gauged and will serve as examples of tributary inputs. Although the Illecillewaet River enters the Columbia

River about 10 km downstream of Revelstoke Dam, it is included as an example of a gauged tributary because of its proximity, size, and long record of water quality data.

***Results***

Flow data for the four tributaries are summarized in Table 6.1. Figures 6.1-6.4 show the (a) daily and (b) mean flow for each tributary. The hydrographs of all of the tributaries are compared for each of the years 2008 to 2017 in Figures 6.5 to 6.13, respectively, along with those of the Columbia River at Donald and the Columbia River at Revelstoke. The hydrographs for the tributaries are very similar, and generally resemble the flow of the uncontrolled Columbia River at Donald. Note that above average flows in June and July 2012 occurred at all sites.

**Table 6.1** Gauged tributaries flowing into the Columbia River

| Station # | Station Name | Year | Drainage Area ($km^2$) | Annual Mean Flow ($m^3/s$) | Yield (m/yr) |
|---|---|---|---|---|---|
| 08NB019 | Beaver River near the Mouth | 1985-2017 | 1150 | 42.2 | 1.15 |
| 08NB014 | Gold River above Palmer Creek | 1973-2017 | 427 | 18.2 | 1.35 |
| 08ND012 | Goldstream River below Old Camp Creek | 1954-2017 | 938 | 39.0 | 1.31 |
| 08ND013 | Illecillewaet River at Greeley | 1963-2017 | 1170 | 52.9 | 1.42 |

In 2008, a strong freshet peak occurred in mid-May and again in early July (Figure 6.5). In 2009, freshet was more gradual, peaking in early and mid-June (Figure 6.6). In 2010, two early and short duration peaks occurred in April and May, followed by a broader peak later in June (Figure 6.7). In 2011, the flow was below average until mid-May (a cold spring) and freshet peaked at the end of June (Figure 6.8). In 2012, there was a large freshet peak from late June to mid-July (Figure 6.9). In 2013, despite the strong onset of freshet in mid-May, local inflow was approximately average through the remainder of the year. In 2014 and 2015, a freshet peaked in mid to late May (Figures 6.11 and 6.12). In 2016, the freshet was early, but the local inflow was below average from mid-June to mid-August (Figure 6.13). In 2017, there was a again a large freshet peak in late May to early June and the flow was below average from mid-July to late August (Figure 6.14).

## 7. Kinbasket Reservoir Water Level

### *Data*

Daily water level data were available for 1974-2017 from WSC station 08ND017, entitled "Kinbasket Lake at Mica Dam". This station is located in Kinbasket Reservoir near Mica Dam.

Daily water level data were also available for 1980-2017 from WSC station 08NB017, entitled "Kinbasket Lake below Garrett Creek". This station is located about 55 km southeast of Mica Dam in the Columbia Reach. Since both stations are on Kinbasket Reservoir, the water levels are expected to be comparable. The difference between the two stations was generally less than 0.5 m (standard deviation 0.2 m), except for April 2-30, 2007, when data at Kinbasket Lake at Mica Dam had a large (3 m) offset; these data were replaced with that from Kinbasket Lake below Garrett Creek.

### *Results*

Figure 7.1a shows the daily water level of Kinbasket Reservoir for 1974-2017. Note the rise in water level in the first two years following the completion of the dam in 1973. Figure 7.1b shows the mean daily post-impoundment water level for 1977-2017.

The water level in Kinbasket Reservoir for 2001-2017 is shown in Figure 7.2 and generally followed the post-impoundment mean level with a few exceptions: in 2001 and 2003 the water level was below average for the entire year, and in 2004 the water level was below average from January to mid-October. In 2012, the water level was slightly below average from March to June, but rose to above average (including surcharge) for July to September. Similarly in 2013 and 2014, the water level was slightly below average from March to May, but was above average for the remainder of the year with brief surcharge in September 2013. In 2015, water level was not drawn down as quickly or as far as in previous years, and as a result, the water level was above average for January to July. In 2016 and 2017, the water level was also not drawn down as far and was slightly above average for May to July 2016 and for January to September 2017.

Figure 7.3a shows the water level for Kinbasket Reservoir, 1977-2017. While the difference between the normal maximum and normal minimum water level is 47 m (754.38 to 707.41 m ASL), drawdown in any given year averages 25 m. There are periods of time when the water level is relatively low throughout the year (e.g. 1992-1994) and at other times it is relatively high (e.g. during the study period 2008-2015).

The minimum and maximum water levels are shown in Figure 7.3b. The area of the reservoir at minimum water level was 240 to 320 $km^3$, only 55-75% of the area at maximum water level later in the year. Also shown are the dates at which the reservoir reached minimum pool in late April, and 90% of full pool in late July (Figure 7.3c). From 2008-2011 and in 2015, the minimum water level occurred significantly later than average (red, Figure 7.3c). In 2015, the reservoir remained at very high water level, which had not been seen since early 1983 (red, Figure 7.3b). In 2016, the reservoir came to an early minimum and in 2017 the reservoir had a relatively late minimum (red, Figure 7.3b).

## 8. Revelstoke Water Level

### *Data*

Daily water level data were available for 1984-2017 from the BC Hydro station located in the Revelstoke forebay.

### *Results*

Figure 8.1a shows the water level of Revelstoke Reservoir for 1984-2017. Note the change in water level due to the completion of the dam in 1984. Figure 8.1b shows the mean daily post-impoundment water level averaged from 1988-2017. The water level varies by only a few meters, as the reservoir is operated run-of-the-river.

The water level for years 2001-2017 is shown in Figure 8.2, together with the mean post-impoundment level averaged from 1988-2017. The water levels generally followed the post-impoundment mean levels. From 2012 to early 2014 there were a number of brief drawdowns below normal minimum, for example in January and November 2013 (Figure 8.2.2f). Water levels below normal minimum were not observed through the rest of 2014 or in 2015. In 2016 there was one brief drawdown just below the minimum water level in early May.

## 9. Flow to storage

### *Data*

Storage flow gives the rate of change of the volume of the reservoir; when the storage flow is positive, the water level rises and the volume of the reservoir increases. The volume was determined from the water level at the forebay using the storage elevation curves provided by BC Hydro (Appendix 3). The storage flow, for day $i$ was computed using centered differences as,

$$Q_{stor}^{i} = \frac{V^{i} + V^{i+1}}{2} - \frac{V^{i-1} + V^{i}}{2} = \frac{V^{i+1} - V^{i-1}}{2}.$$

Note the storage flow is a small difference of large values, and can be noisy.

### *Results*

The storage flow for Kinbasket Reservoir is shown in Figure 9.1a for 1976-2017. The average flow is shown in Figure 9.1b; the average flow is positive during the spring and summer as the reservoir fills, and negative through the remainder of the year as the water level falls. Daily storage flow for 2001-2017 is shown without smoothing in Figure 9.2. The flow in recent years, 2008 to 2014, generally followed the mean, although flow in 2012 was above average from June to July. In 2015, flow to storage was below average both in early spring (April to May) and late summer (July to August). The flow to storage was reduced because the water level had not been drawn down as far as usual in spring 2015. The flow to storage was above average in 2016 from March to May. In 2017, the flow followed the mean except for some high flows from late May to early June.

Revelstoke Reservoir is operated as run-of-the-river with only small changes in water level (Figures 8.1 and 8.2). As a result, the storage flow for Revelstoke is small and noisy (not shown).

## 10. Local Inflow

### *Data*

The local flow is composed of all inflow to the reservoir other than the main inflow. The local flow includes tributaries of all sizes, as well as the net precipitation to the surface of the reservoir. The local inflow was computed for both Kinbasket and Revelstoke Reservoirs using a water balance for inflows and outflows:

$$Q_{in} + Q_{loc} = Q_{stor} + Q_{out},$$

where $Q_{in}$ is the main inflow, $Q_{loc}$ is the local flow, $Q_{stor}$ is the storage flow computed in the previous section, and $Q_{out}$ is the outflow. The Columbia River at Donald is the main inflow, $Q_{in}$, to Kinbasket Reservoir, and the outflow from Mica Dam is the main inflow to Revelstoke Reservoir.

Like the storage flow, the local flow is a small difference of large values, and as a result it is subject to considerable error, and can be very noisy. Large spikes in the data are often followed by a large correcting dip. While negative local inflow is not physical (water flowing up a river), the negative values shown are typically balanced by the positive spikes.

*Results*

Figure 10.1 shows the annual and mean local flow for Kinbasket Reservoir. The mean (Figure 10.1b) follows the shape of the natural hydrograph seen in the Columbia at Donald (Figure 3.1). The peak in the local flow is about twice that of the Columbia at Donald, consistent with the annual water balance (Table 2.1).

Figure 10.2 shows the annual and mean local flow for Revelstoke Reservoir for 1989-2017. The mean hydrograph is consistent with that of local inflow, though it is noisier because there are fewer years of data than for Kinbasket Reservoir.

The annual local flow for both Kinbasket and Revelstoke Reservoirs is shown in Figure 10.3 for 2001-2017. The data were lightly filtered with three passes of a 3 point moving average, and were scaled by drainage area and yield for comparison to the Columbia River at Donald. The Columbia River at Donald and the two local flows show similar peaks across the three respective drainage areas. There are also some regional differences; for example in May 2008, the local freshet flow rises sooner in Kinbasket and Revelstoke Reservoirs than in the Columbia River at Donald (Figure 10.3.2a), and in July 2012 the local flow to Revelstoke Reservoir declined before the others (Figure 10.3.2e).

The local flow to Revelstoke Reservoir is compared to the main inflow to Revelstoke Reservoir of the Columbia from Mica Dam in Figure 10.4. From May to mid-July, when Kinbasket Reservoir is filling and the outflow from Mica Dam is low, the inflow to Revelstoke Reservoir is dominated by local inflow.

## 11. Summer 2008 to 2017

The El-Nino/Southern Oscillation ENSO index (Wolter, 2012) and the size of winter snow packs (BCRFC, 2017?) are summarized in Table 11.1 for the study years.

**Table 11.1** Summary of meteorological and hydrological conditions during study years

| | |
|---|---|
| 2008 | Strong* La Nina (Jan - Mar 2008)<br>Columbia Region Snow Basin Index (April 1st), 104%<br>Flow slightly below average, sharp onset of freshet in mid-May<br>Cool mid-March to mid-May |
| 2009 | Weak La Nina (Aug 2007 - Mar 2008)<br>Columbia Region Snow Basin Index (April 1st), 78%<br>Flow generally below average |
| 2010 | Strong El Nino (Jan - Mar 2010; winter Olympics)<br>Columbia Region Snow Basin Index (April 1st), 84%<br>Flow generally below average<br>High inflow event during late September |

2011 Strong La Nina (Jul 2010 - Apr 2011)
Columbia Region Snow Basin Index (April 1st), 101%
Flow average
Consistently colder than average from late March to early May

2012 Weak El Nino (Apr 2012)
Columbia Region Snow Basin Index (April 1st), 125%
Local flow above average in late June and early July

2013 Weak La Nina (Jun - Aug 2013)
Columbia Region Snow Basin Index (April 1st), 103%
Flow average

2014 El Nino (Apr - Aug 2014)
Upper Columbia Region Snow Basin Index (April 1st), 123%
Flow average

2015 Strong El Nino (Mar - Dec 2015)
Upper Columbia Region Snow Basin Index (April 1st), 86%
Flow below average (after early and high freshet mid-May to mid-June)
High inflow event during late September
High outflow from Kinbasket Reservoir, April to September

2016 Strong El Nino (Mar 2015 - May 2016)
Upper Columbia Region Snow Basin Index (April 1st), 99%
Flow average (mid-Apr to mid-May slightly above average; mid-Jun to end Jul, slightly below average)
Mica outflow average

2017 El Nino (Mar - Jun 2017)
Upper Columbia Region Snow Basin Index (April 1st), 100%
Flow average (May to early-June slightly above average; mid-July to August slightly below average)
Mica outflow average
Winter of 2016-2017 cold with extensive ice cover

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* Strong is defined as one of the top 6 bi-months since 1950.

The summer, including those of 2008 to 2017 (but excluding that of 2015), can be divided into two periods. From May to mid-July inflow to Kinbasket Reservoir is stored resulting in a rapid increase in water level (Figure 7.2.2) and little outflow (Figure 4.2.2). In 2010, this low outflow period extended to the end of July (Figure 4.2.2c). For Revelstoke Reservoir, downstream of Kinbasket, this means that the major inflow from May to mid-July is freshet inflow from local drainage. Because Revelstoke Reservoir is operated as run-of-the-river (Figure 8.2.2), the outflow from Revelstoke Reservoir is driven by local freshet inflow during the periods of low Mica outflow.

The second period is mid-July to September, when Kinbasket Reservoir has almost filled and the tail of the freshet is discharged from Mica Dam (Figure 4.2.2). This increased flow from Kinbasket to Revelstoke makes up for the decline in local freshet inflow to Revelstoke; as a consequence, the discharge from Revelstoke is similar in both periods (Figure 5.2.2; Figure 10.4.2). Note that 2015 was an exception, as outflow from Mica Dam remained very high in mid-April to mid-May when it was low in previous years, and high from mid-June onward (Figure 4.2.2h).

**Acknowledgements**

We gratefully acknowledge funding provided by B.C. Hydro and the assistance of D. Robb, A. Akkerman, J. Bowman, A. Sharp, K. Lywe, C. Huang, T. Rodgers, and A. Law.

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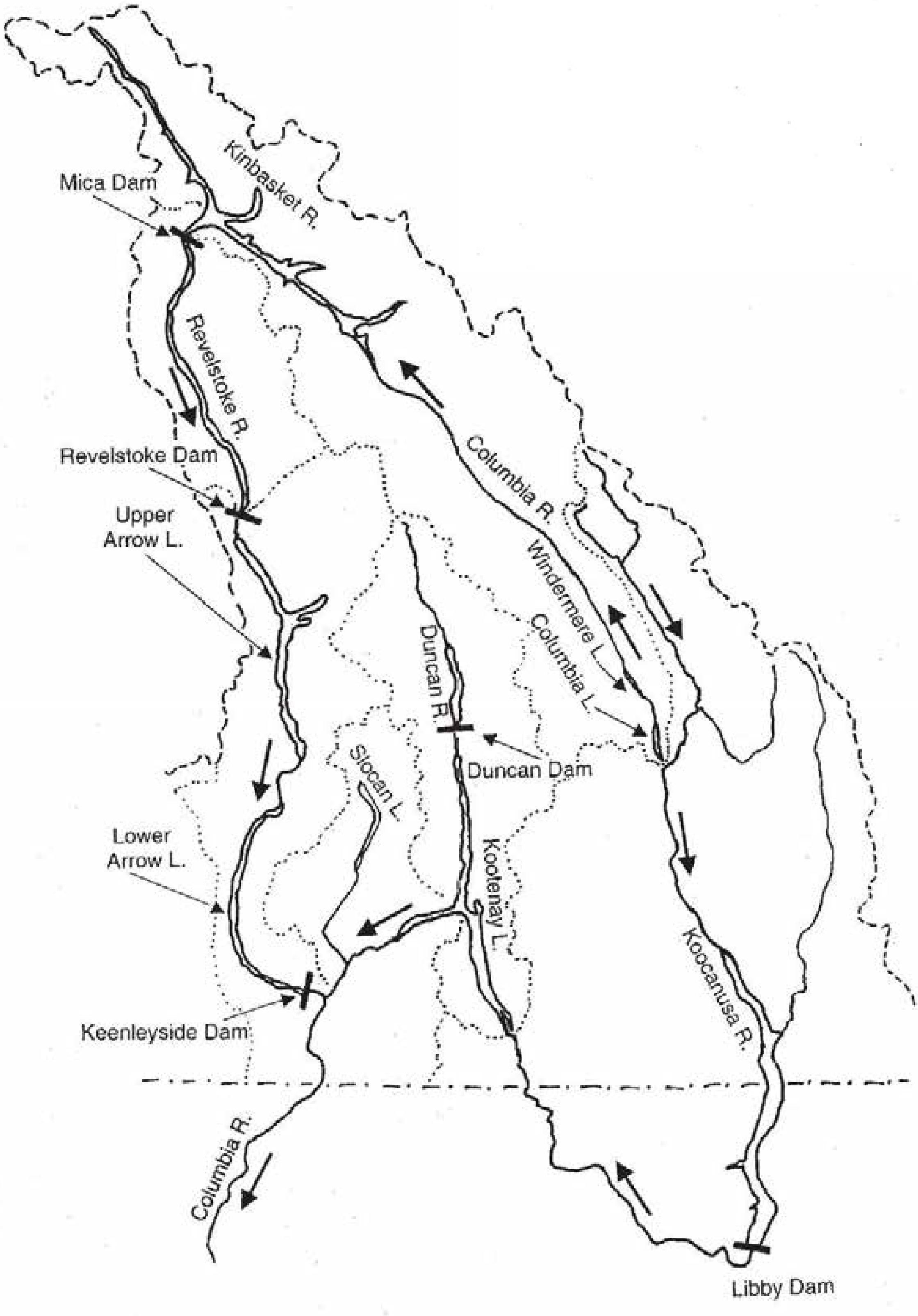



**Figure 1.1.** Upper Columbia River Basin

**Figure 1.2** Kinbasket Reservoir with gauging stations (RED) and sampled tributaries (YELLOW).

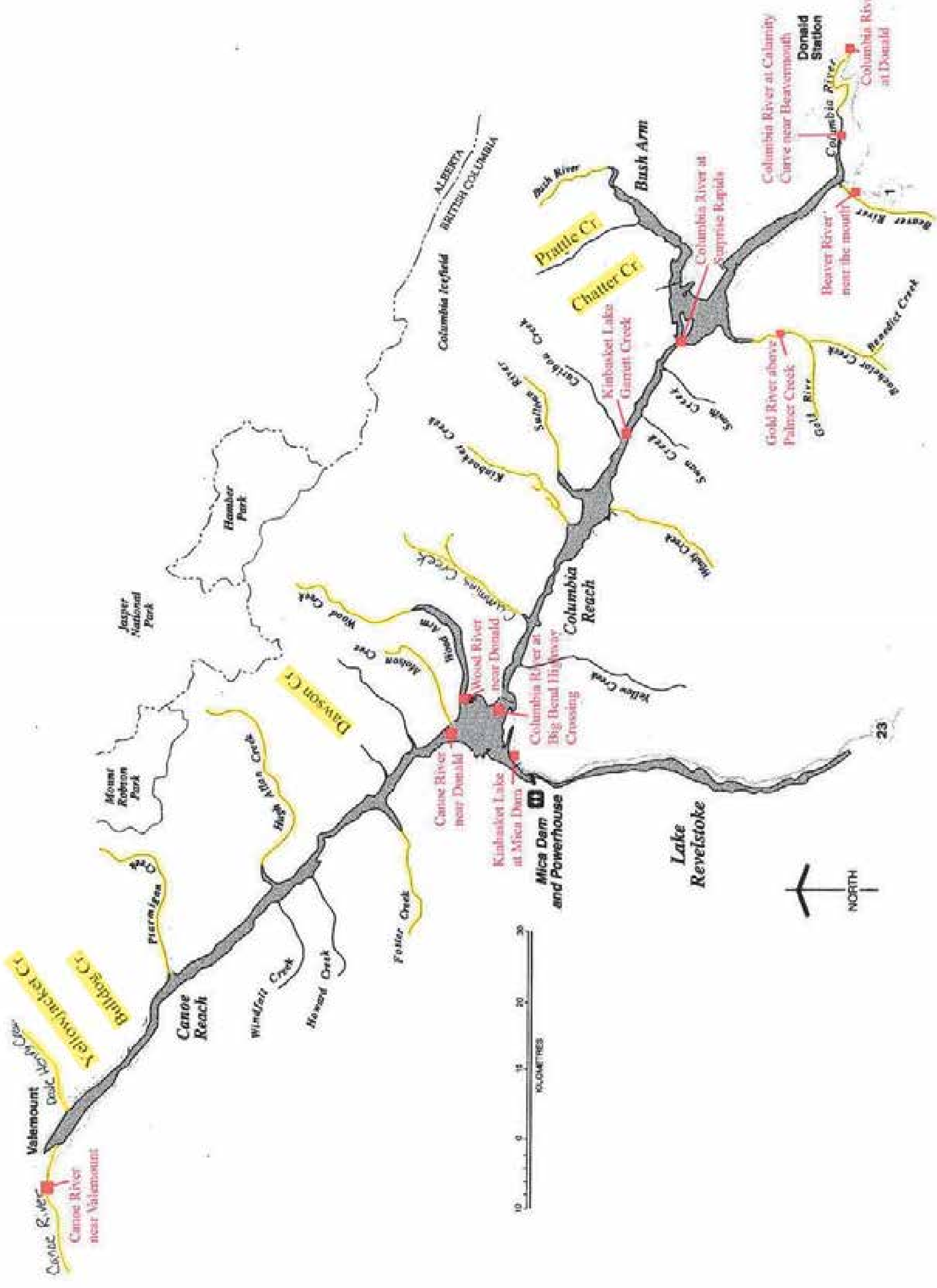
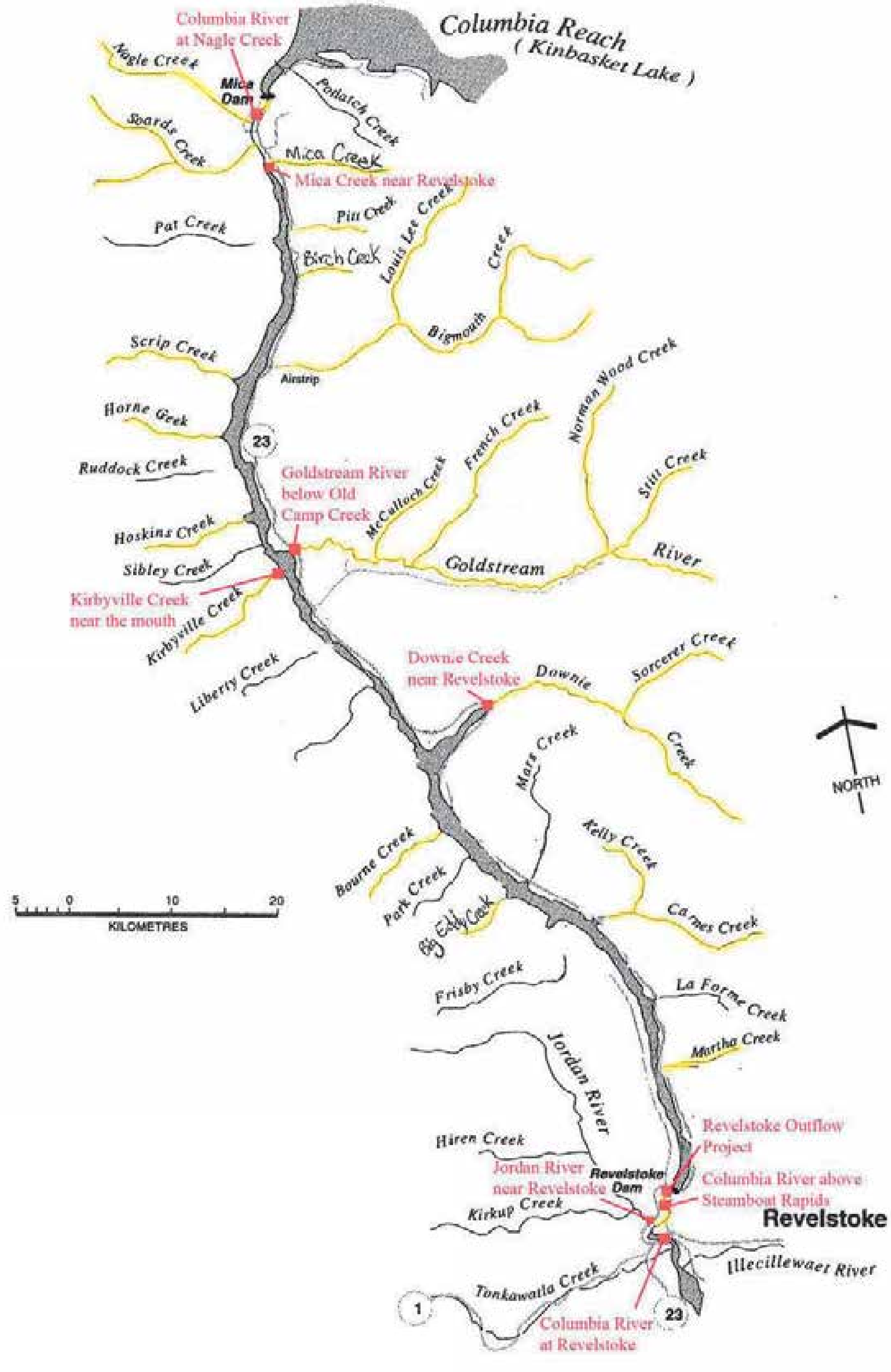


Figure 1.3 Revelstoke Reservoir with gauging stations (RED) and sampled tributaries (YELLOW).



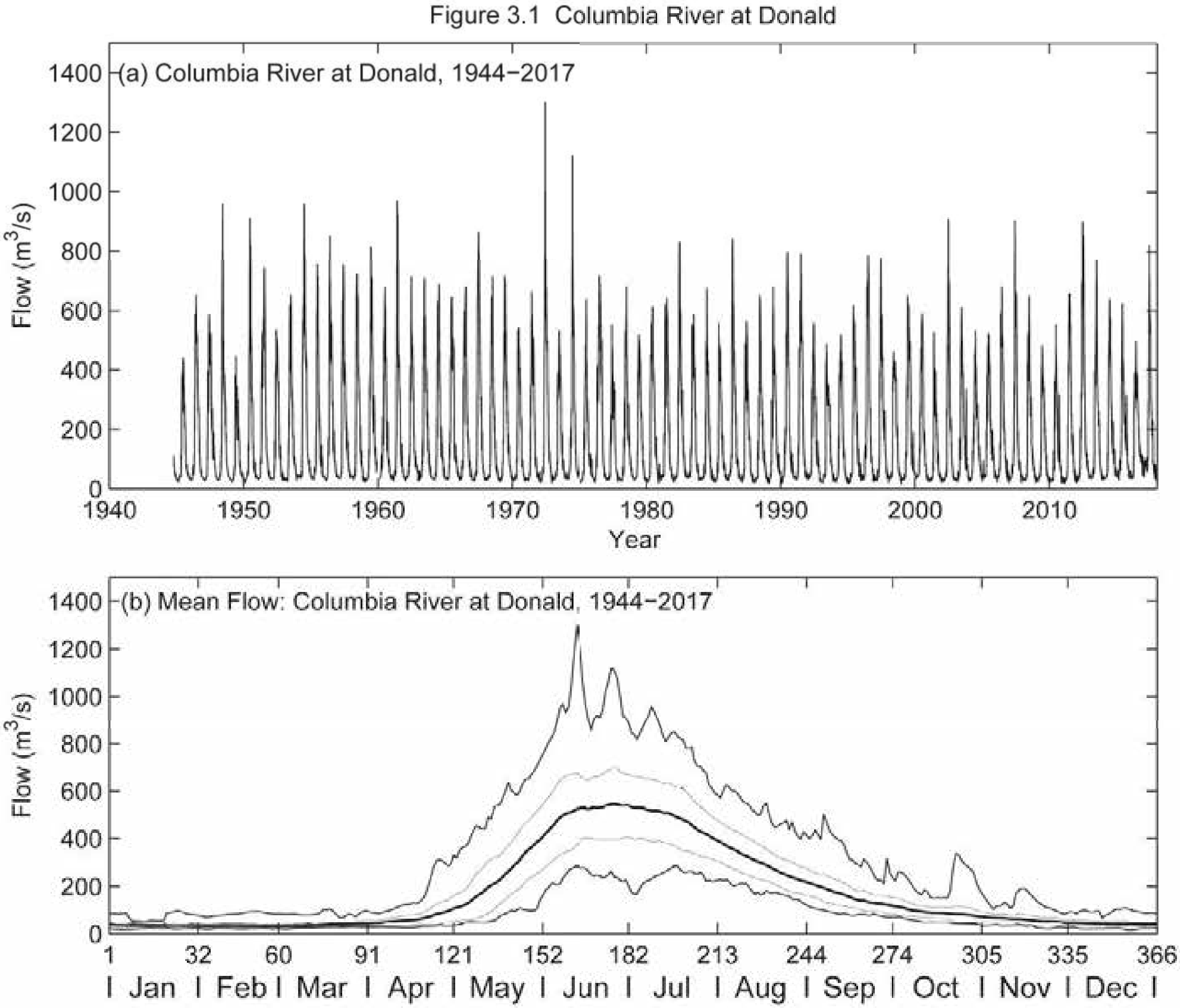



**Figure 3.1.** **(a)** WSC station 08NB005, "Columbia River at Donald", 1944-2017. **(b)** Mean flow for the years indicated. Mean (heavy line), maximum and minimum (medium lines) and mean ± one standard deviation (light lines).

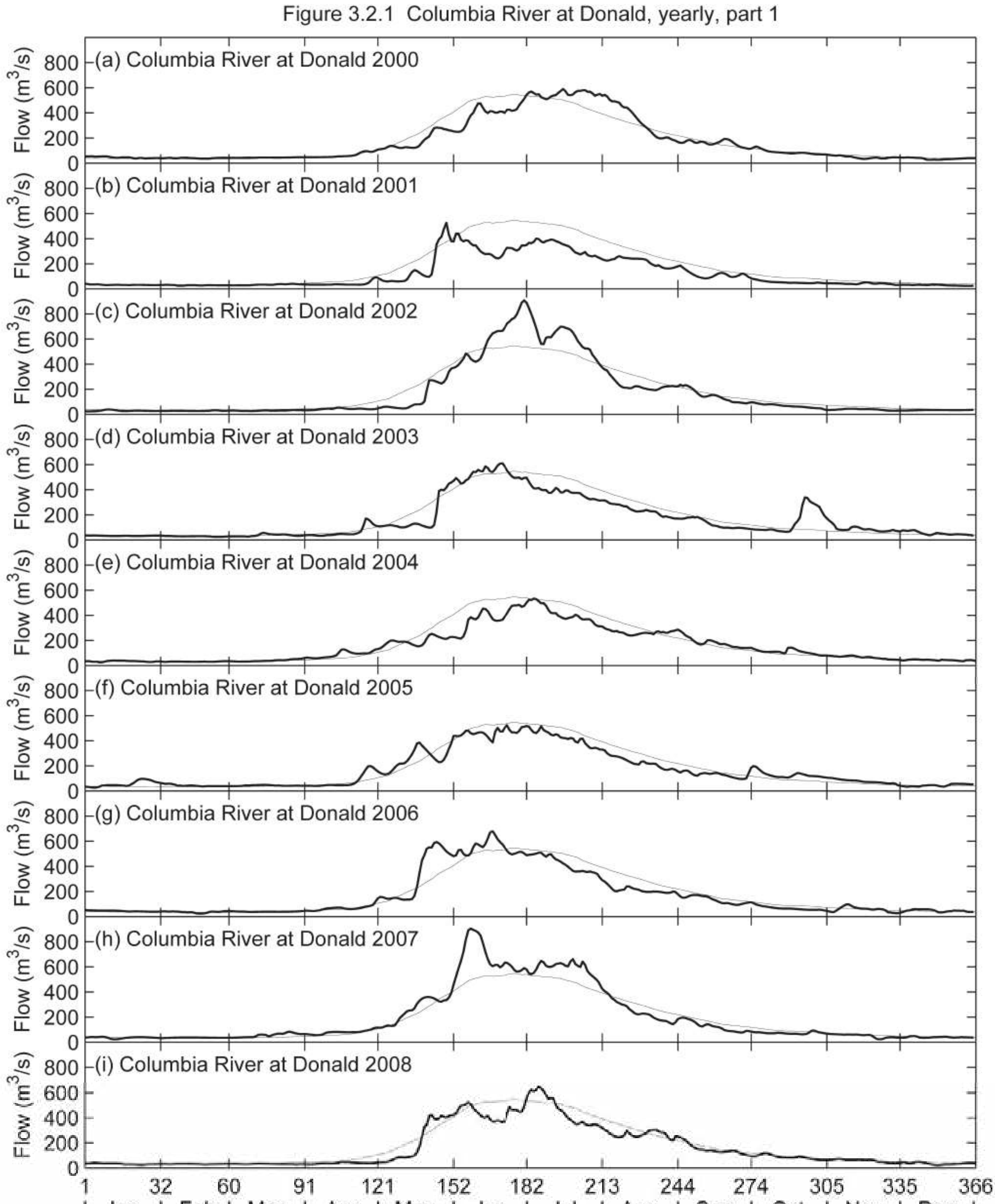



**Figure 3.2.1.** WSC station 08NB005, "Columbia River at Donald", selected years (heavy line). Mean flow for 1944-2017 (light line) is shown for comparison.

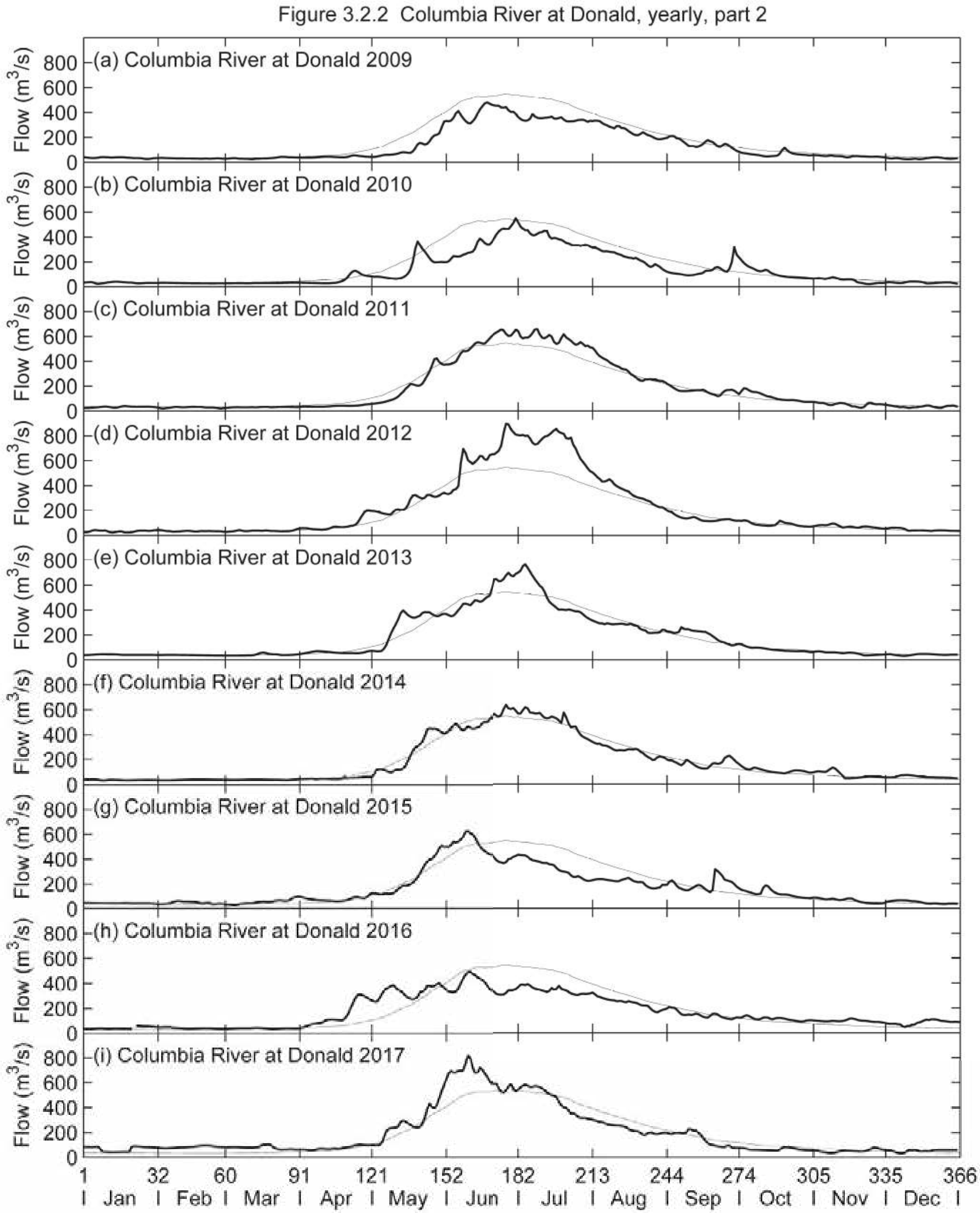



**Figure 3.2.2.** WSC station 08NB005, "Columbia River at Donald", selected years (heavy line). Mean flow for 1944-2017 (light line) is shown for comparison.

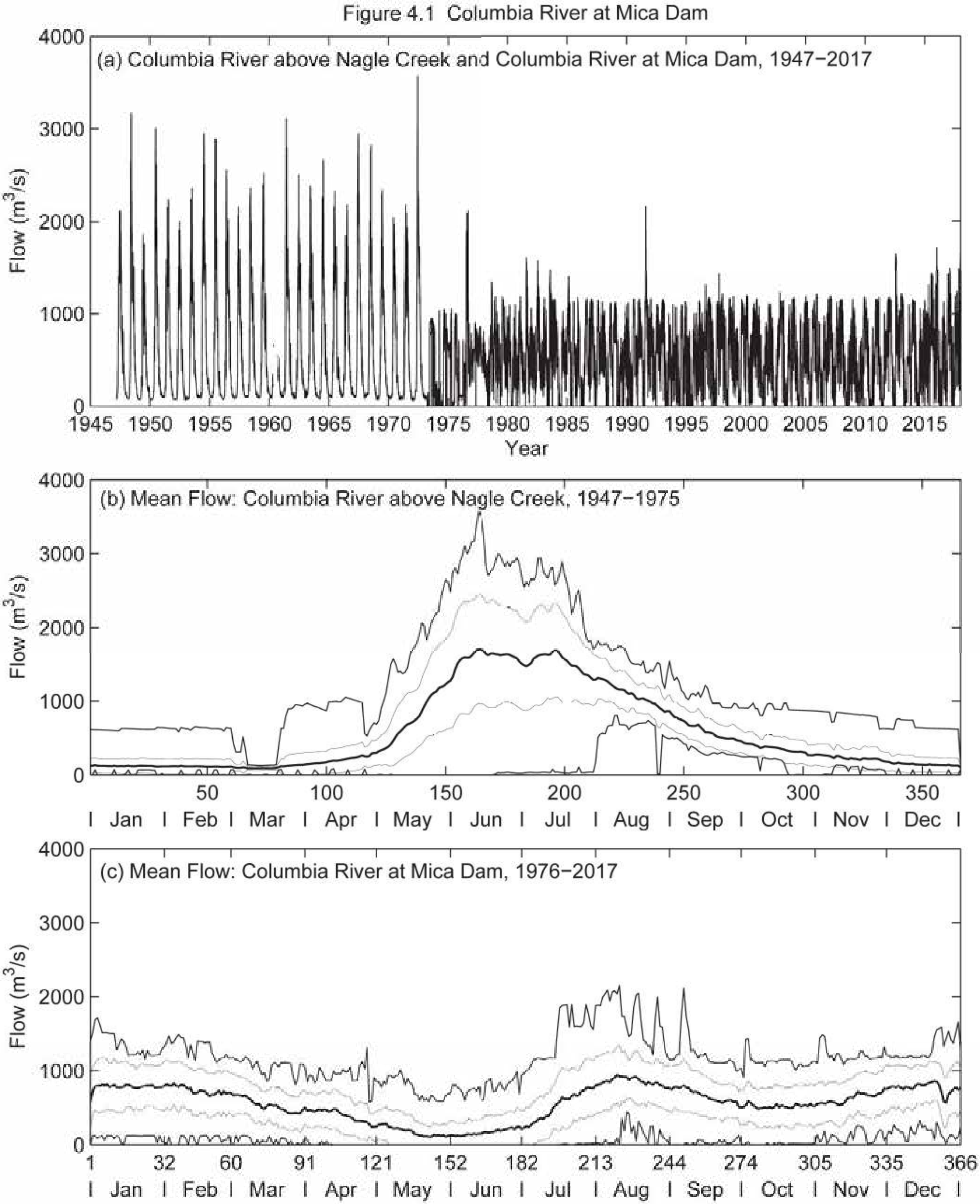



**Figure 4.1.** **(a)** WSC station 08ND007, "Columbia River above Nagle Creek", 1947-1975 and BC Hydro station "Columbia River at Mica Dam Outflow", 1976-2017. **(b)** Mean pre-impoundment flow for the years indicated. **(c)** Mean post-impoundment flow for the years indicated. Mean (heavy line), maximum and minimum (medium lines) and mean ± one standard deviation (light lines).

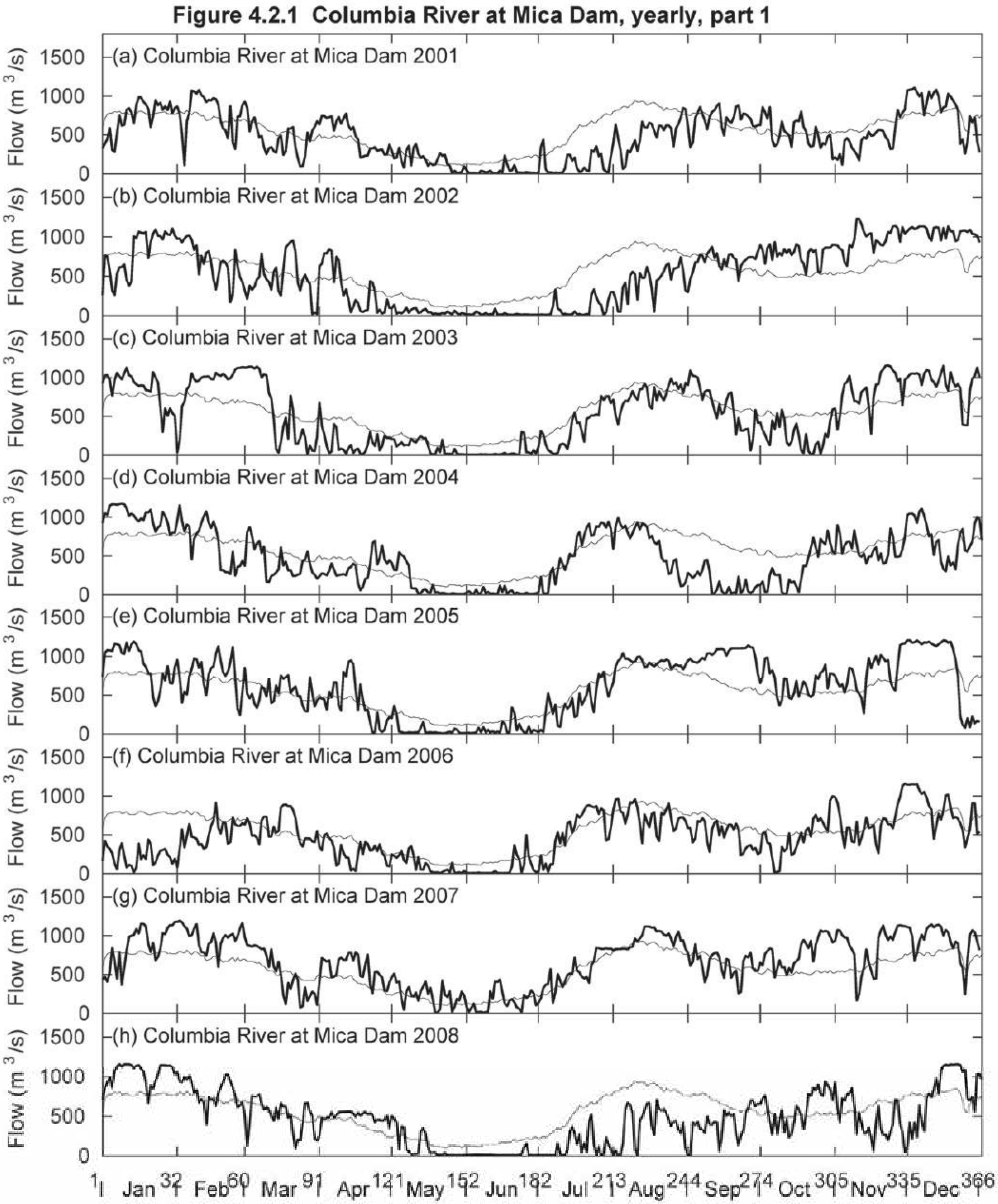



**Figure 4.2.1.** BC Hydro station "Columbia River at Mica Dam Outflow", selected years (heavy line). Mean flow for 1976-2017 (light line) is shown for comparison.

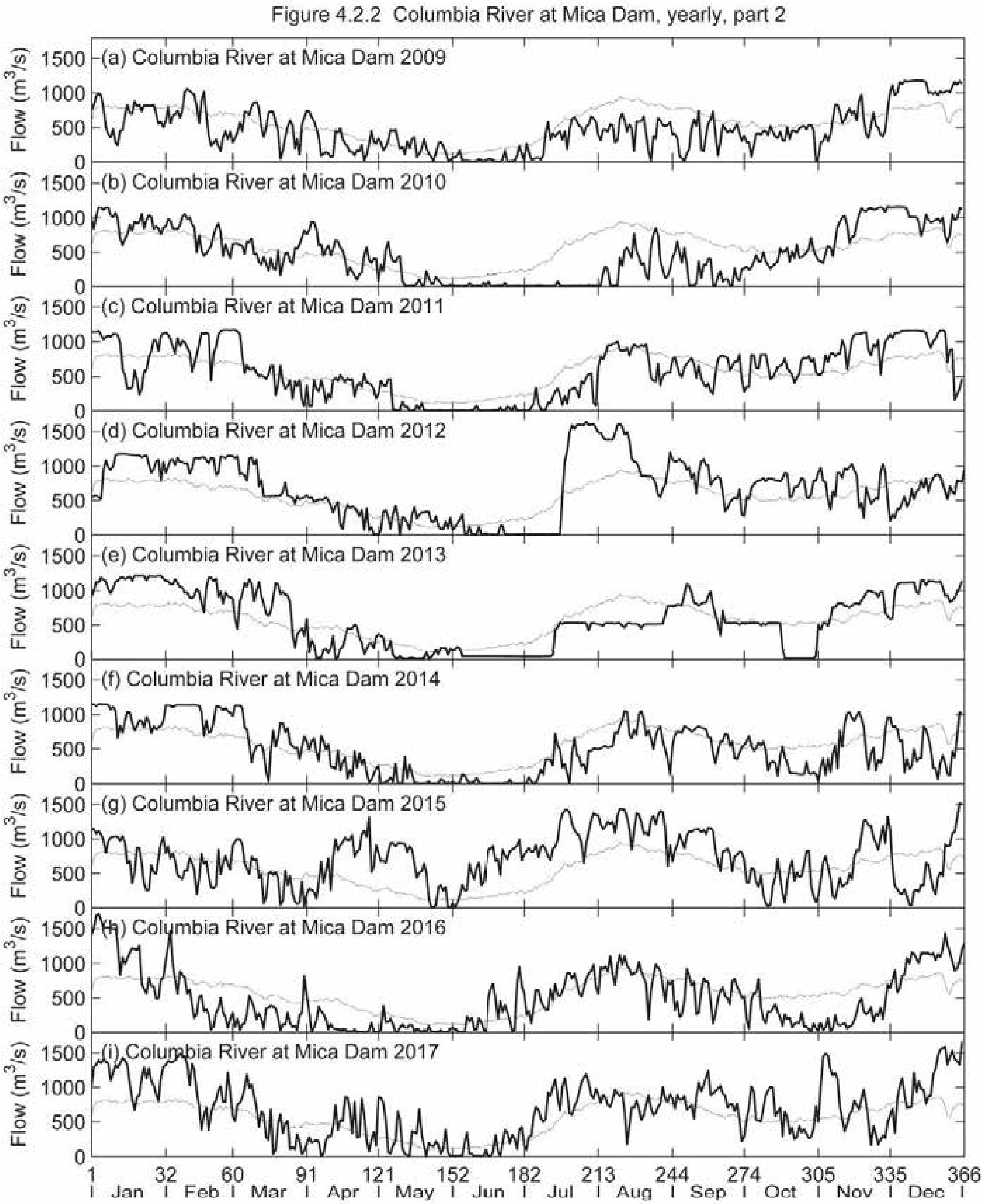



**Figure 4.2.2.** BC Hydro station "Columbia River at Mica Dam Outflow", selected years (heavy line). Mean flow for 1976-2017 (light line) is shown for comparison.

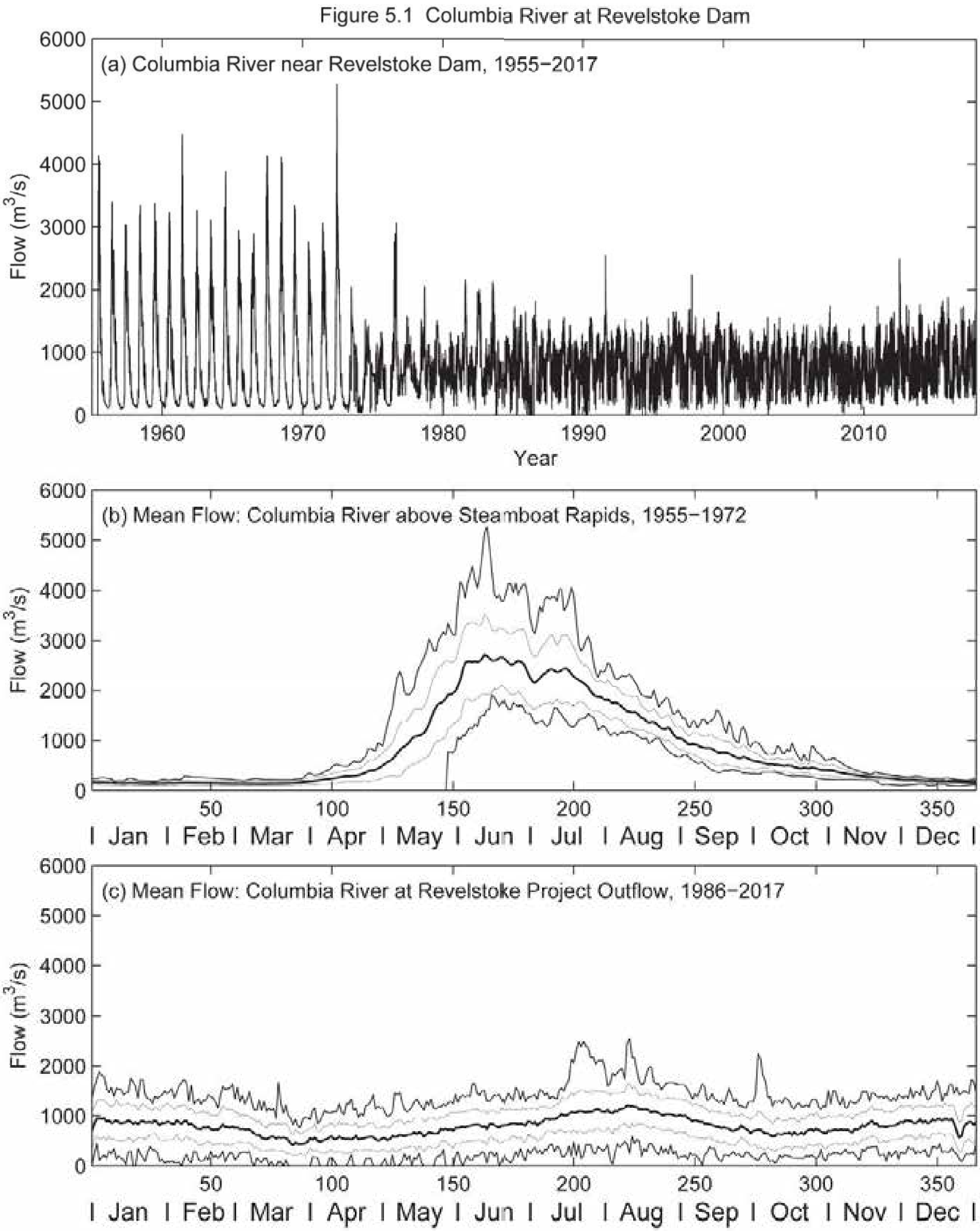



**Figure 5.1. (a)** WSC station 08ND011, "Columbia River above Steamboat Rapids", 1955-1985 and WSC station 08ND025, "Revelstoke Project Outflow", 1986-2017. **(b)** Mean pre-impoundment flow for the years indicated. **(c)** Mean post-impoundment flow for the years indicated. Mean (heavy line), maximum and minimum (medium lines) and mean ± one standard deviation (light lines).

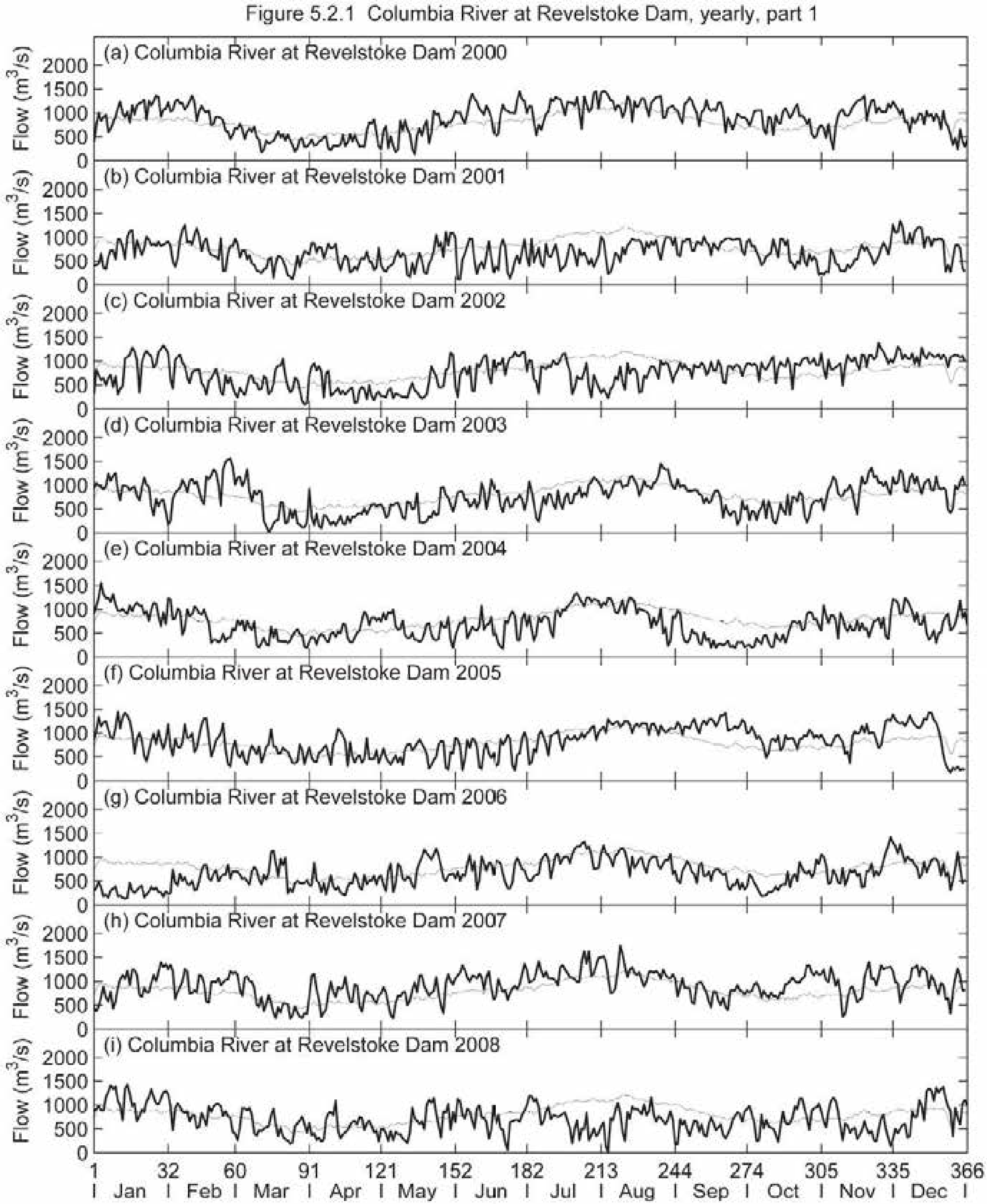



**Figure 5.2.1.** WSC station 08ND025, "Revelstoke Project Outflow", selected years (heavy line). Mean flow for 1986-2017 (light line) is shown for comparison.

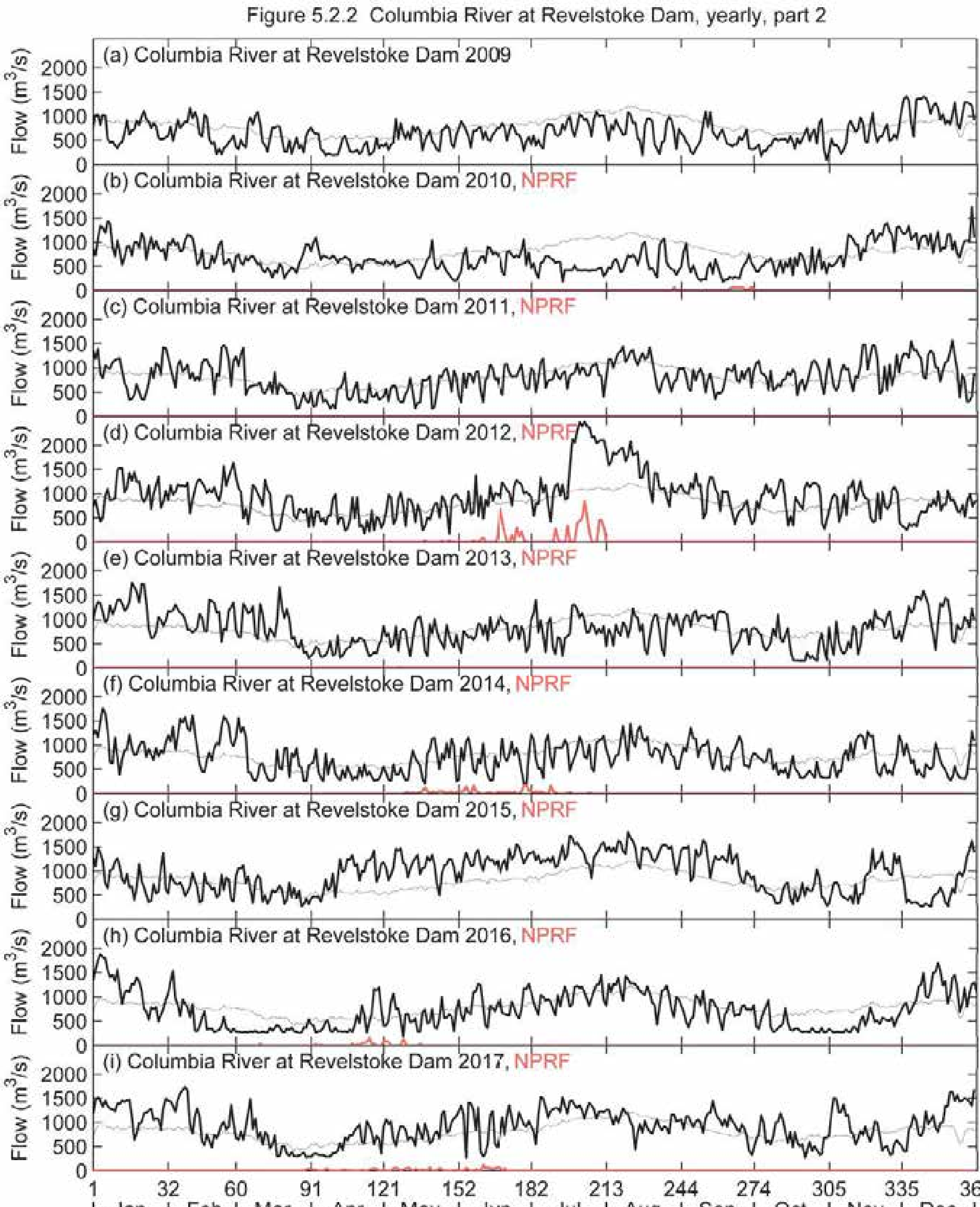



**Figure 5.2.2.** WSC station 08ND025, "Revelstoke Project Outflow", selected years (heavy line). Mean flow for 1986-2017 (light line) is shown for comparison. NPRF (RED) marks non-power flow (spill).

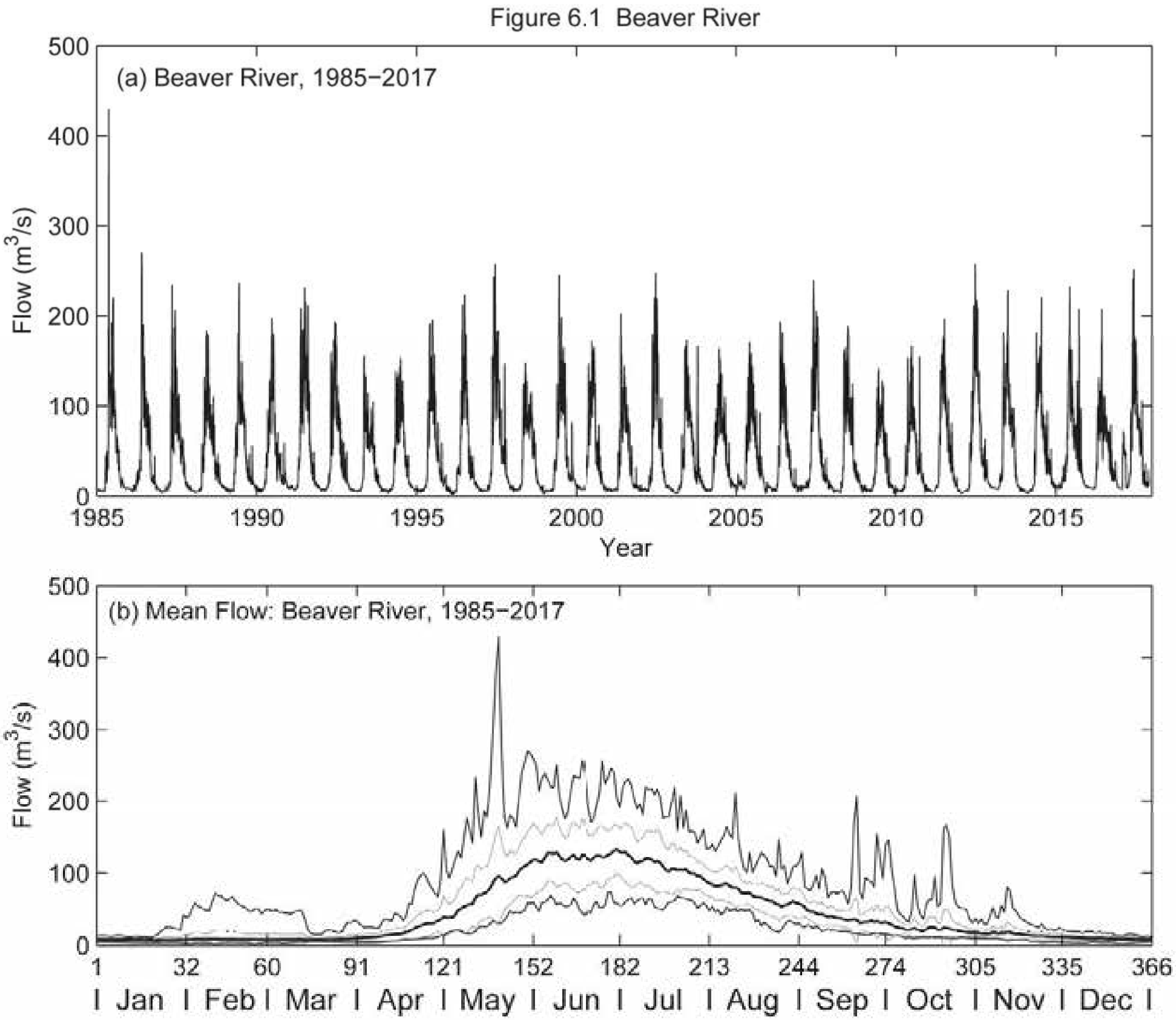



**Figure 6.1.** **(a)** WSC station 08NB019, "'Beaver River near the Mouth", 1985-2017. **(b)** Mean flow for the years indicated. Mean (heavy line), maximum and minimum (medium lines) and mean ± one standard deviation (light lines).

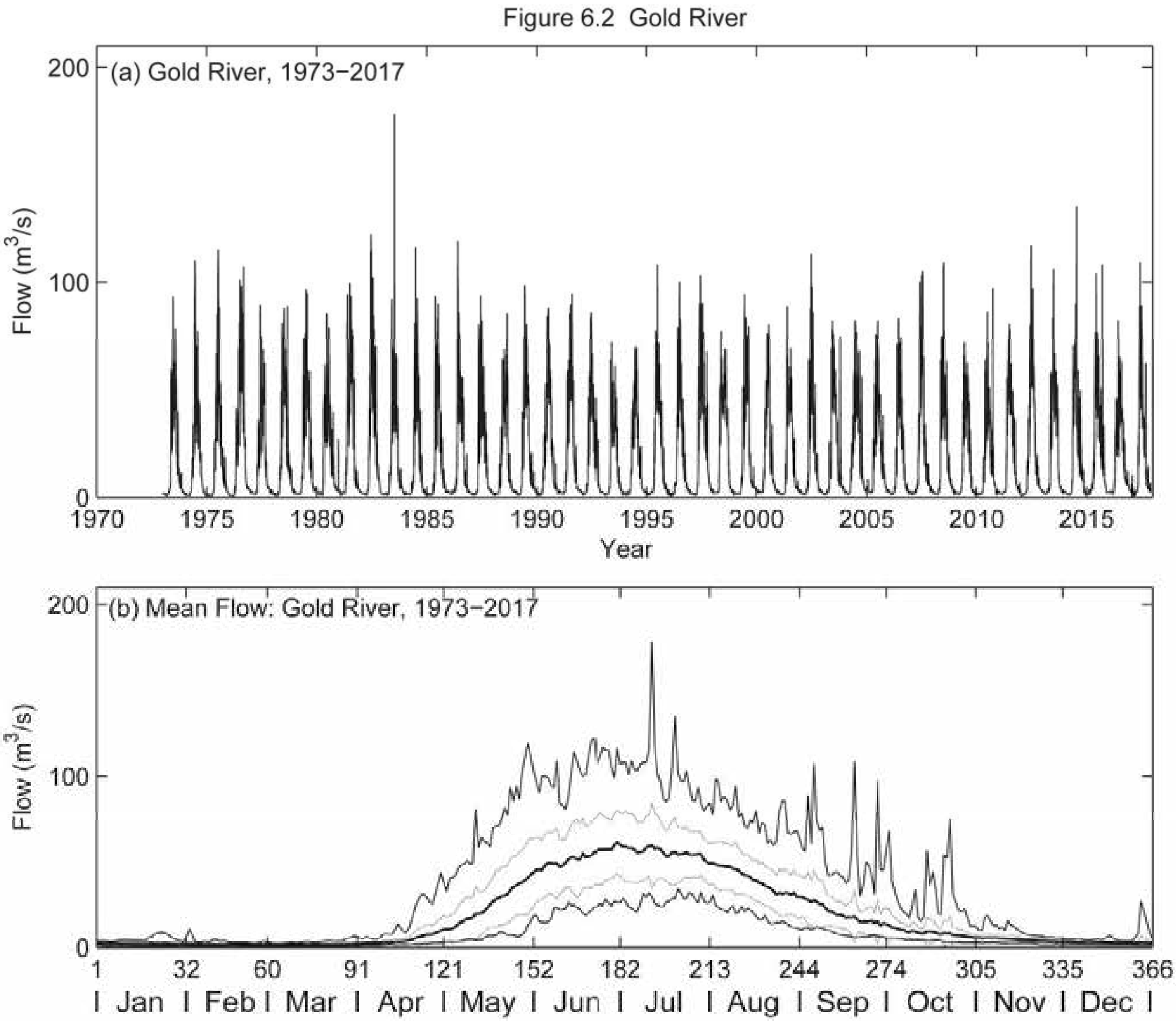



**Figure 6.2.** **(a)** WSC station 08NB014, "Gold River above Palmer Creek", 1973-2017. **(b)** Mean flow for the years indicated. Mean (heavy line), maximum and minimum (medium lines) and mean ± one standard deviation (light lines).

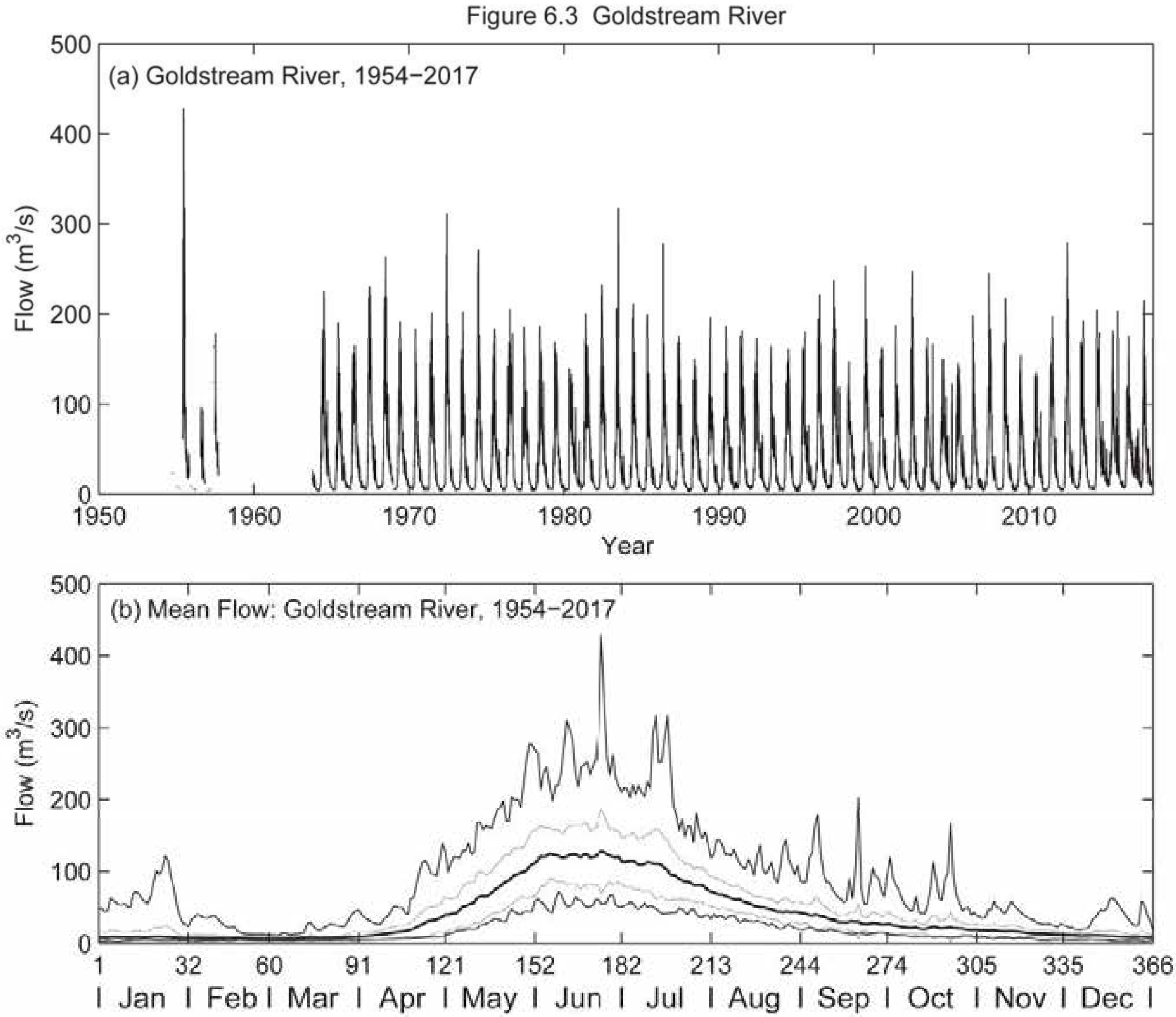



**Figure 6.3.** **(a)** WSC station 08ND012, "Goldstream River below Old Camp Creek", 1954-2017. **(b)** Mean flow for the years indicated. Mean (heavy line), maximum and minimum (medium lines) and mean ± one standard deviation (light lines).

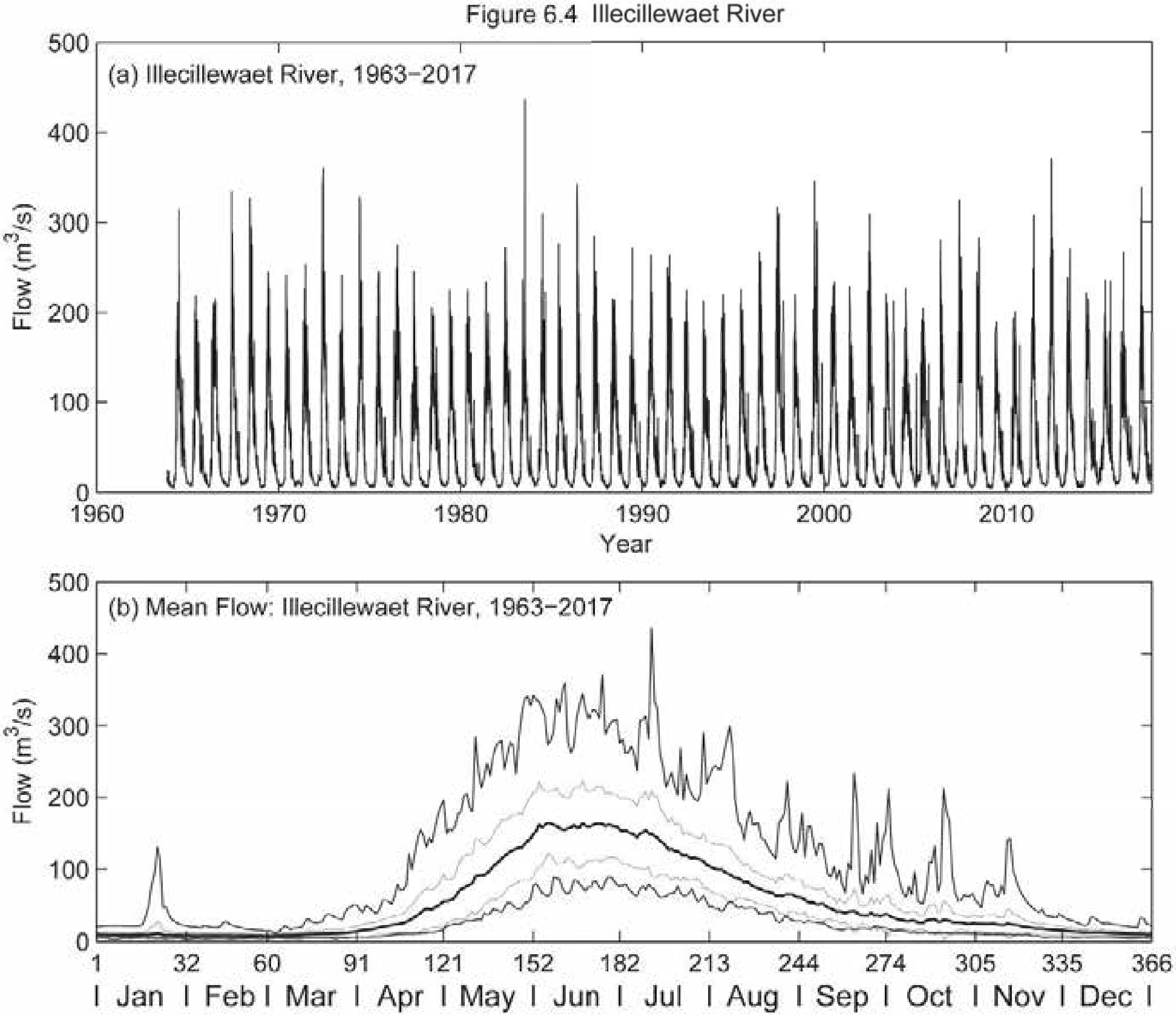



**Figure 6.4.** **(a)** WSC station 08ND013, "Illecillewaet River at Greeley", 1963-2017. **(b)** Mean flow for the years indicated. Mean (heavy line), maximum and minimum (medium lines) and mean ± one standard deviation (light lines).

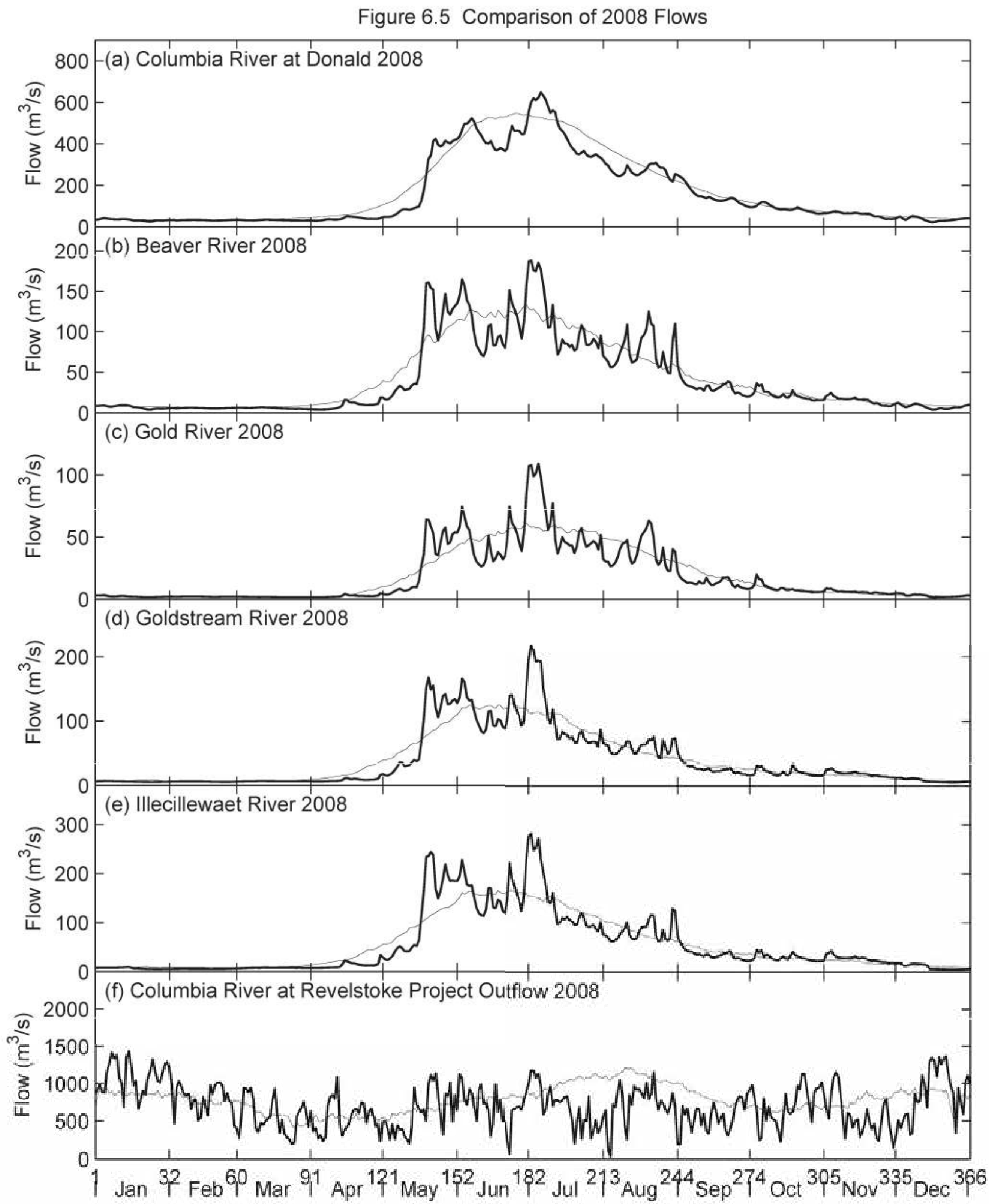



**Figure 6.5.** Comparison of flows in 2008 for the stations indicated (heavy line). Mean flows for **a)** 1944-2016 **b)** 1985-2016 **c)** 1973-2016 **d)** 1954-2016 **e)** 1963-2016 **f)** 1986-2016 (light line).

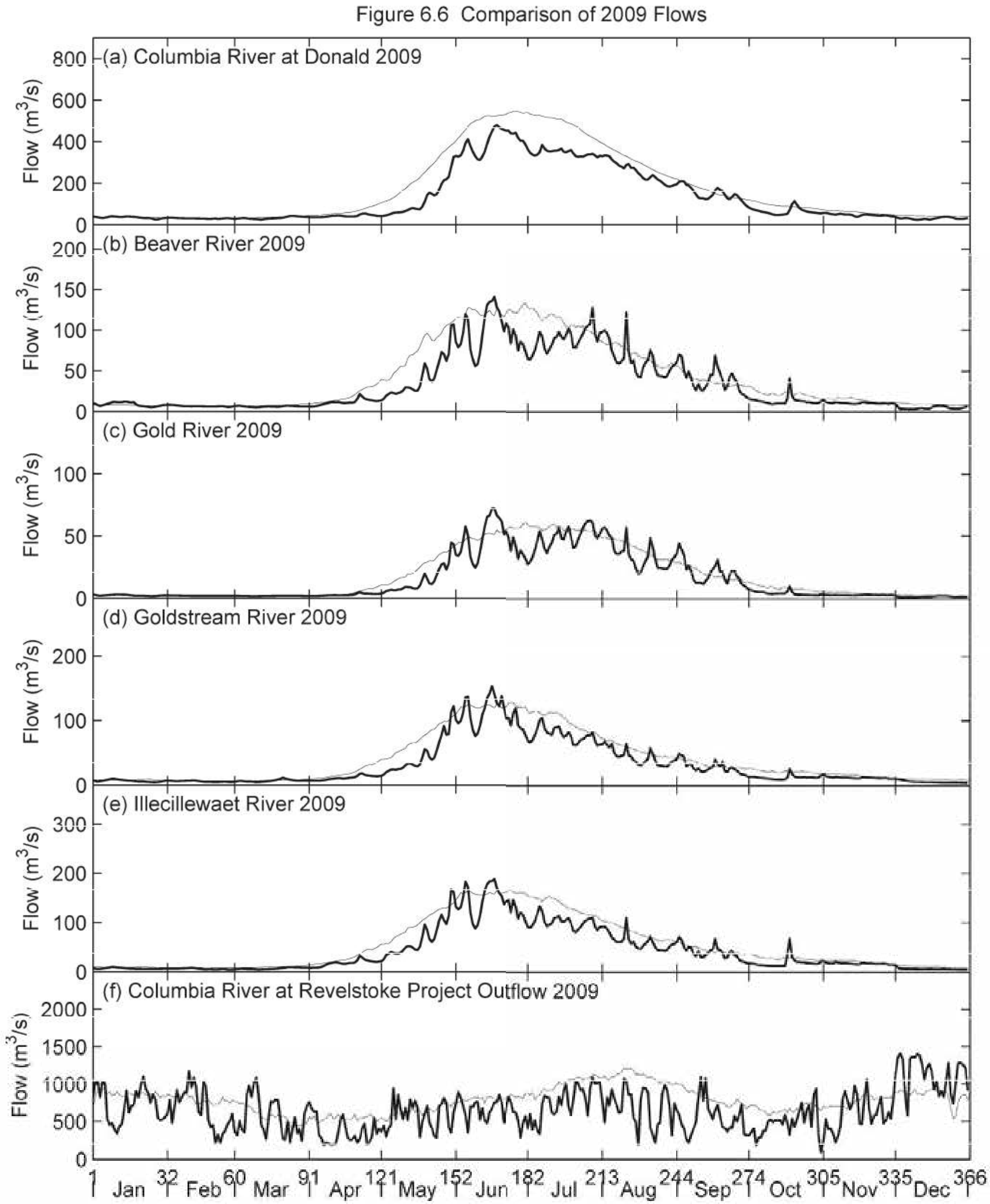



**Figure 6.6.** Comparison of flows in 2009 for the stations indicated (heavy line). Mean flows for **a)** 1944-2016 **b)** 1985-2016 **c)** 1973-2016 **d)** 1954-2016 **e)** 1963-2016 **f)** 1986-2016 (light line).

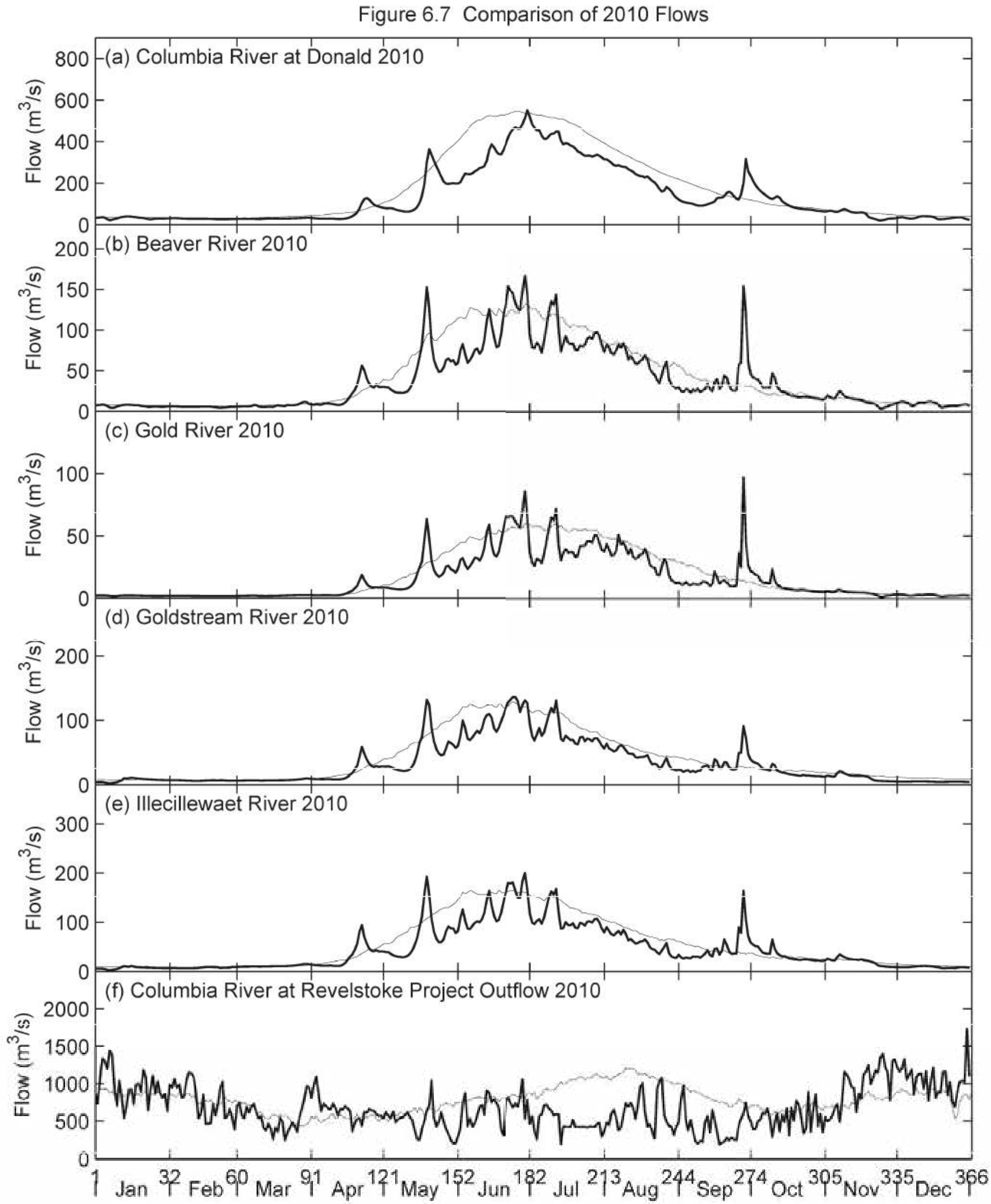



**Figure 6.7.** Comparison of flows in 2010 for the stations indicated (heavy line). Mean flows for **a)** 1944-2016 **b)** 1985-2016 **c)** 1973-2016 **d)** 1954-2016 **e)** 1963-2016 **f)** 1986-2016 (light line).

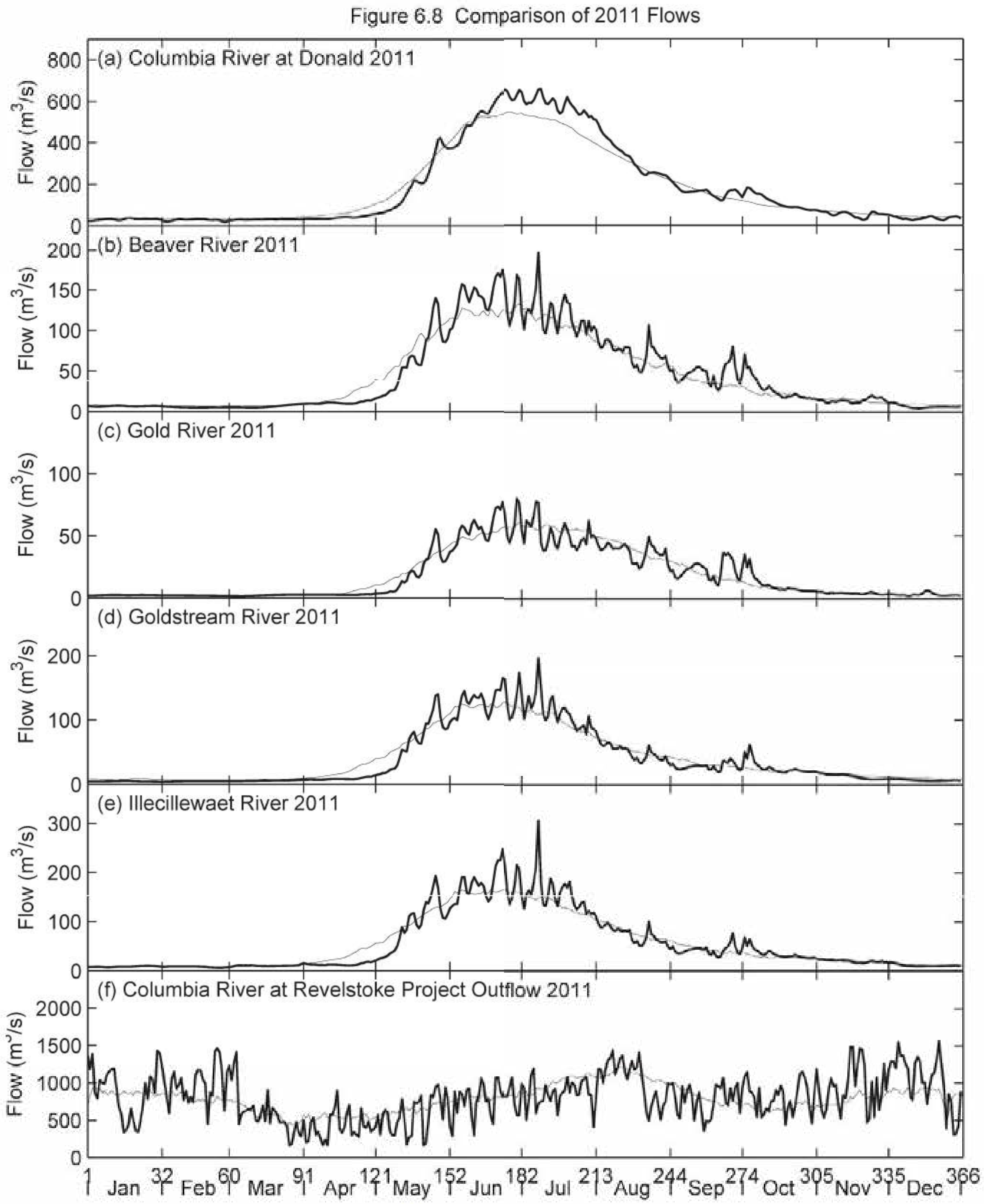



**Figure 6.8.** Comparison of flows in 2011 for the stations indicated (heavy line). Mean flows for **a)** 1944-2016 **b)** 1985-2016 **c)** 1973-2016 **d)** 1954-2016 **e)** 1963-2016 **f)** 1986-2016 (light line).

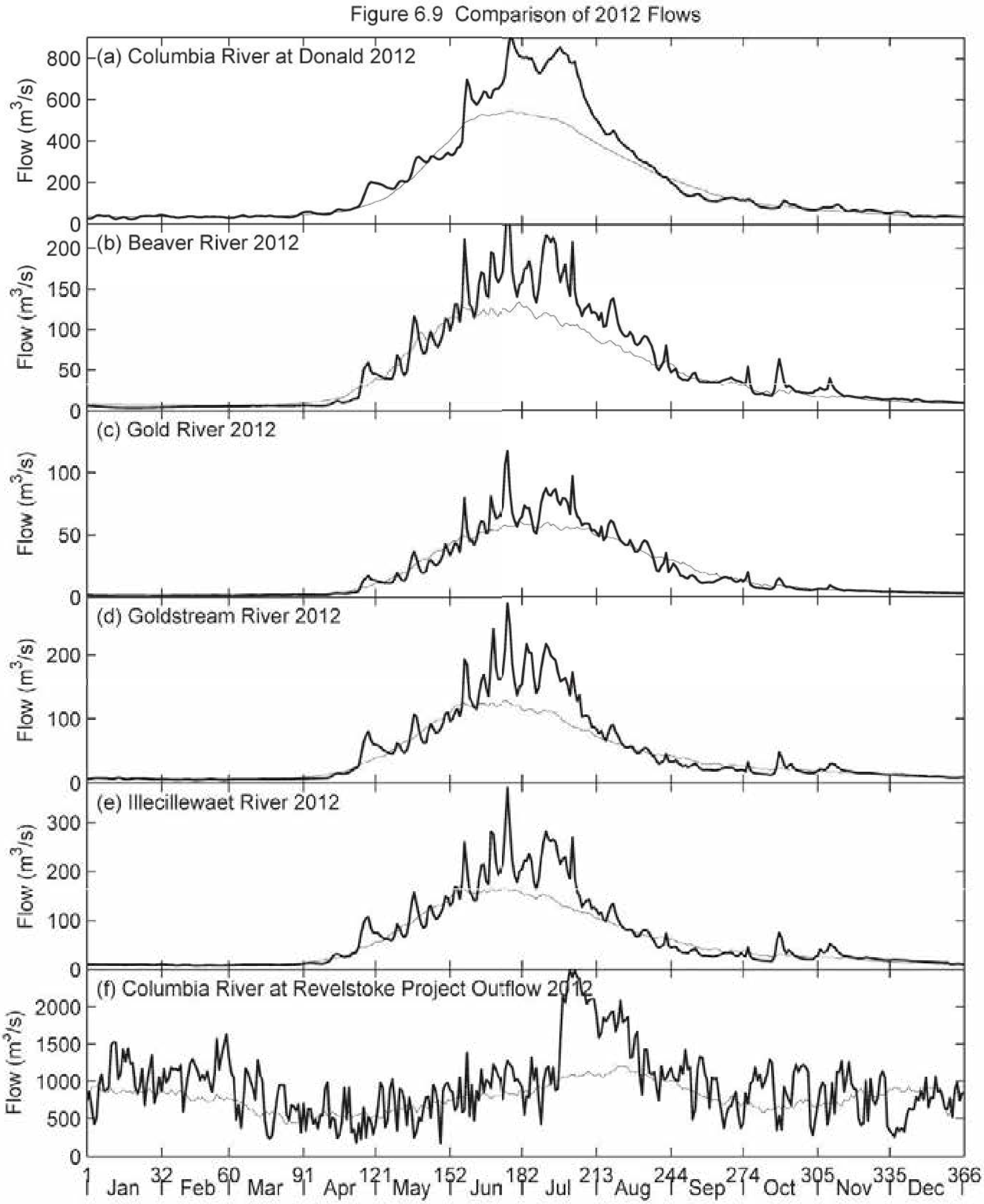



**Figure 6.9.** Comparison of flows in 2012 for the stations indicated (heavy line). Mean flows for **a)** 1944-2016 **b)** 1985-2016 **c)** 1973-2016 **d)** 1954-2016 **e)** 1963-2016 **f)** 1986-2016 (light line).

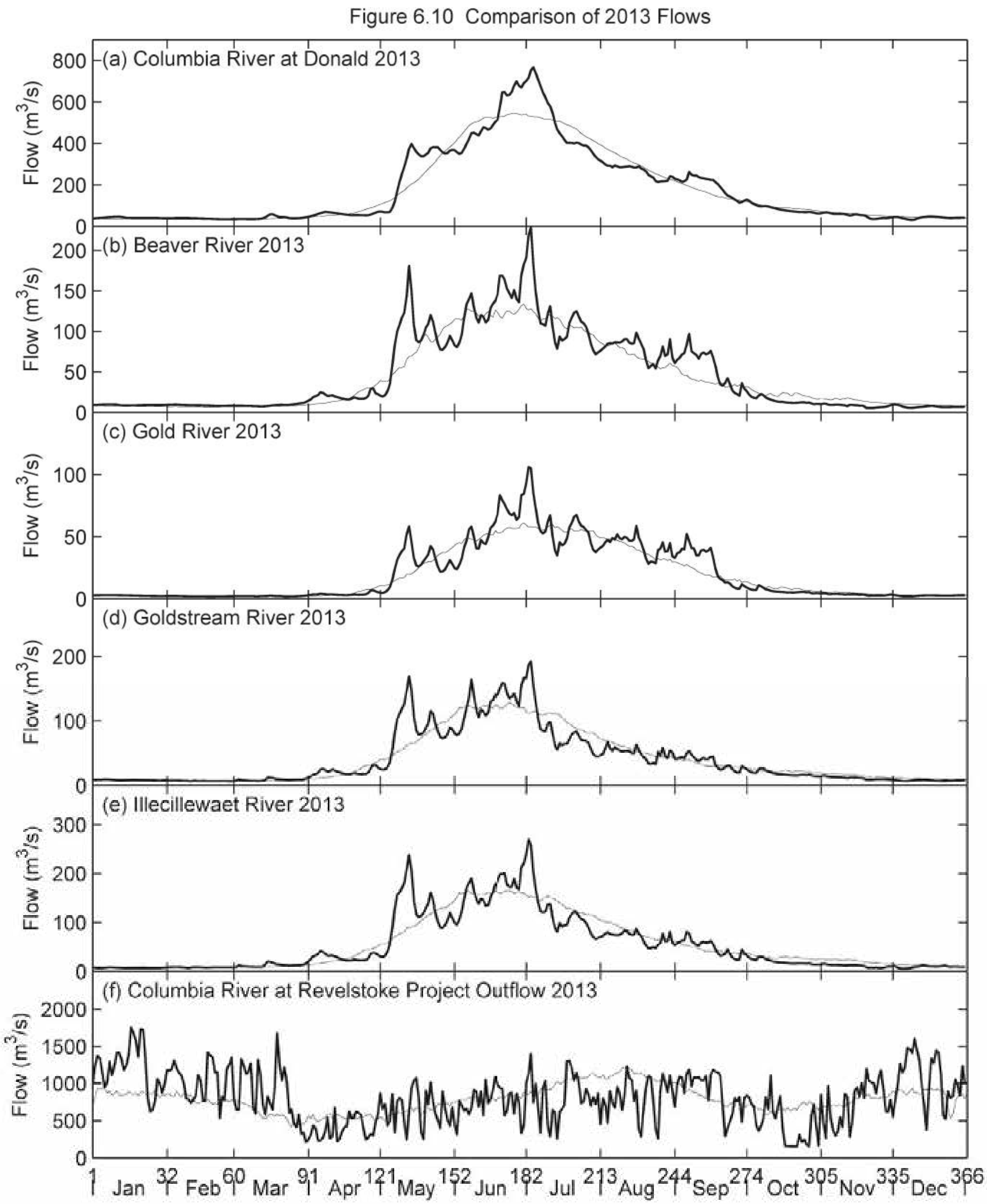



**Figure 6.10.** Comparison of flows in 3 for the stations indicated (heavy line). Mean flows for **a)** 1944-2016 **b)** 1985-2016 **c)** 1973-2016 **d)** 1954-2016 **e)** 1963-2016 **f)** 1986-2016 (light line).

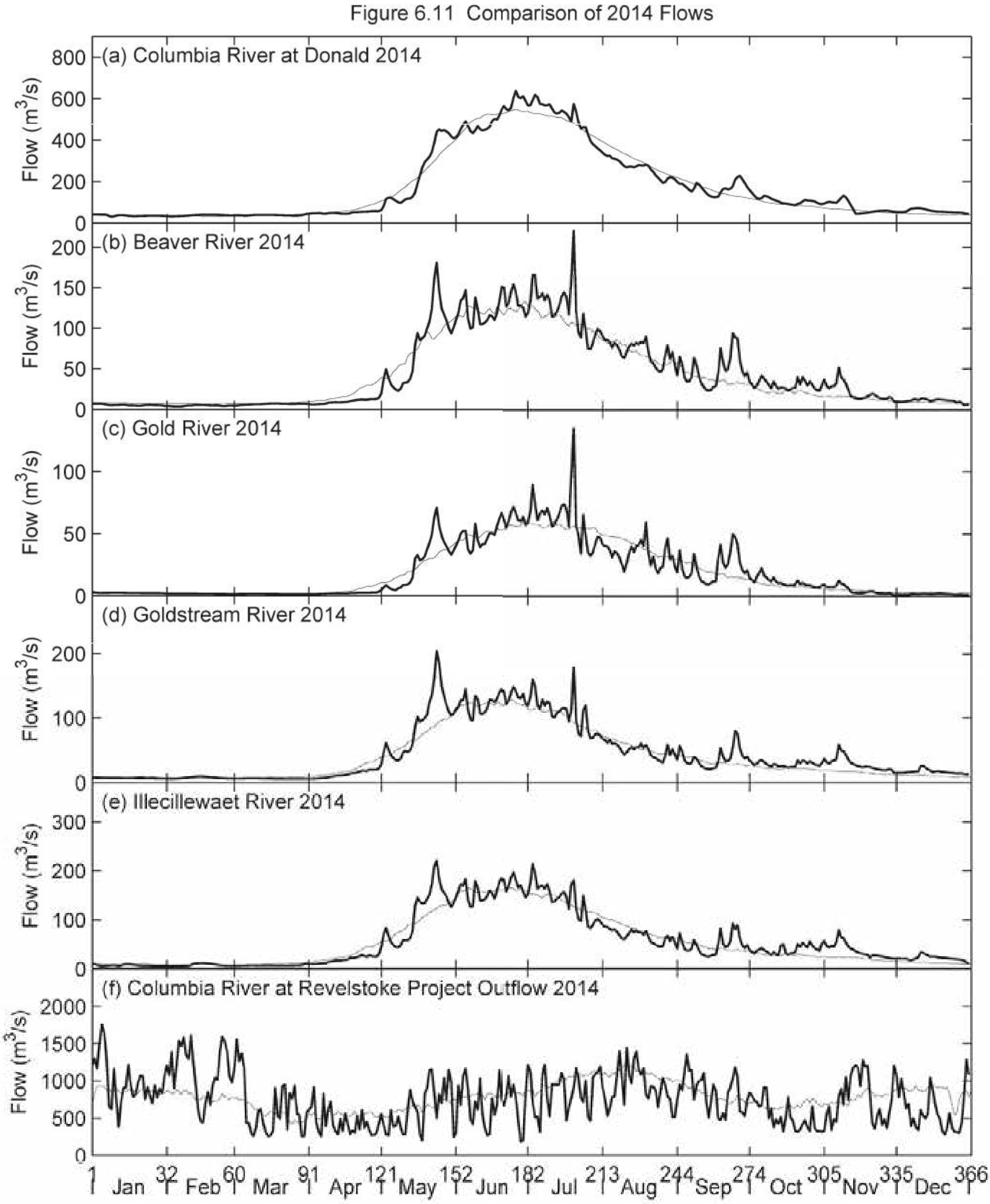



**Figure 6.11.** Comparison of flows in 2014 for the stations indicated (heavy line). Mean flows for **a)** 1944-2016 **b)** 1985-2016 **c)** 1973-2016 **d)** 1954-2016 **e)** 1963-2016 **f)** 1986-2016 (light line).

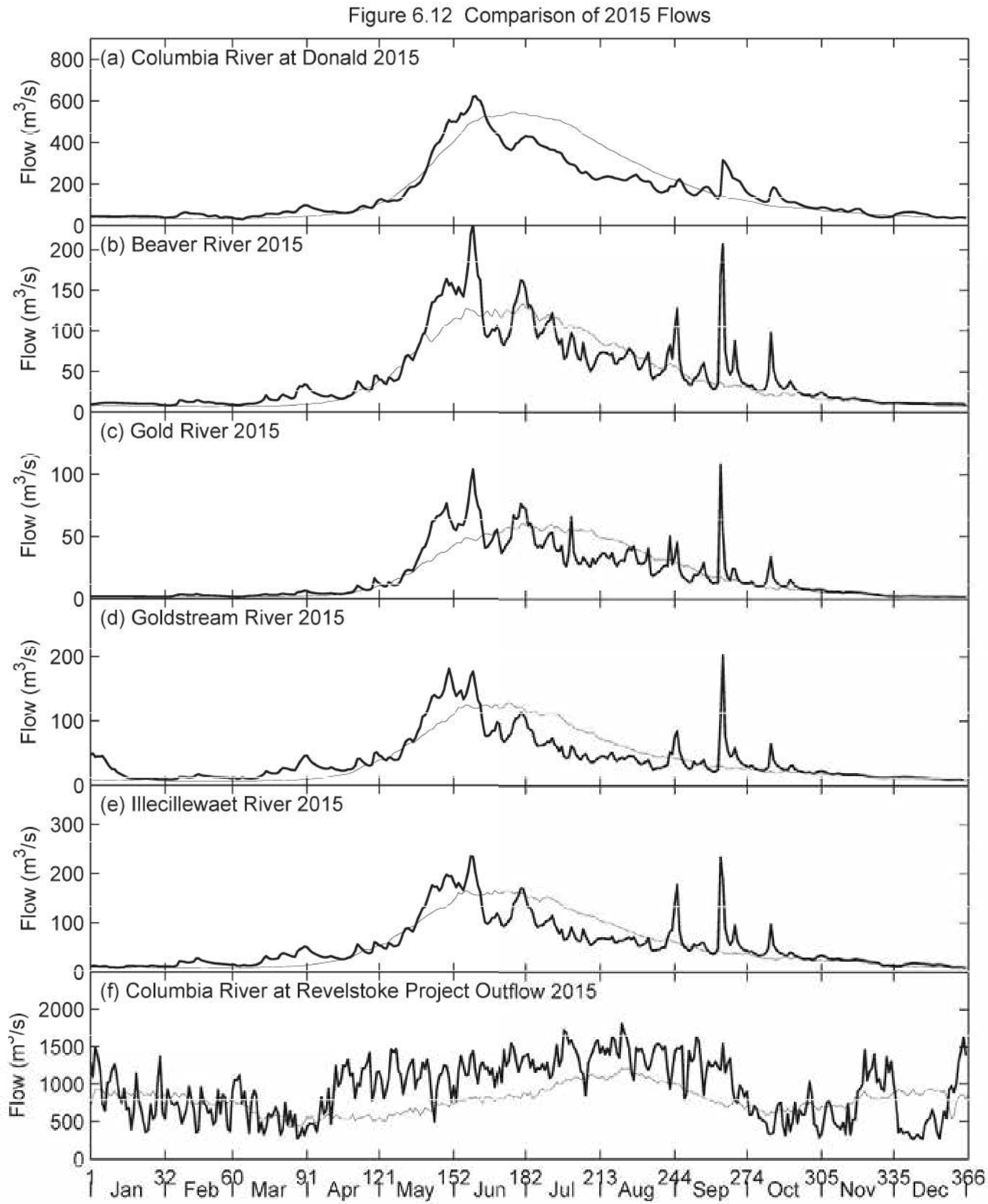



**Figure 6.12.** Comparison of flows in 2015 for the stations indicated (heavy line). Mean flows for **a)** 1944-2016 **b)** 1985-2016 **c)** 1973-2016 **d)** 1954-2016 **e)** 1963-2016 **f)** 1986-2016 (light line).

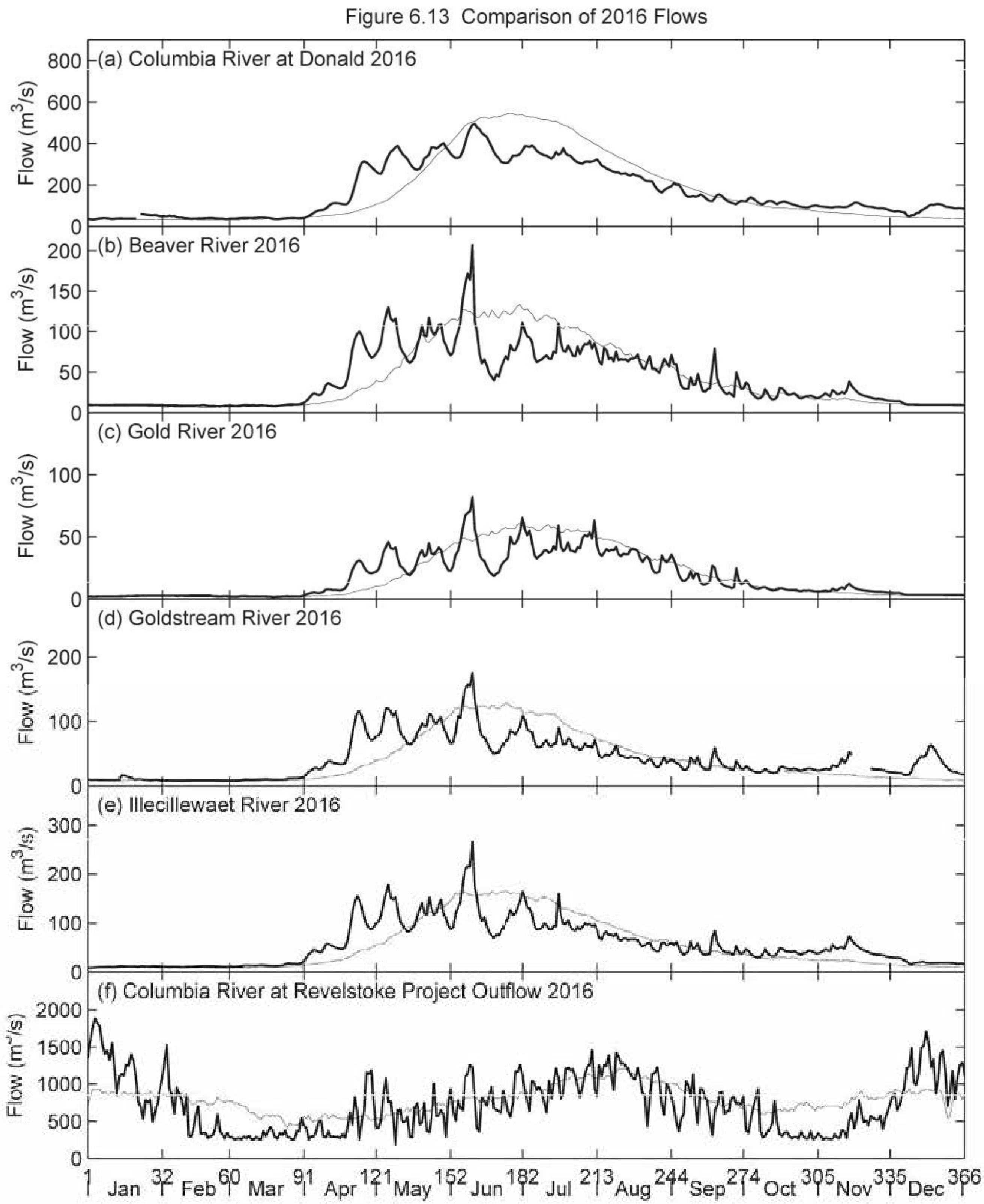



**Figure 6.13.** Comparison of flows in 2016 for the stations indicated (heavy line). Mean flows for **a)** 1944-2016 **b)** 1985-2016 **c)** 1973-2016 **d)** 1954-2016 **e)** 1963-2016 **f)** 1986-2016 (light line).

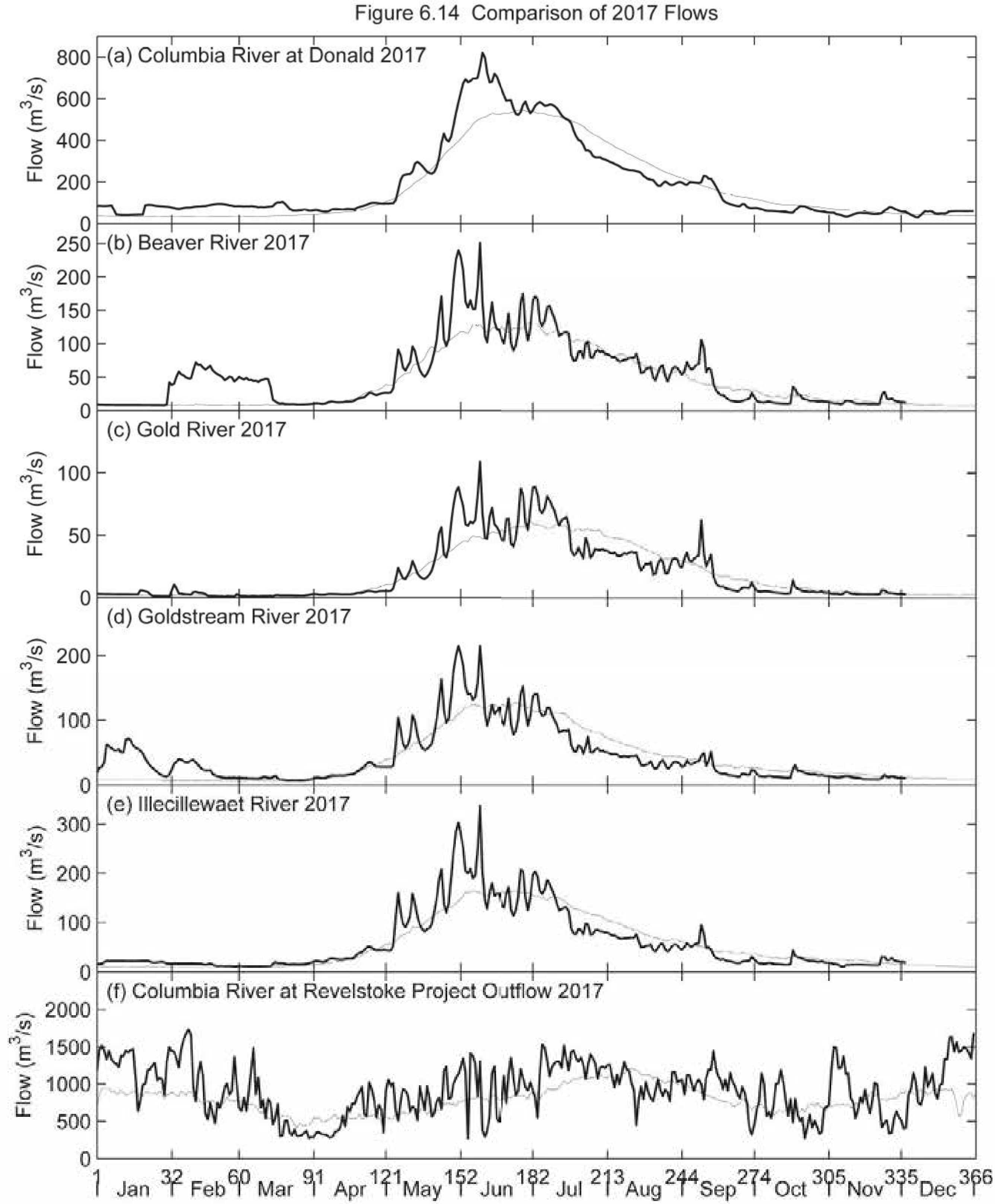



**Figure 6.14.** Comparison of flows in 2017 for the stations indicated (heavy line). Mean flows for **a)** 1944-2017 **b)** 1985-2017 **c)** 1973-2017 **d)** 1954-2017 **e)** 1963-2017 **f)** 1986-2017 (light line).

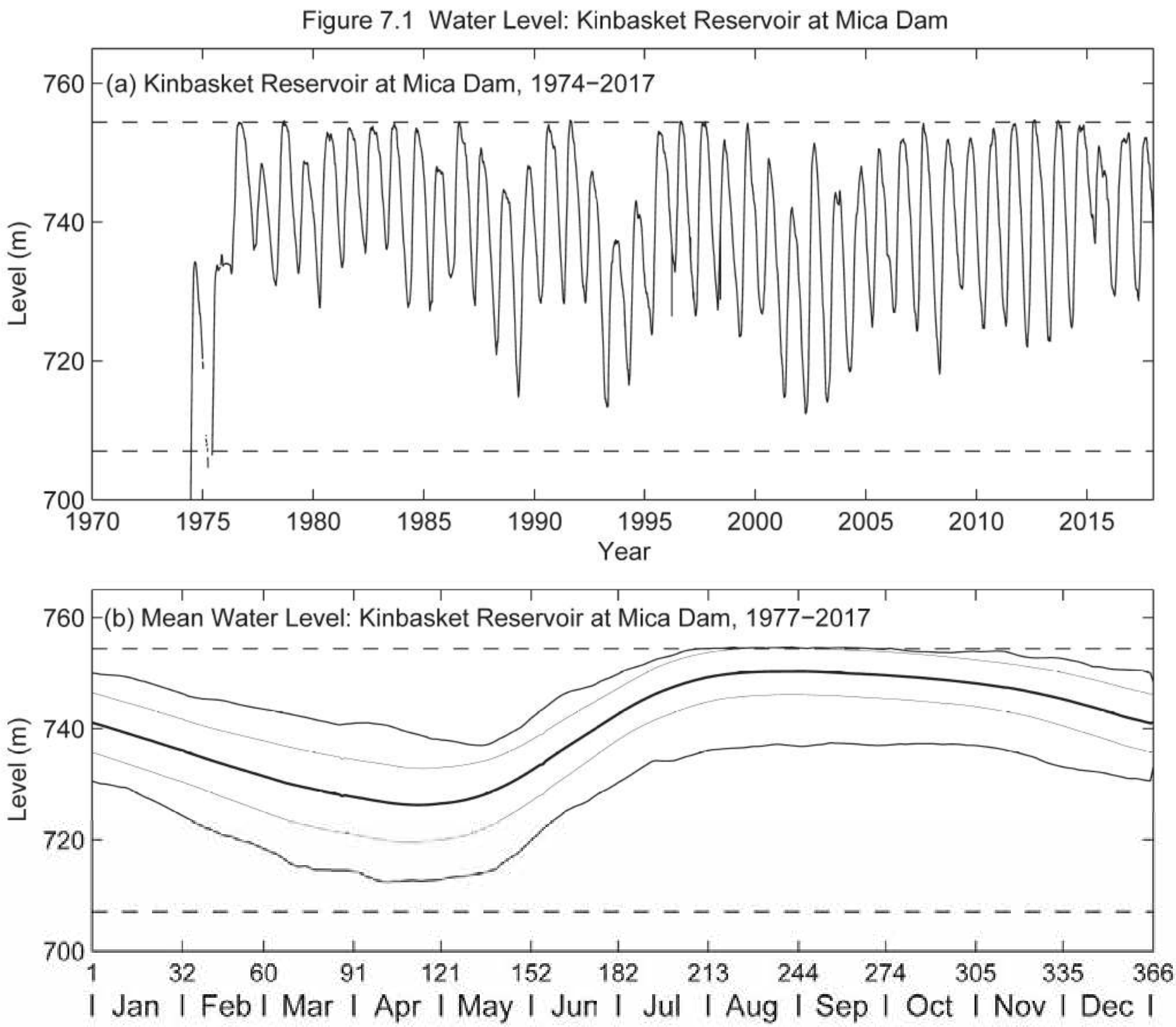



**Figure 7.1.** **(a)** WSC station 08ND017 "Kinbasket Lake at Mica Dam", 1974-2017. **(b)** Mean daily water level for 1977-2017. Mean (heavy line), maximum and minimum (medium lines) and mean ± one standard deviation (light lines). Dash lines mark the normal minimum and maximum elevation.

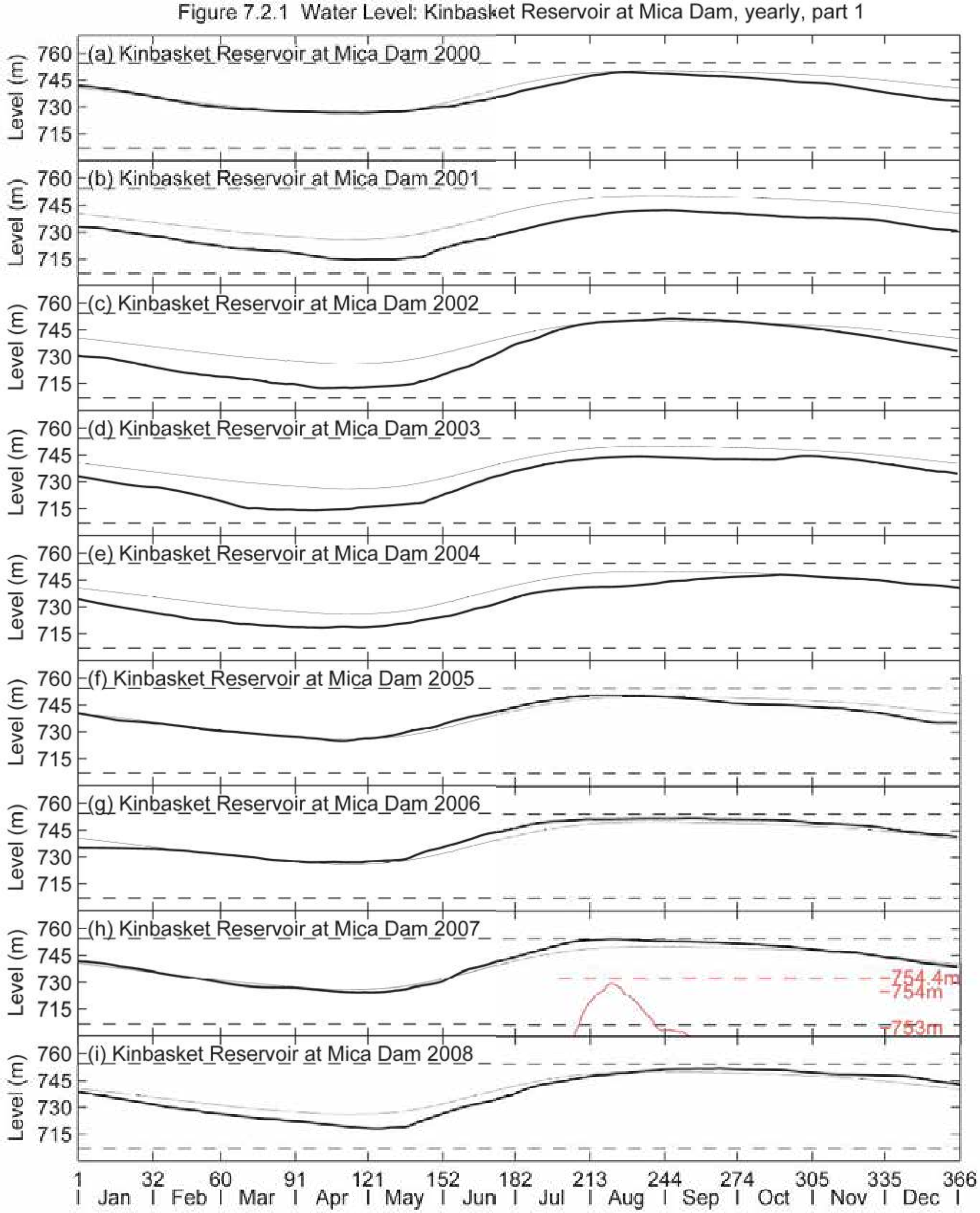



**Figure 7.2.1.** Water levels for WSC station 08ND017 "Kinbasket Lake at Mica Dam", selected years (heavy line). Mean daily water level for 1977-2017 (light line) is shown for comparison. Data for 2-30 April 2007 replaced with that from Kinbasket Lake below Garrett Creek. Dash lines mark the normal minimum and maximum elevation.

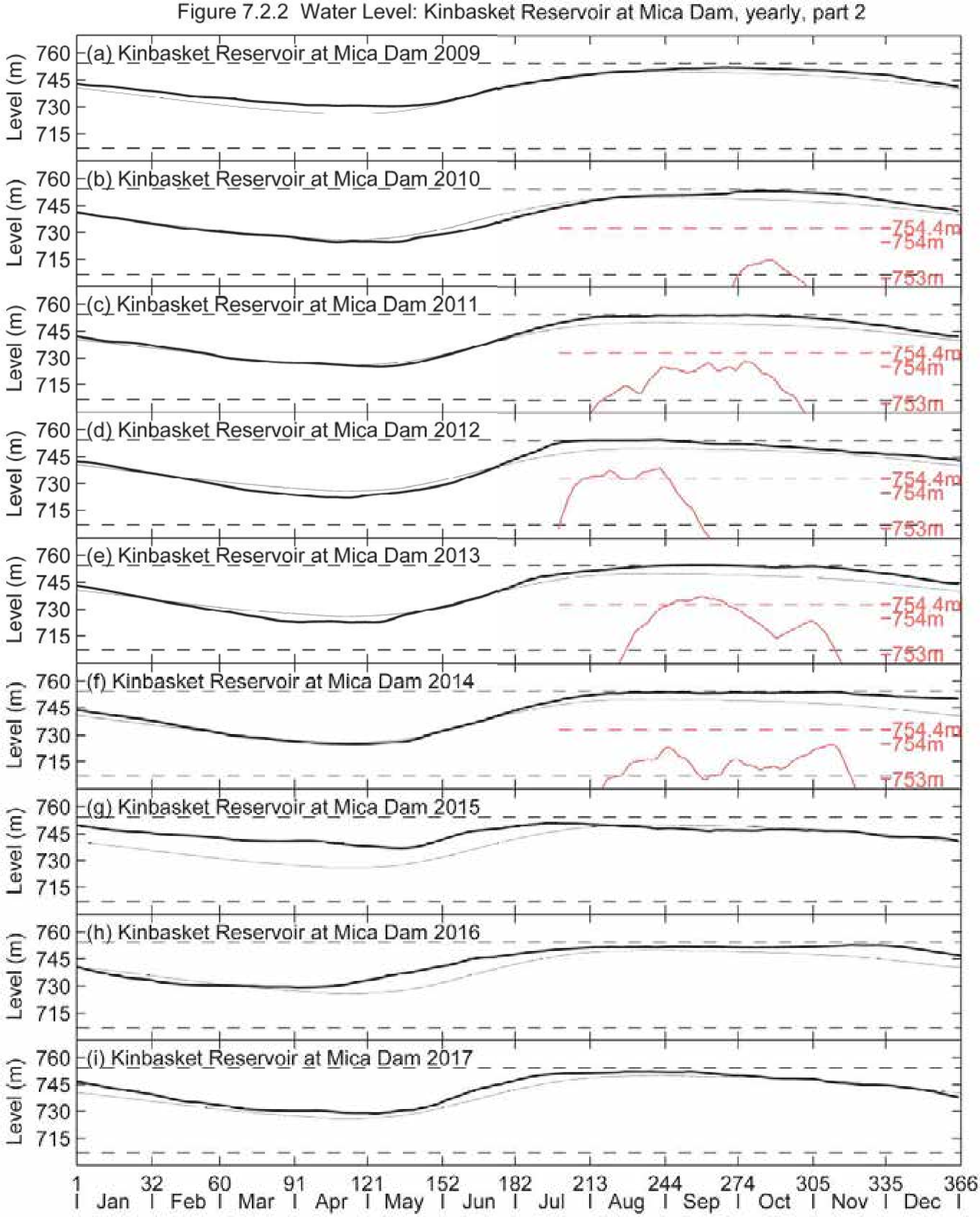
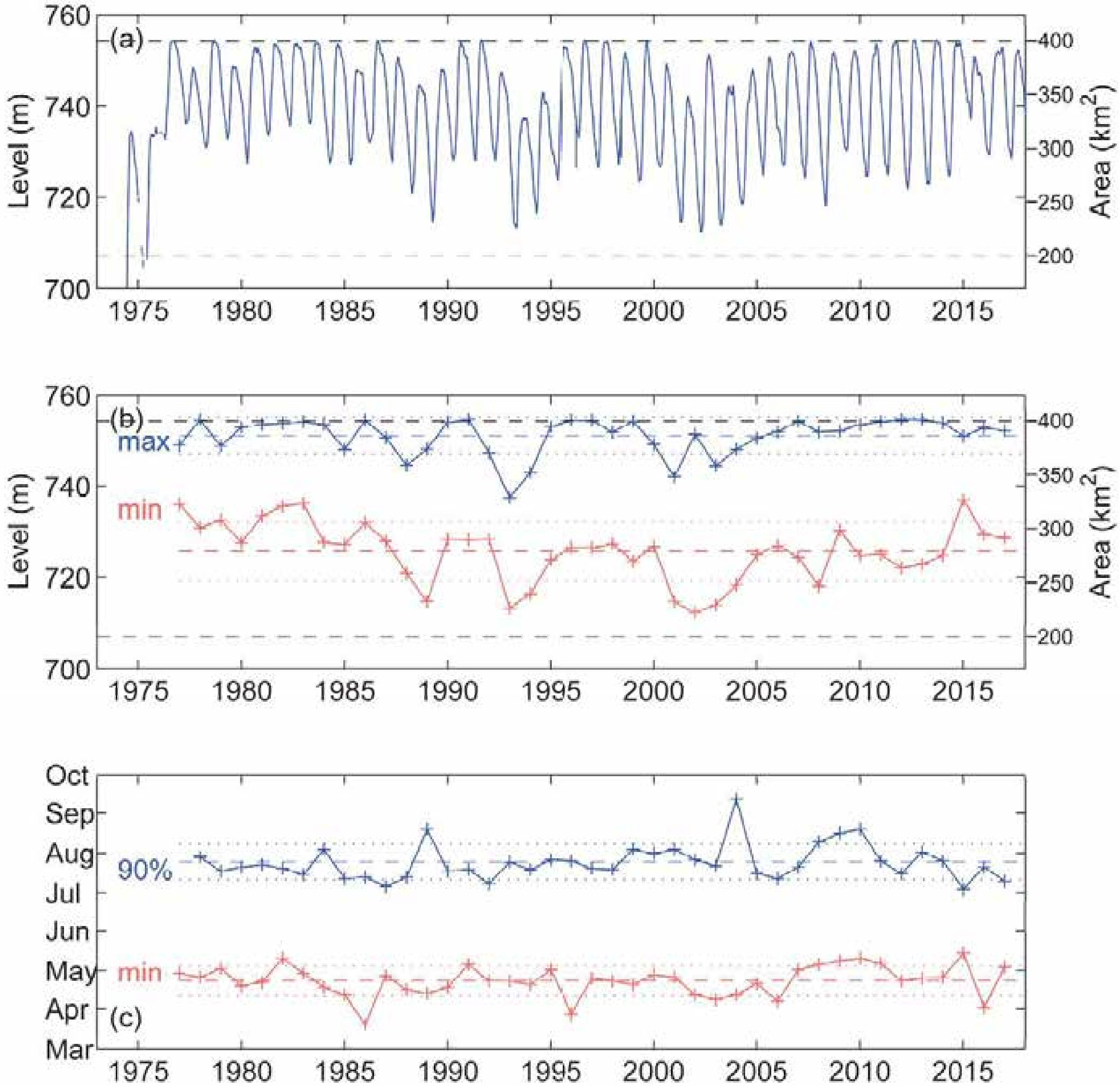



**Figure 7.2.2.** Water levels for WSC station 08ND017 "Kinbasket Lake at Mica Dam", selected years (heavy line). Mean daily water level for 1977-2017 (light line) is shown for comparison. Data for 2-30 April 2007 replaced with that from Kinbasket Lake below Garrett Creek. Dash lines mark the normal minimum and maximum elevation.




/ocean/rpieters/kr/flow/plot17/fig73syn.m fig= 4 2018−Jan−19

**Figure 7.3** (a) Water level in Kinbasket Reservoir, 1973-2017. Black dash lines mark normal minimum and maximum water level. (b) Minimum (red) and maximum (blue) water level for 1977-2017. (c) Date of minimum (red), 90% maximum (blue) water level for 1977-2017. The time to 90% full is shown because the time to the maximum water level can occur later in some years. Red and blue dash lines mark the average, and dotted lines mark ± 1 standard deviation.

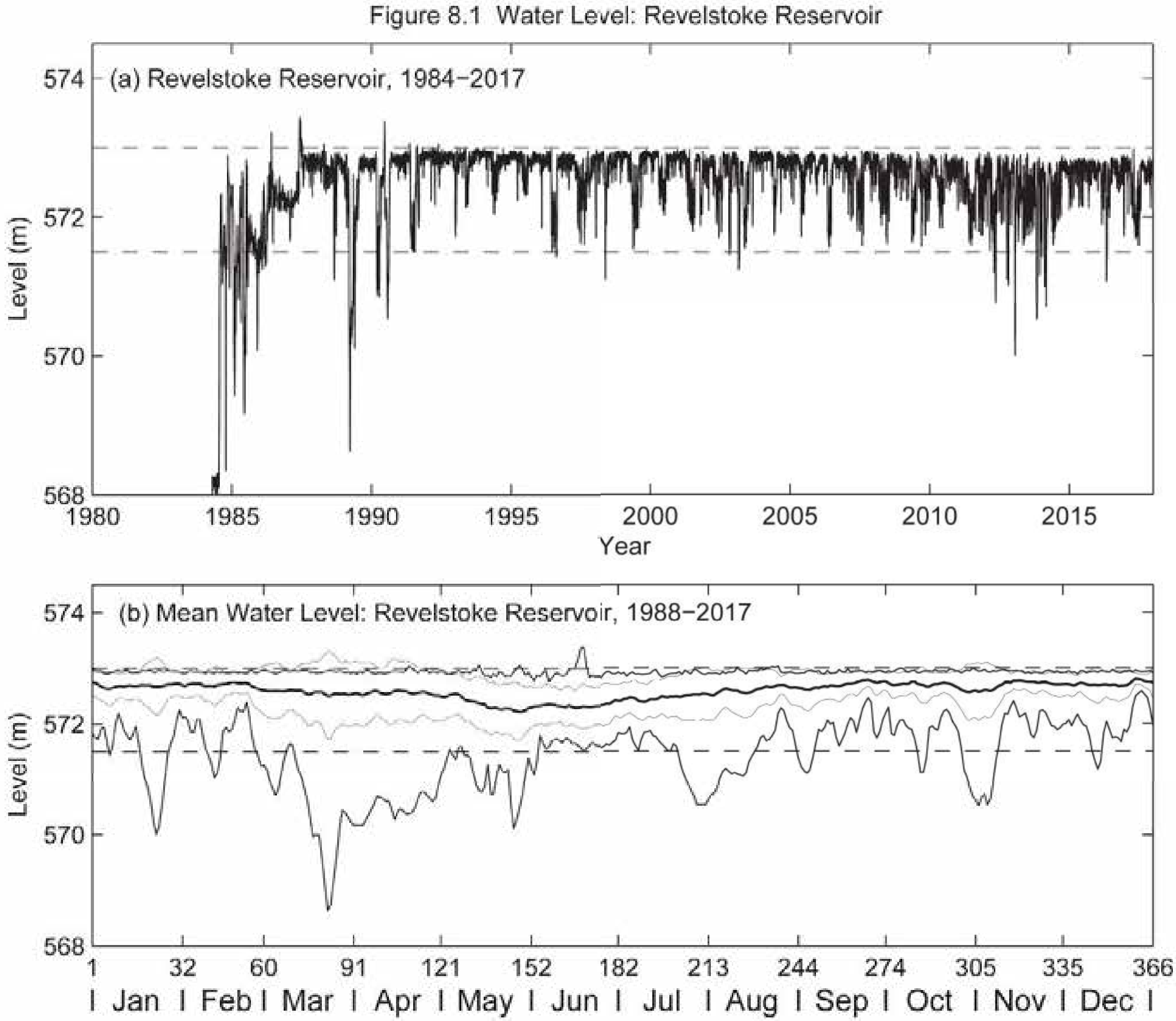



**Figure 8.1.** **(a)** BC Hydro station "Revelstoke Lake Forebay", 1984-2017. **(b)** Mean daily water level for 1988-2017. Mean (heavy line), maximum and minimum (medium lines) and mean ± one standard deviation (light lines). Dash lines mark the normal minimum and maximum elevation.

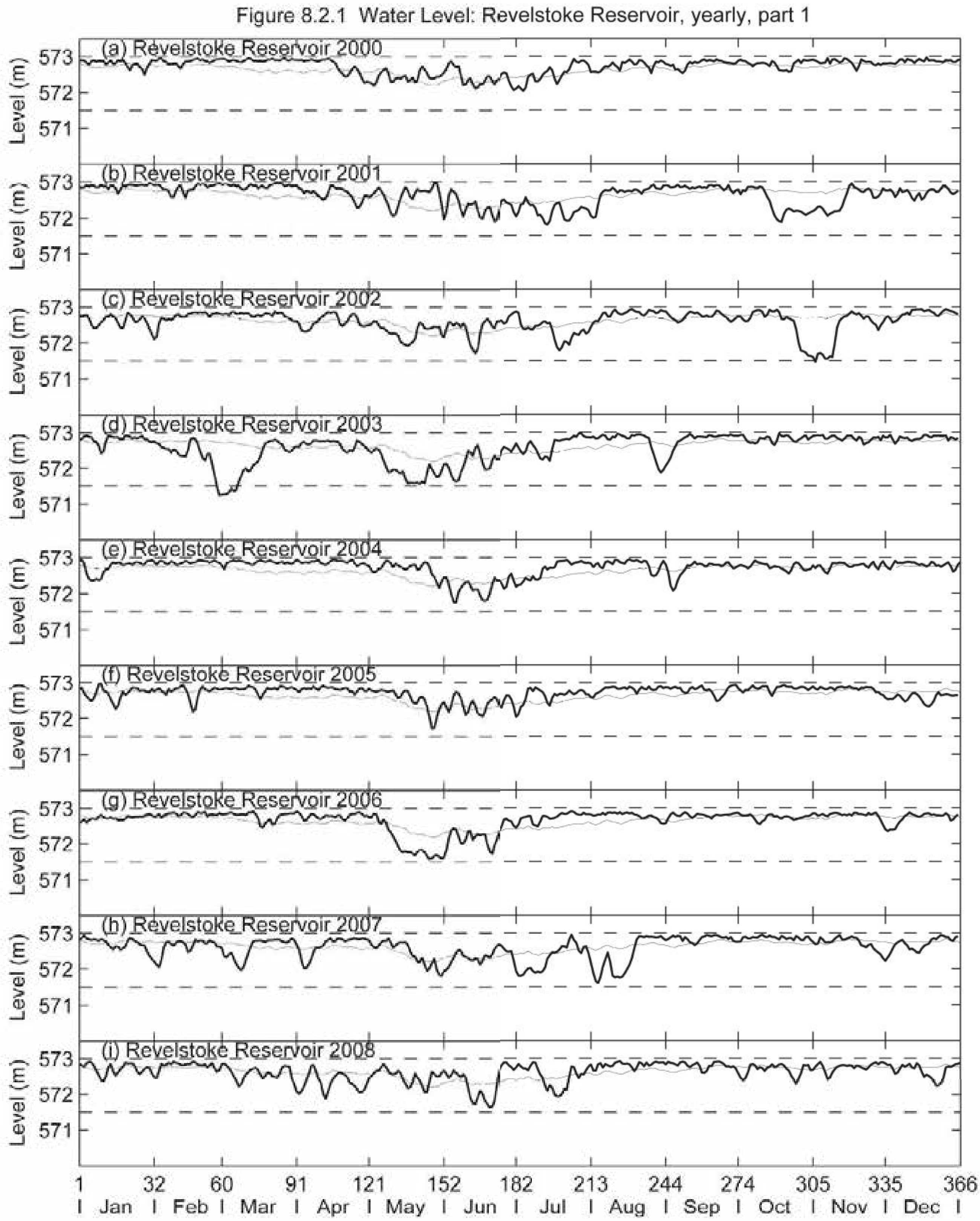



**Figure 8.2.1.** BC Hydro station "Revelstoke Lake Forebay", selected years (heavy line). Mean daily water level for 1988-2017 (light line) is shown for comparison. Dash lines mark the normal minimum and maximum elevation.

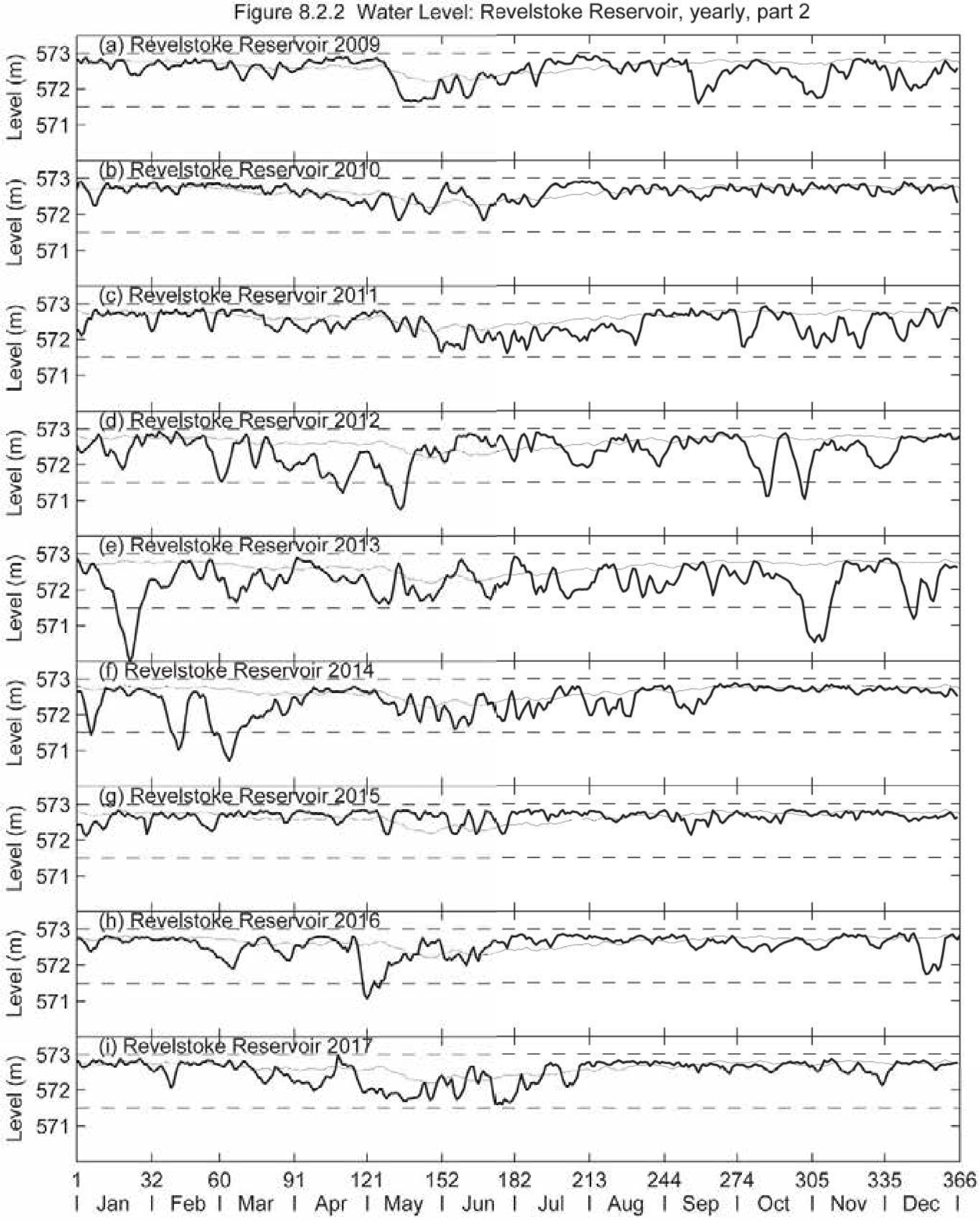



**Figure 8.2.2.** BC Hydro station "Revelstoke Lake Forebay", selected years (heavy line). Mean daily water level for 1988-2017 (light line) is shown for comparison. Dash lines mark the normal minimum and maximum elevation.

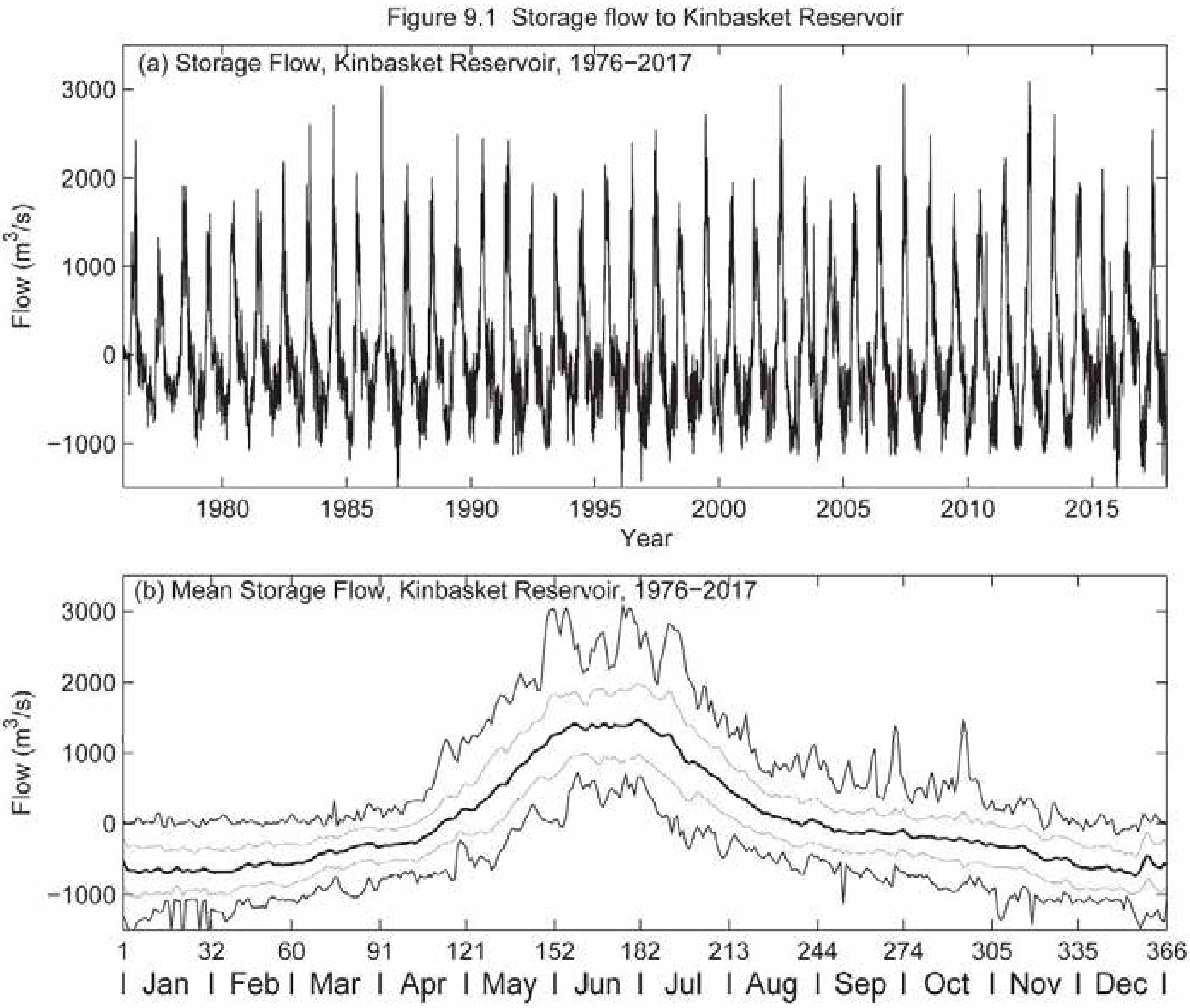



**Figure 9.1.** **(a)** Storage flow to Kinbasket Reservoir, 1976-2017. **(b)** Mean daily storage flow for 1976-2017. Mean (heavy line), maximum and minimum (medium lines) and mean ± one standard deviation (light lines).

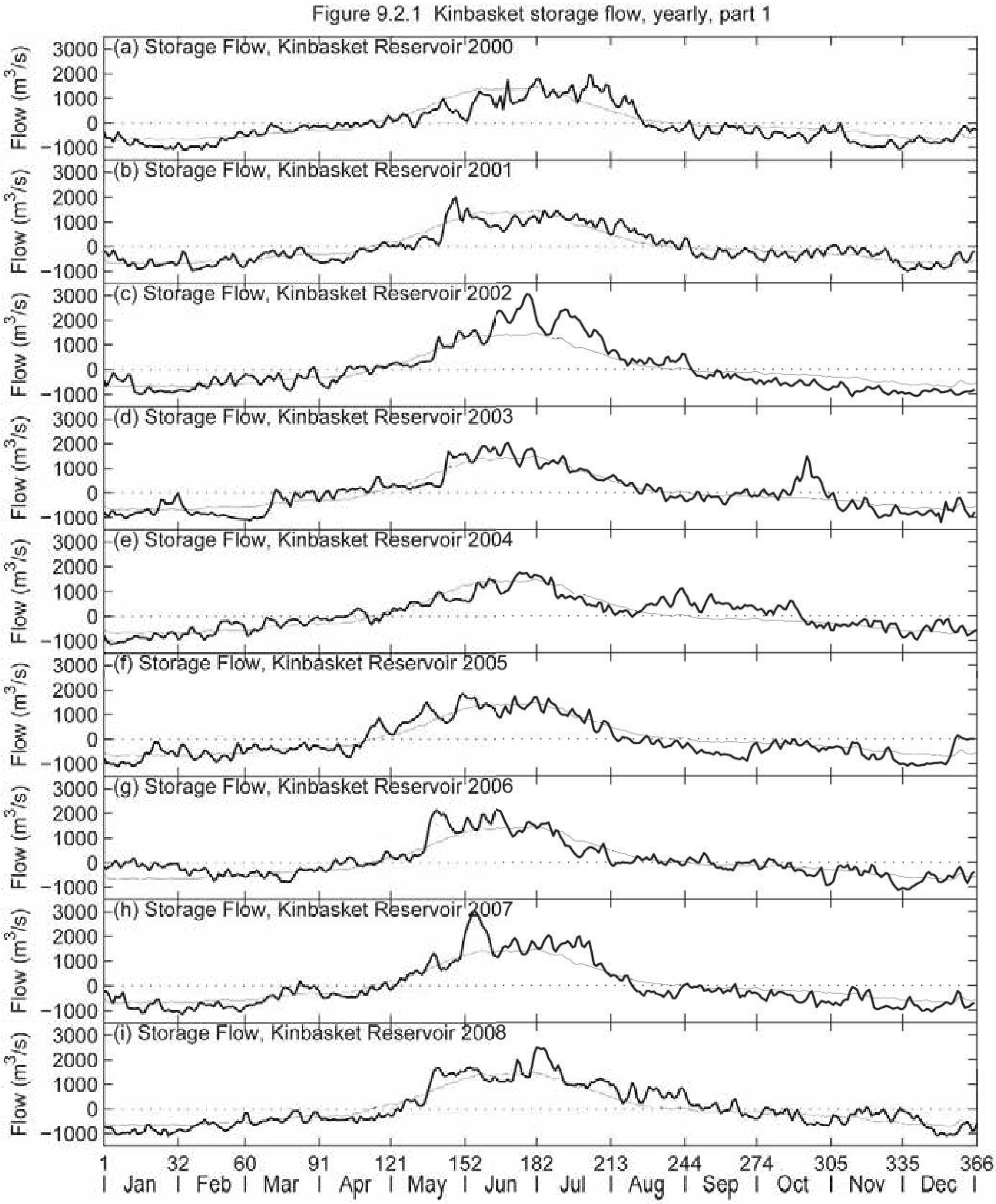



**Figure 9.2.1.** Storage flow to Kinbasket Reservoir, selected years (heavy line). Mean daily storage flow for 1976-2017 (light line) is shown for comparison.

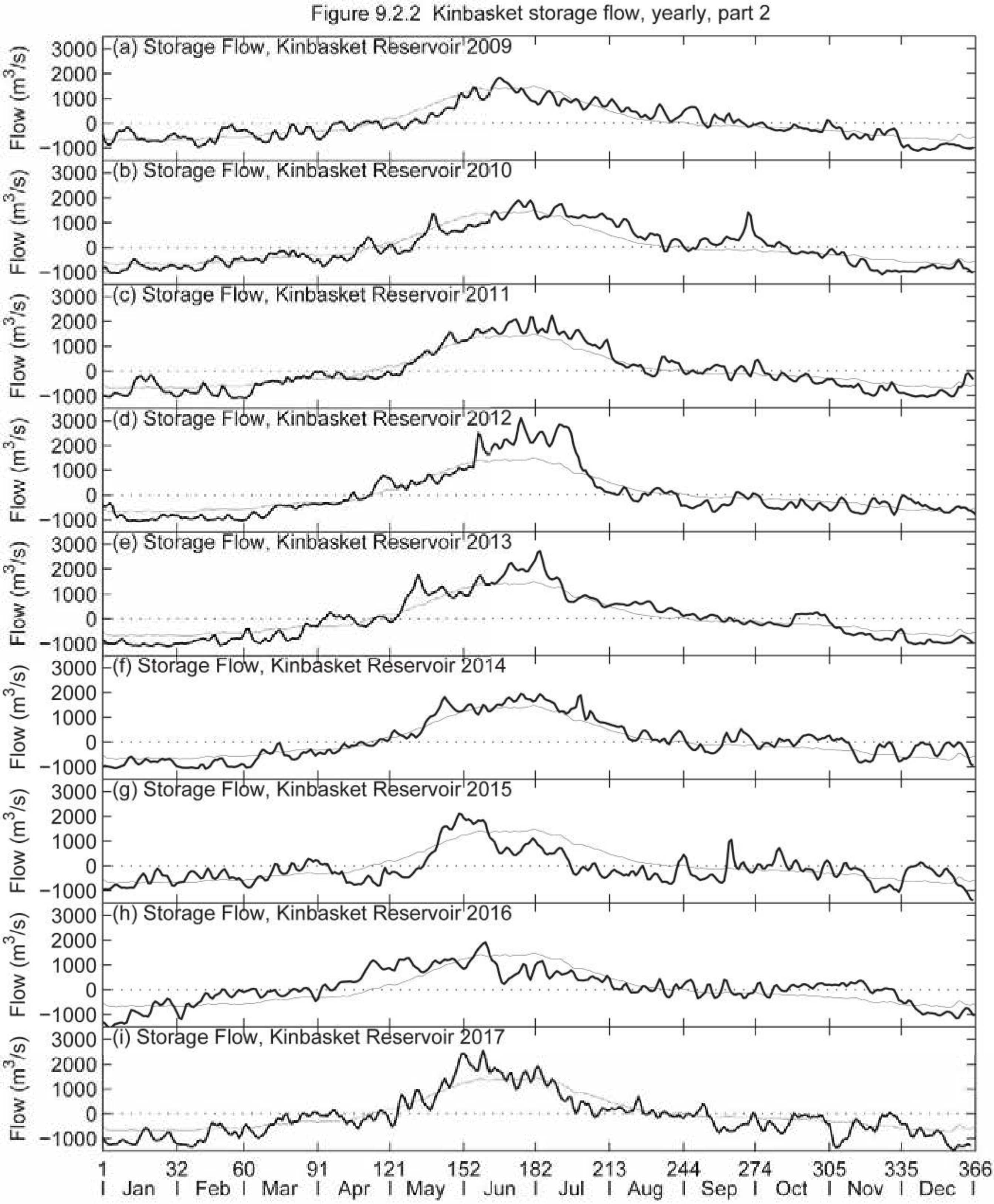



**Figure 9.2.2.** Storage flow to Kinbasket Reservoir, selected years (heavy line). Mean daily storage flow for 1976-2017 (light line) is shown for comparison.

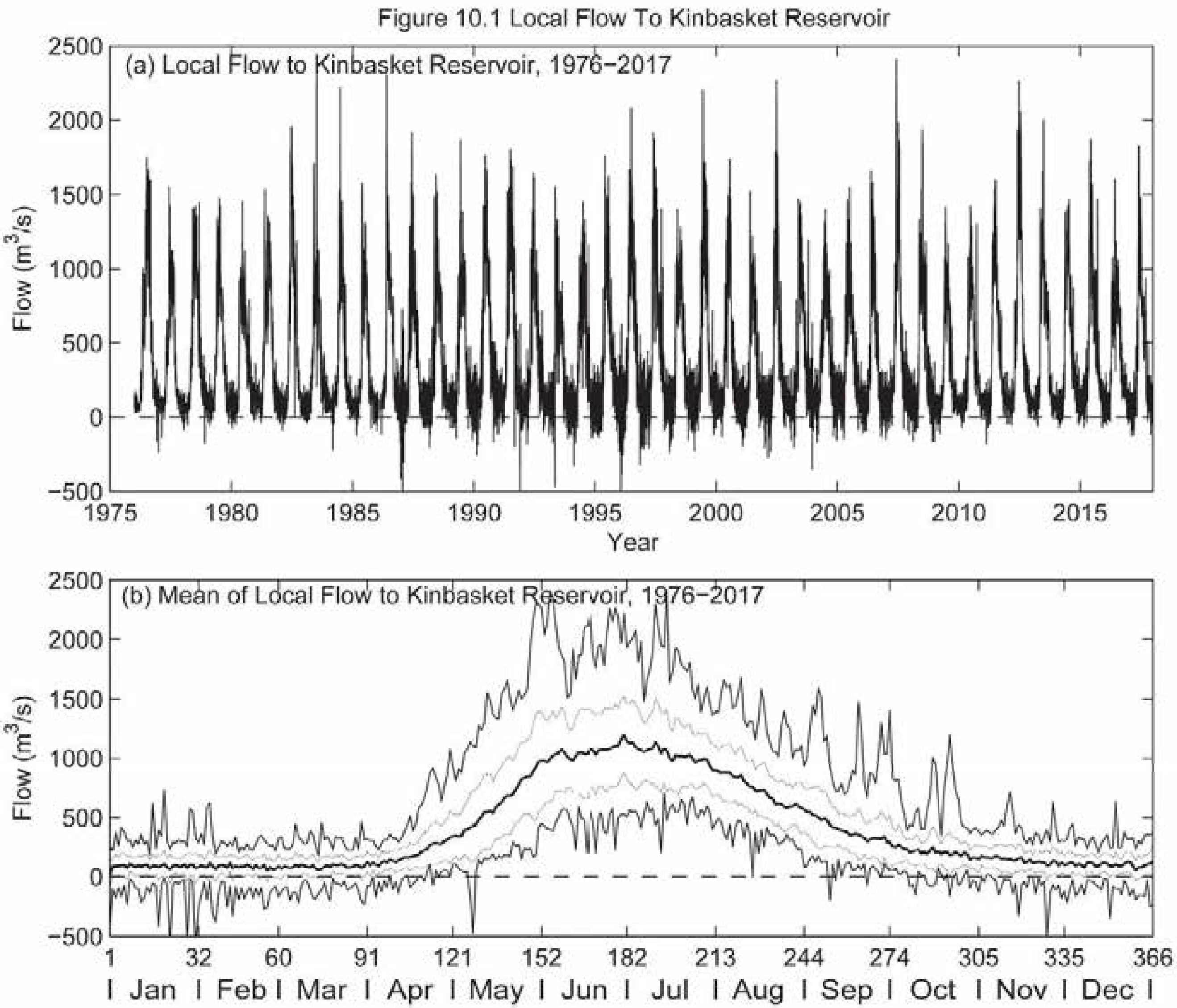



**Figure 10.1.** **(a)** Local flow to Kinbasket Reservoir, 1976-2017. **(b)** Mean daily local flow for 1976-2017. Mean (heavy line), maximum and minimum (medium lines) and mean ± one standard deviation (light lines).

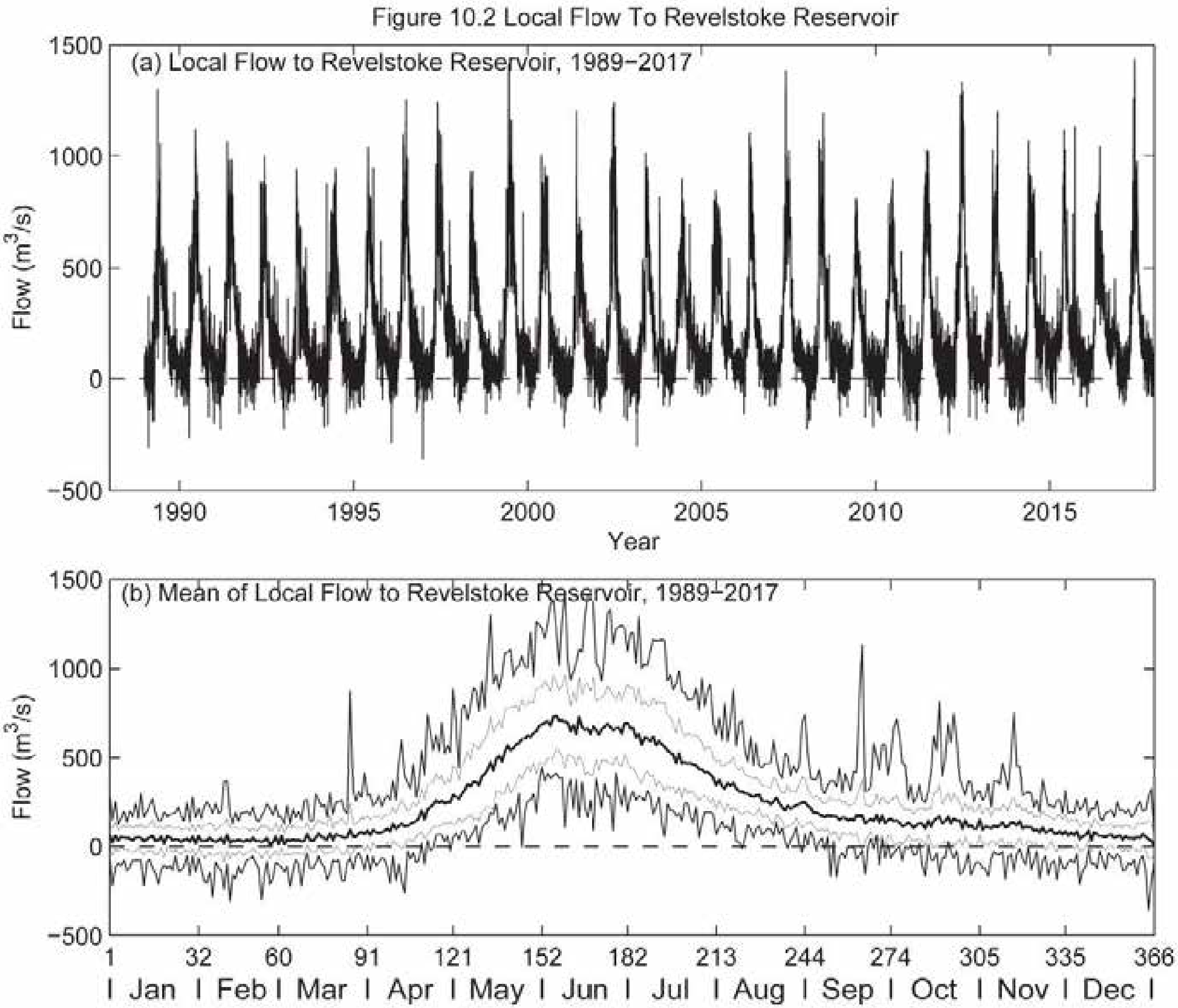



**Figure 10.2.** **(a)** Local flow to Revelstoke Reservoir, 1976-2017. **(b)** Mean daily local flow for 1976-2017. Mean (heavy line), maximum and minimum (medium lines) and mean ± one standard deviation (light lines).

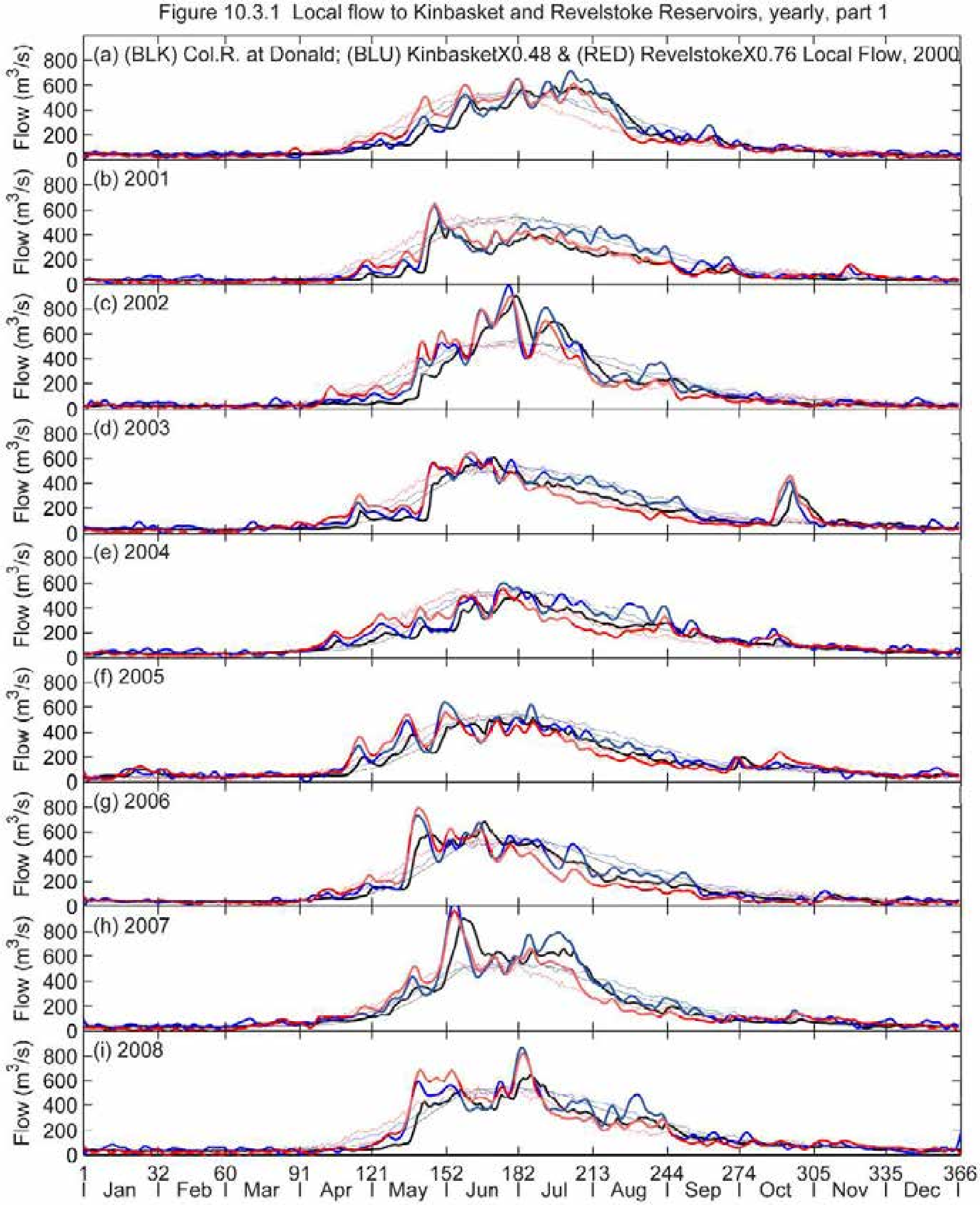



**Figure 10.3.1.** Local flow to Kinbasket and Revelstoke Reservoirs, selected years. The Columbia River at Donald, for the given year and the mean for 1944-2017 (light line) are shown for comparison. Local flows were scaled for comparison to the Columbia at Donald.

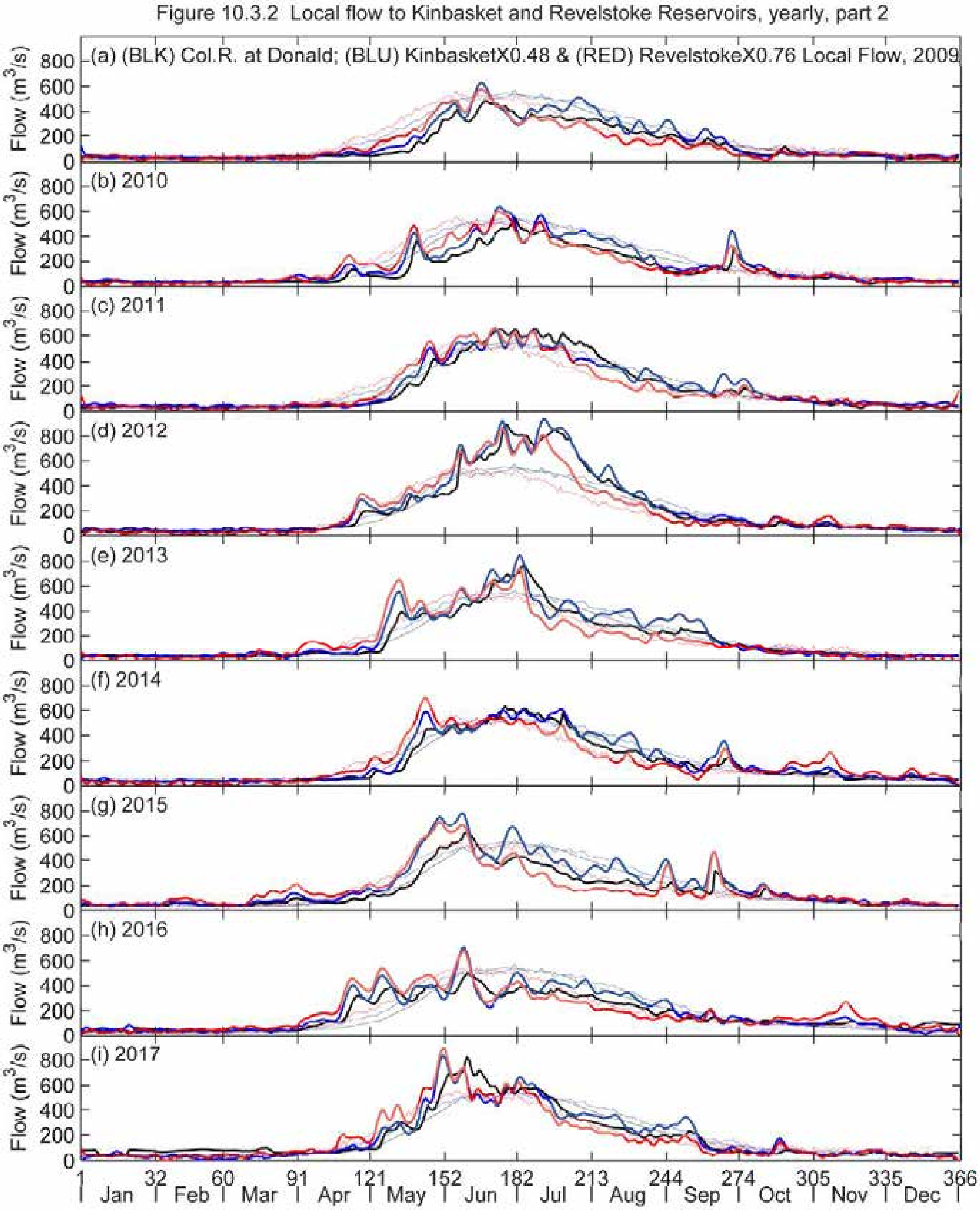



**Figure 10.3.2.** Local flow to Kinbasket and Revelstoke Reservoirs, selected years. The Columbia River at Donald, for the given year and the mean for 1944-2017 (light line) are shown for comparison. Local flows were scaled for comparison to the Columbia at Donald.

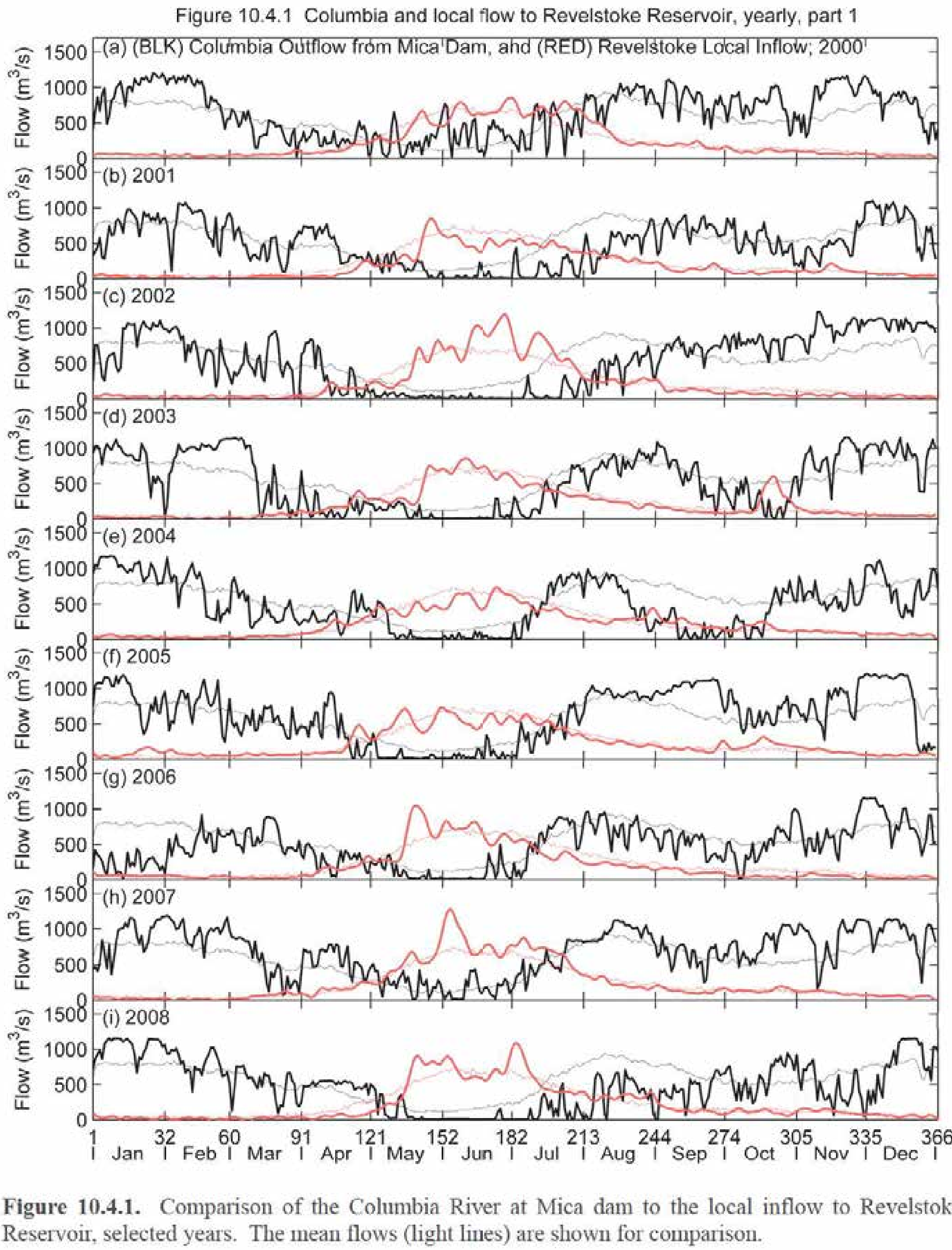



**Figure 10.4.1.** Comparison of the Columbia River at Mica dam to the local inflow to Revelstoke Reservoir, selected years. The mean flows (light lines) are shown for comparison.

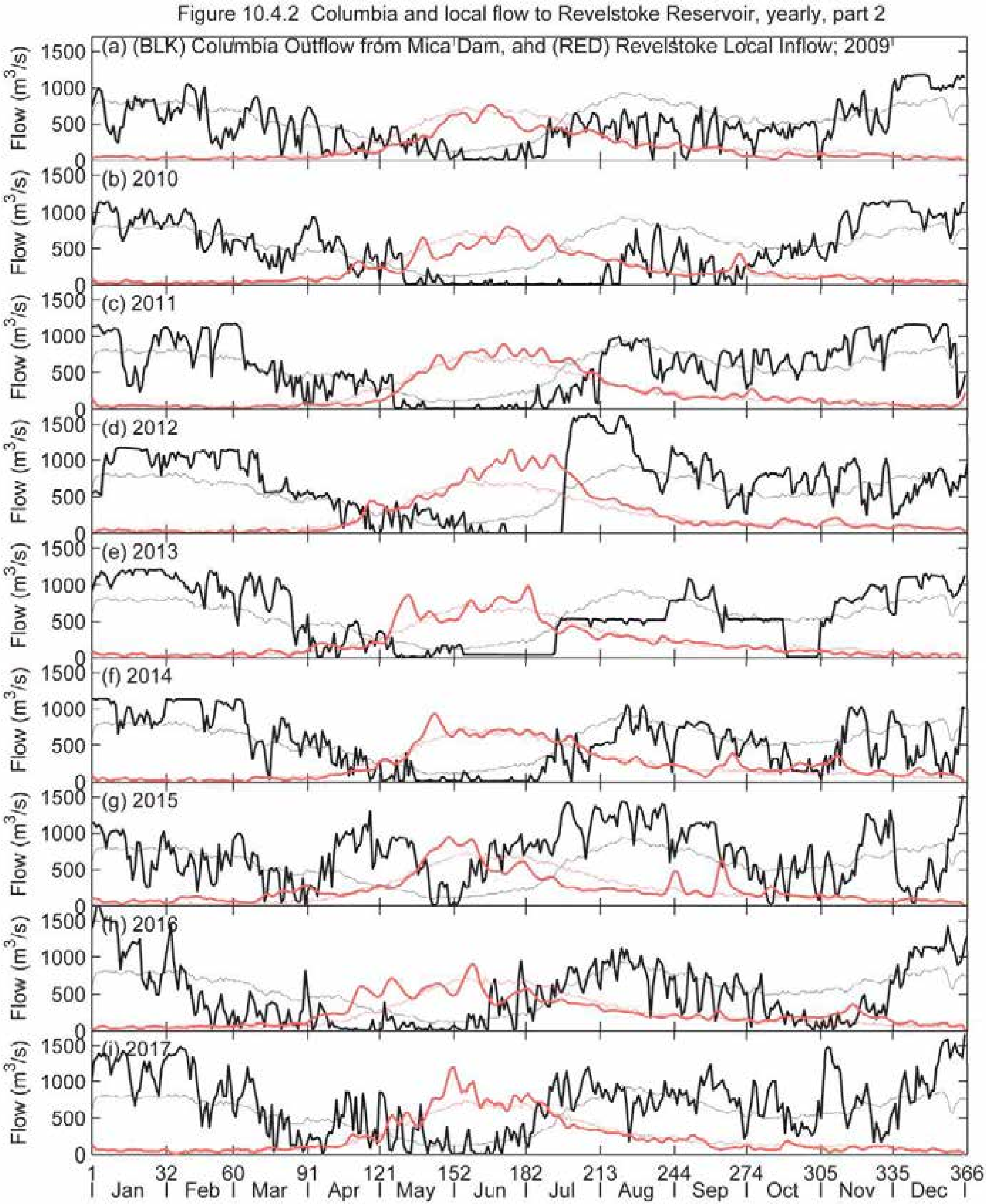



**Figure 10.4.2.** Comparison of the Columbia River at Mica dam to the local inflow to Revelstoke Reservoir, selected years. The mean flows (light lines) are shown for comparison.

## Appendix 1 Gauging Stations in the Kinbasket/ Revelstoke Drainage

| Type* | Station # | Abbr | Station Name | Year | Drainage Area[1] (km²) | Mean Flow[1] ($m^3/s$) | Yield (m/yr) |
|---|---|---|---|---|---|---|---|
| **Columbia River** | | | | | | | |
| Q | 08NA045 | | Columbia River near Fairmont Hot Springs | 1944-1996 | 891 | 10.4 | 0.37 |
| WL | 08NA004 | | Columbia River at Athalmer | 1944-1984 | 1340 | - | - |
| ND | 08NA027 | | Columbia River near Athalmer | - | - | - | - |
| Q | 08NA052 | | Columbia River near Edgwater | 1950-1956 | 3550 | 58.7 | 0.52 |
| Q | 08NA002 | | Columbia River at Nicholson | 1903-present | 6660 | 107 | 0.51 |
| Q | 08NB005 | coldo | Columbia River at Donald | 1944-present | 9710 | 172 | 0.56 |
| ND | 08NB008 | | Columbia River at Calamity Curve near Beavermouth | - | - | - | - |
| Q | 08NB006 | colsu | Columbia River at Surprise Rapids | 1948-1966 | 14000 | 337 | 0.76 |
| WL | 08NB017 | lking | Kinbasket Lake below Garrett Creek | 1980-present | - | - | - |
| Q | 08NB011 | colbb | Columbia River at Big Bend Highway Crossing | 1944-1949 | 16800 | 472 | 0.89 |
| WL | 08ND017 | lkinm | Kinbasket Lake at Mica Dam | 1974-present | - | - | - |
| Q | 08ND007 | colna | Columbia River above Nagle Creek | 1947-1983 | 21500 | 567 | 0.83 |
| ND | 08ND010 | | Columbia River above Downie Creek | - | - | - | - |
| Q | 08ND025 | revpo | Revelstoke Project Outflow | 1986-present | - | 773 | - |
| Q | 08ND011 | colsr | Columbia River above Steamboat Rapids | 1955-1986 | 26400 | 796 | 0.95 |
| Q | 08ND002 | | Columbia River at Revelstoke | 1912-1989 | 26700 | 854 | 1.01 |
| WL | - | lreff | Revelstoke Reservoir | 1984-present | - | - | - |
| **Local Flow in Kinbasket Lake** | | | | | | | |
| Q | 08NB019 | beavr | Beaver River near the Mouth | 1985-present | 1150 | 41.9 | 1.15 |
| Q | 08NB014 | goldr | Gold River above Palmer Creek | 1973-present | 427 | 18.3 | 1.35 |
| Q | 08NC001 | woodd | Wood River near Donald | 1948-1972 | 956 | 40.1 | 1.32 |
| Q | 08NC003 | canva | Canoe River at Valemont | 1966-1967 | 368 | *18.7* | 1.60 |
| Q | 08NC002 | cando | Canoe River near Donald | 1947-1967 | 3290 | 105 | 1.01 |
| **Local Flow in Revelstoke Lake** | | | | | | | |
| Q | 08ND015 | micac | Mica Creek near Revelstoke | 1964-1965 | 82.4 | *4.0* | 1.53 |
| Q | 08ND012 | golds | Goldstream River below Old Camp Creek | 1954-present | 938 | 39.0 | 1.31 |
| Q | 08ND019 | kirby | Kirbyville Creek near the Mouth | 1973-2005 | 112 | 6.14 | 1.73 |
| Q | 08ND009 | downi | Downie Creek near Revelstoke | 1953-1983 | 655 | 30.2 | 1.45 |
| **Other** | | | | | | | |
| Q | 08ND013 | illgr | Illecillewaet River at Greeley | 1963-present | 1170 | 53.5 | 1.44 |

* Q - Flow, WL - Water Level, ND - No Data

[1] From Water Survey of Canada, values in italics were estimated

**Appendix 2 Reference Elevations for the Mica and Revelstoke Projects**

**Kinbasket Reservoir Elevations**

| Elevation (ft) | Elevation (m) | Storage ($Mm^3$) | Area ($km^2$) | Comments |
|---|---|---|---|---|
| 2500.0 | 762.0 | | | Crest of dam |
| 2486.5 | 757.9 | 26306.1 | 446.4 | DSI, Dam Safety Incident level when spill gates are open |
| 2484.9 | 757.4 | 26083.5 | 444.2 | Expected maximum reservoir level during the PMF inflow event (11,780 $m^3/s$, 246,000 cfs) |
| 2475.0 | 754.4 | 24770.7 | 431.0 | Nmax, Normal maximum operating elevation. WLU, Water License Upper Limit |
| 2319.4 | 707.0 | 9875.8 | 206.9 | Nmin, Normal minimum pool level WLL, Calculated water license limit |
| 2275.0 | 693.4 | | | Sill elevation of 3.0 m W x 5.49 m H (10' W x 18' H) outlet gates (2) |
| 2274.0 | 693.1 | | | Top of intake conduit |
| 2252.0 | 686.4 | | | Sill elevation of power intakes (6) (Bottom of intake conduit) |

**Revelstoke Reservoir Elevations**

| Elevation (ft) | Elevation (m) | Storage ($Mm^3$) | Area ($km^2$) | Comments |
|---|---|---|---|---|
| 1894.0 | 577.6 | | | Crest of dam |
| 1885.0 | 574.6 | 5449.4 | 118.2 | DSI, Dam Safety Incident level when spill gates are open. Expected maximum reservoir level during the PMF inflow event (7100 m3/s, 250,000 cfs) |
| 1880.0 | 573.0 | 5264.8 | 116.0 | Nmax, Normal maximum operating elevation. WLU, Water License Upper Limit |
| 1875.0 | 571.5 | 5089.9 | 113.6 | Nmin, Normal minimum pool level |
| 1830.0 | 557.8 | 3692.7 | 88.7 | Minimum pool level (power intake limit) |
| 1820.0 | 554.7 | | | Minimum pool level (water license storage limit) |
| 1772.6 | 540.3 | | | Sill elevation of power intakes (6) |

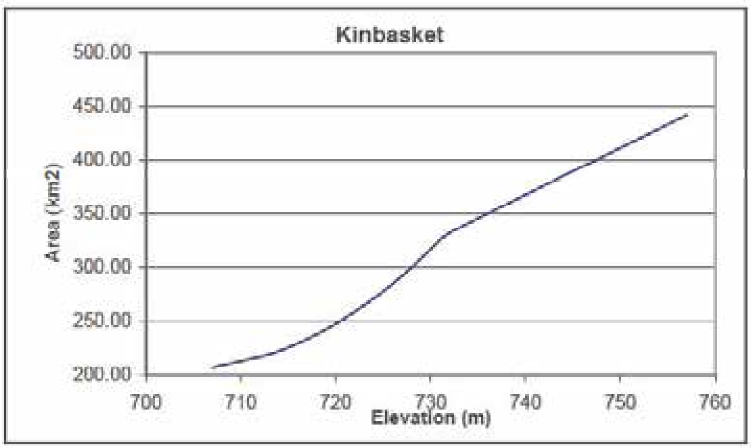
## Appendix 3 Storage Elevation Curves

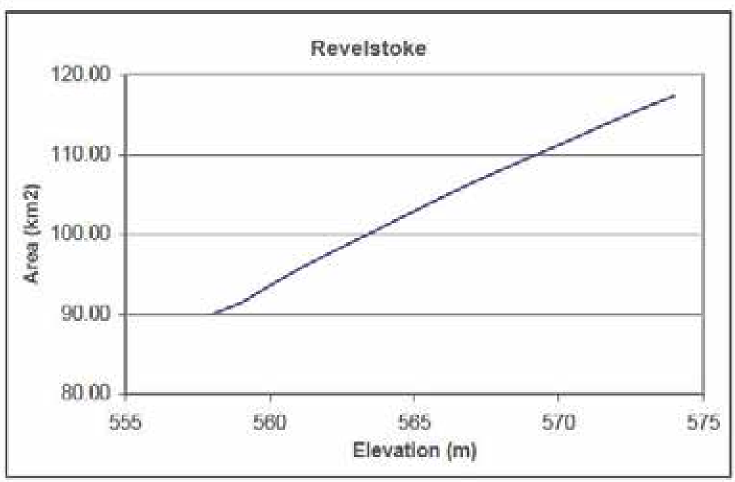
Kinbasket

| Elevation (m) | Storage (Mm3) | Area (km2) |
|---|---|---|
| 706 | 9.66997E+03 | |
| 707 | 9.87585E+03 | 206.94 |
| 708 | 1.00838E+04 | 209.03 |
| 709 | 1.02939E+04 | 211.09 |
| 710 | 1.05060E+04 | 213.12 |
| 711 | 1.07201E+04 | 215.13 |
| 712 | 1.09363E+04 | 217.11 |
| 713 | 1.11544E+04 | 219.27 |
| 714 | 1.13748E+04 | 222.16 |
| 715 | 1.15987E+04 | 225.73 |
| 716 | 1.18263E+04 | 229.56 |
| 717 | 1.20578E+04 | 233.67 |
| 718 | 1.22936E+04 | 238.05 |
| 719 | 1.25339E+04 | 242.71 |
| 720 | 1.27790E+04 | 247.69 |
| 721 | 1.30293E+04 | 252.97 |
| 722 | 1.32850E+04 | 258.59 |
| 723 | 1.35464E+04 | 264.54 |
| 724 | 1.38140E+04 | 270.85 |
| 725 | 1.40882E+04 | 277.54 |
| 726 | 1.43691E+04 | 284.60 |
| 727 | 1.46574E+04 | 292.06 |
| 728 | 1.49532E+04 | 299.94 |
| 729 | 1.52572E+04 | 308.24 |
| 730 | 1.55697E+04 | 316.98 |
| 731 | 1.58912E+04 | 325.72 |
| 732 | 1.62212E+04 | 332.33 |
| 733 | 1.65558E+04 | 336.89 |
| 734 | 1.68949E+04 | 341.27 |
| 735 | 1.72384E+04 | 345.65 |
| 736 | 1.75862E+04 | 350.04 |
| 737 | 1.79385E+04 | 354.42 |
| 738 | 1.82951E+04 | 358.81 |
| 739 | 1.86561E+04 | 363.20 |
| 740 | 1.90215E+04 | 367.59 |
| 741 | 1.93913E+04 | 371.98 |
| 742 | 1.97654E+04 | 376.38 |
| 743 | 2.01440E+04 | 380.77 |
| 744 | 2.05270E+04 | 385.17 |
| 745 | 2.09143E+04 | 389.57 |
| 746 | 2.13061E+04 | 393.96 |
| 747 | 2.17023E+04 | 398.36 |
| 748 | 2.21028E+04 | 402.77 |
| 749 | 2.25078E+04 | 407.17 |
| 750 | 2.29172E+04 | 411.57 |
| 751 | 2.33309E+04 | 415.98 |
| 752 | 2.37491E+04 | 420.38 |
| 753 | 2.41717E+04 | 424.79 |
| 754 | 2.45987E+04 | 429.20 |
| 755 | 2.50301E+04 | 433.61 |
| 756 | 2.54659E+04 | 438.02 |
| 757 | 2.59062E+04 | 442.43 |
| 758 | 2.63508E+04 | |

Revelstoke

| Elevation (m) | Storage (Mm3) | Area (km2) |
|---|---|---|
| 557.75 | 3.68827E+03 | |
| 558 | 3.71048E+03 | 89.97 |
| 559 | 3.80073E+03 | 91.35 |
| 560 | 3.89318E+03 | 93.55 |
| 561 | 3.98783E+03 | 95.62 |
| 562 | 4.08442E+03 | 97.50 |
| 563 | 4.18283E+03 | 99.31 |
| 564 | 4.28305E+03 | 101.13 |
| 565 | 4.38508E+03 | 102.94 |
| 566 | 4.48893E+03 | 104.75 |
| 567 | 4.59458E+03 | 106.49 |
| 568 | 4.70191E+03 | 108.11 |
| 569 | 4.81081E+03 | 109.68 |
| 570 | 4.92127E+03 | 111.25 |
| 571 | 5.03330E+03 | 112.81 |
| 572 | 5.14690E+03 | 114.38 |
| 573 | 5.26206E+03 | 115.91 |
| 574 | 5.37871E+03 | 117.36 |
| 575 | 5.49678E+03 | |



# Appendix 2

## Tributary Water Quality
## Kinbasket and Revelstoke Reservoirs, 2017

Roger Pieters, P. Buskas, and Greg Lawrence
University of British Columbia

# Tributary Water Quality
# Kinbasket and Revelstoke Reservoirs, 2017

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Revelstoke Reservoir, 25 May 2018

Prepared for

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March 12, 2019

## Contents

## List of Figures

## 1. Introduction

This report examines water quality data collected from tributaries to Kinbasket and Revelstoke Reservoirs in 2017. These data were collected as part of the ongoing BC Hydro project entitled "CLBMON-3 Kinbasket and Revelstoke Ecological Productivity Monitoring".*

Two types of tributary samples have been collected:

1. Reference tributaries were sampled from April to November. Regular sampling of reference tributaries began in 2009 (Pieters *et al.,* 2011-2018); here we report on the data from the reference tributaries in 2017.
2. Surveys of several tributaries at a given time. Sampling of tributary surveys were undertaken across both reservoirs in June and August 2008 (Pieters *et al.*, 2010), on 7-8 July 2009 (Pieters *et al.*, 2011), and on 6 May 2013 (Pieters *et al.* 2016). A survey was not conducted from 2014 to 2017; see previous reports for details of tributary surveys.

## 2. Methods

### *Reference Tributary sample collection*

There are five reference tributaries: Columbia River at Donald, Goldstream River, Beaver River, Kinbasket Reservoir (Mica Dam) Outflow, and Revelstoke Reservoir (Revelstoke Dam) Outflow. In 2016, Downie Creek, a major inflow to Revelstoke Reservoir, was added as a reference tributary. Sampling of the reference tributaries was conducted by BC Hydro. The exception has been the Beaver River which is sampled by Environment Canada. In 2013, BC Hydro began collecting additional samples of the Beaver River near the confluence with Kinbasket Reservoir.

Samples were collected from the point at which the tributary crossed a road. The Columbia River at Donald was sampled near the Highway 1 Bridge. Mica outflow was sampled at the bridge downstream of the dam. Goldstream River and Downie Creek enter the east side of Revelstoke Reservoir, and were sampled from Highway 23. Revelstoke outflow was sampled below the dam. Coordinates for the sample locations are given in Appendix 2.

The Beaver River was sampled at the east gate of Glacier National Park by Environment Canada, and this location represents about half of the total drainage of the Beaver River. Additional sampling of the Beaver River by BC Hydro began in 2013 at sampling sites near the confluence with the Kinbasket Reservoir. Beaver River was sampled near

* In 2003, eight tributaries to Revelstoke Reservoir were sampled as part of an embayment study (K. Bray, personal communication).

Kinbasket Resort when the water level in the reservoir was low, but as the water level increased, the sampling location moved upstream; see Appendix 2 for detail.

### *Sample Processing*

Water samples were collected in a bucket and then transferred into sample bottles. Temperature was measured with a handheld thermometer. Filtration was done later the same day; water samples were either frozen or kept on ice and shipped within 48 hours. From 2008 to 2012, samples were analyzed by the Cultus Lake Salmon Research Laboratory, Department of Fisheries and Oceans (4222 Columbia Valley Highway, Cultus Lake, British Columbia). From 2013 to 2017 samples were analyzed by Maxxam Analytics (4606 Canada Way, Burnaby, British Columbia). In all years, samples were analyzed for the water quality parameters listed in Table 1. Laboratory methods are summarized in Appendix 1. The tributaries sampled are listed in Appendix 2. Data are given in Appendix 3. A problem was found with alkalinity data prior to 2013; this report shows corrected alkalinity for all years (see Appendix 1 for detail).

**Table 1 Parameters measured**

| Parameter | Units | Symbol | Detection Limit (Maxxam) |
|---|---|---|---|
| pH | | pH | |
| Conductivity (C25) | µS/cm | Cond | 1 µS/cm |
| Nitrate and Nitrite (NN) | µg/L N | NN | 2 ug/L |
| Soluble Reactive Phosphorus (SRP) | µg/L P | SRP | 1 ug/L |
| Total Dissolved Phosphorus (TDP) | µg/L P | TDP | 2 ug/L |
| Total Phosphorus (TP)* | µg/L P | TP | 2 or 20 ug/L |
| Turbidity (Turb) | NTU | Turb | 0.1 NTU |
| Alkalinity (Alk) | $mgCaCO_3/L$ | Alk | 0.5 $mgCaCO_3/L$ |
| Water Temperature (T) | °C | T | |

*A color/turbidity correction for TP is only available for 2008-2012 data.

## 3. Reference Tributaries

Intensive sampling of the reference tributaries began in 2009. Comparison of the 2009 through 2017 data is shown for April to November in Figures 3.1 to 3.7. The exception is Figure 3.3 for the Beaver River, which is plotted from January to December as data were available throughout the year.

### *Columbia River at Donald (Figure 3.1)*

The Columbia River at Donald is a major inflow into Kinbasket Reservoir. Water quality data for 2009 to 2017 are shown in Figures 3.1. River flow is shown in Figure 3.1a; flow is dominated by spring freshet which peaks from early June to mid-July.

The temperature of the Columbia River at Donald, having wound its way through the Rocky Mountain Trench, was relatively warm peaking at 15 - 18 °C in July and August each year (Figure 3.1b). The conductivity (C25), shown in Figure 3.1c, declined through the freshet to about half of the spring value by mid-summer (Figure 3.1c). The turbidity was highly variable (Figure 3.1d), while pH remained slightly alkaline throughout the sampling period (Figures 3.1e).

In a well oxygenated environment such as a river, nitrite will be low, and data for nitrate and nitrite (NN) gives the nitrate concentration. Nitrate concentrations in the Columbia River at Donald declined rapidly after the onset of freshet (Figure 3.1f). For example, nitrate declined by a factor of 7 from a high of 264 µg/L on 8 May 2017 to a low of 37.6 µg/L on 26 June 2017.

Note a peak in nitrate occurs at the beginning of freshet; much of this nitrate is thought to come from the snow that received atmospheric deposition of nitrogen over the winter. The subsequent decrease in nitrate reflects depletion of the supply of nitrate from the snowpack and from shallow soil water pools before the end of freshet (Sebestyen *et al.*, 2008).

Soluble reactive phosphorus (SRP), also known as orthophosphate (OP) or phosphate ($PO_4$), was low and variable over the years (Figure 3.1g). The SRP values ranged from < 1 to 6.6 µg/L in 2017. One exceptional reading of 19 µg/L occurred in September 2017, and is likely erroneous. The detection limit for SRP was 1 µg/L.

Total dissolved phosphorus (TDP) values showed some variability in 2017, with values ranging from < 2 to 7.9 µg/L (Figure 3.1h). The detection limit for TDP was 2 µg/L.

Total phosphorus (TP) ranged from 2.3 to 107.1 µg/L in all years from 2009 to 2017; the values ranged from 4.1 to 55.9 µg/L in 2017 (Figure 3.1i). Particulate phosphorus can be estimated as the difference between total phosphorus and total dissolved phosphorus, PP = TP - TDP. In glacially dominated systems, with high turbidity, much of the total phosphorus measured may have been extracted from particulate minerals (e.g. apatite) by the step in the analysis in which the sample undergoes digestion with persulphate (Appendix 1). As a result, for tributaries with high PP, it is likely that much of this phosphorus is of low biological availability.

In 2017, the values for the NN:TDP ratio (by weight) in the Columbia at Donald was similar to other years being generally > 10, though values < 10 were observed during the summer. In particular, in the summer of 2012, the NN:TDP ratios below 10 persisted until late October (Figure 3.1j). Low tributary nitrate during summer may result in nitrogen and phosphorus co-limitation in the reservoir.

***Goldstream River (Figure 3.2)***

Data from 2009 to 2017 for the Goldstream River are shown in Figure 3.2. Flow in the Goldstream River (Figure 3.2a) shows a similar pattern to the Columbia at Donald with spring freshet from early June to mid-July, followed by gradually declining flow into August. Notable is a peak in late September 2015, due to an autumn rainstorm.

Compared to the Columbia River at Donald, the Goldstream River was cooler, with July temperatures of only 7 - 12 °C with the exception of 14 °C measured on 28 July 2009 (Figure 3.2b).

The conductivity (C25) in Goldstream River declined to approximately half of its spring value by mid-summer (Figure 3.2c). From 2015-2017 C25 data were available from late March, unlike earlier years when data began after C25 had already begun to decline. From September to December, C25 gradually increased, and, by December, it had reached pre-freshet levels.

Turbidity was generally below 50 NTU, except for outliers of 198 NTU on 28 July 2009 and 110 NTU on 30 May 2017 (Figure 3.2d). The pH remained slightly alkaline, varying from about 8 pH units in winter to a range of 7.2 to 7.8 pH units during summer (Figure 3.2e).

Similar to the Columbia River at Donald, the Goldstream River experienced a peak in nitrate (NN) concentration during the start of freshet (Figure 3.2f). The highest observed nitrate was 565 µg/L on 8 May 2013. In 2017, the high was 440 µg/L on 9 May 2017 which declined by a factor of 7 to a low of 62 µg/L on 8 August 2017.

In 2017, soluble reactive phosphorus (SRP) was highly variable with higher values in the spring and late summer. (Figure 3.2g). The highest value of SRP was 10 µg/L and observed on 5 September 2017. Total dissolved phosphorus (TDP) concentrations for 2017 were similar to previous years and ranged from < 2 µg/L on 4 April 2017 and 6 November 2017 to 6.7 µg/L on 14 June 2017 (Figure 3.2h).

As in previous years, total phosphorus (TP) concentrations for 2017 showed high variability, and ranged from 2.8 µg/L to 141 µg/L (Figure 3.2i). The NN:TDP ratios in

Goldstream River were generally greater than 10, suggesting phosphorus limitation (Figure 3.2j).

***Beaver River (Figure 3.3)***

Similar to Goldstream River and the Columbia River at Donald, flow in Beaver River was dominated by spring freshet (Figure 3.3a). The anomalous high flows from February to March 2017 are the uncorrected effect of ice on the gauge found in the real time data; this will be replaced with corrected archive data when available. Compared to Goldstream and the Columbia at Donald, the temperature in Beaver River was cooler, with a maximum of 8 °C in 2017 (Figure 3.3b).

Recall, there are two sets of data collected from the Beaver River, by Environment Canada at East Park Gate, and by B.C. Hydro near confluence with Kinbasket Reservoir; we focus here on the later data representing the entire drainage. The conductivity (C25) in 2017 declined from 183 µS/cm on 3 April 2017 to 73 µS/cm on 29 May 2017 (Figure 3.3c). This decline during freshet was similar to that observed in other years. As in previous years, the turbidity in Beaver River varied considerably in 2017 generally ranging from 0.5 NTU to 12 NTU, with the exception of freshet, with 26 NTU on 8 May 2017 and 38 NTU on 29 May 2017(Figure 3.3d).

The pH in Beaver River for 2016 remained slightly alkaline (Figure 3.3e). Note that samples collected by BC Hydro near confluence (marked +) were slightly less alkaline in summer compared to samples collected further upstream near East Park Gate by Environment Canada. The average pH in 2017 was approximately 7.9 pH units, similar to previous years.

Data for nitrate (NN) in 2017 followed the pattern of previous years (Figure 3.3f). Values of nitrate were moderate in winter (e.g. 175 µg/L on 20 March 2017) and increased rapidly at the start of freshet (to 407 µg/L on 8 May 2017). This large increase in nitrate then declined dramatically after the start of freshet, to a low in summer (37.6 µg/L on 6 September 2017). Finally, nitrate gradually increased through fall to winter levels of about 170 µg/L by December.

For the most part, the concentrations of soluble reactive phosphorus (SRP) were low, and near the detection level (1 ug/L), though occasional higher values were observed in the data collected near confluence (Figure 3.3g). The data for 2017 also followed this pattern. A few slightly higher values were observed near confluence in 2017 (up to 5.9 ug/L). Note the absence, with two exceptions, of SRP value above detection in the Environment Canada data from East Park Gate.

Total dissolved phosphorus (TDP) collected near confluence in 2017 was variable with values ranging from < 2 ug/L to 9.5 ug/L (Figure 3.3i). In 2016, Environment Canada began to also analyze for TDP for all the samples. The Environment Canada data for 2016 (*) and 2017 (x) were lower than those collected by BC Hydro (+). In the

Environment Canada data the detection limit appears to be 0.5 ug/L, and most values were at detection, with the highest value being 0.9 ug/L.

Total phosphorus (TP) was variable in Beaver River ranging between the detection limit (2 ug/L BC Hydro and 0.5 ug/L Environment Canada), and 56 ug/L in 2017 (Figure 3.3i). The NN:TDP ratio also remained high in Beaver River, with all but two value values greater than ten (Figure 3.3j).

***Kinbasket and Revelstoke Outflows (Figures 3.4 and 3.5)***

Note that the location at which Kinbasket outflow was sampled is referred to as the "Columbia at Mica Outflow" in Appendix 3.1, and the location at which Revelstoke outflow was sampled is referred to as the "Columbia above Jordan". It should also be noted that the Revelstoke Reservoir backs all the way to the foot of Mica Dam (Kinbasket Reservoir); as a result, samples of Kinbasket outflow taken from the riverine section below the dam can be influenced by Revelstoke Reservoir when outflow from Kinbasket is low, which typically occurs from late spring to early summer (Figure 3.4a).

As in previous years, the temperature of the outflows from the dams were cold (≤11 °C) as a result of the deep intakes (Figures 3.4b and 3.5b). Unlike other years, there were no exceptions for the Kinbasket (Mica Dam) outflow in 2017; at low flow, the temperature below Mica Dam has in the past been noticeably influenced by Revelstoke Reservoir.

The conductivity of the outflow from the Kinbasket and Revelstoke Reservoirs was relatively steady in 2017, with the occasional lower value during low outflow from Mica Dam as in previous years (Figures 3.4c and 3.5c). The turbidity of the outflow from both Mica and Revelstoke was generally low, compared to the natural tributaries. The turbidity of the outflow from Mica Dam had slightly higher turbidity in late spring to early summer with a maximum of 6.45 NTU on 9 May 2017 (Figure 3.4d). Outflow from Revelstoke Dam was very low, generally < 2 NTU (Figure 3.5d). The average turbidity for the Kinbasket outflow was 1.72 NTU in 2017 and for Revelstoke outflow was 0.56 NTU in 2017 (maximum 1.15 NTU), similar to previous years. Like the tributaries, the pH was relatively constant and slightly alkaline (Figures 3.4e and 3.5e). There were some lower values of pH below Mica Dam from mid-May to mid-June, again corresponding to low outflow conditions.

Nitrate and nitrite concentrations (NN) in the Kinbasket outflow were generally constant throughout the year at approximately 100 µg/L (Figure 3.4f). The exceptions occurred mainly during spring when outflow was low. Exceptions include 221 µg/L on 30 May 2017. In the outflow from Revelstoke, nitrate was also relatively constant throughout the year, varying from 107 to 180 µg/L (Figures 3.5f). There was one exception of 519 µg/L on 4 April 2017; the cause of this one outlier is not known.

For both Kinbasket and Revelstoke outflows, SRP concentrations were close to the detection limit and generally below 5 µg/L (Figures 3.4g and 3.5g). Both TDP (Figures

3.4h and 3.5h) and TP (Figures 3.4i and 3.5i) were low and relatively constant in the Kinbasket and Revelstoke outflows (ranging from about 2 to 5 µg/L). There were a few exceptions, with a higher TP value in the Kinbasket outflow of 30.8 µg/L and in the Revelstoke outflow of 23 µg/L, both on 14 June 2017. The maximum TP for 2017 was at Revelstoke outflow with a value of 45 µg/L on 4 December 2017. The NN:TDP ratio for the Kinbasket and Revelstoke outflows exceeded 10 throughout 2017, suggesting nutrients from these sources were phosphorus limited (Figures 3.4j and 3.5j).

***Downie Creek (Figure 3.6)***

Because Downie Creek has a large influence on the lower half of Revelstoke Reservoir, it was decided to add Downie Creek as another reference tributary beginning in 2016. The 2016 and 2017 data are shown in Figure 3.6, which generally follow the pattern of the other natural tributaries.

## 4. Discussion

Most of the tributaries to Kinbasket and Revelstoke Reservoirs are remote and difficult to access, making it prohibitive to collect enough samples from each site to show the seasonal variation. As a result, intensive sampling of a set of reference tributaries has been undertaken to provide an indicator of seasonal variability.

Another example of seasonal variability is given by the long record of water quality data available for the Illecillewaet River, which is located just south of the Revelstoke Reservoir (Figures 3.7 and 3.8). The Illecillewaet is the largest local inflow to the Arrow Reservoir, with a drainage area of 1,170 $km^2$, and including flow of glacial origin. Water quality data from 1997 to 2001 are shown in Figure 3.7. Also shown in grey is the flow from the Illecillewaet at Greeley (WSC Station 08ND013). Similar to that observed in the reference tributaries, there is a clear seasonal cycle in C25 and nitrate, with concentrations high during the start of freshet and then decreasing rapidly to lower values during the summer (Figures 3.7a and 3.7d). In late August, the values begin to increase again. Also shown for reference are water temperature, pH, $NH_3$, SRP, TDP, and TP (Figures 3.7).

Figure 3.8 compares the seasonal evolution of the flow, C25 and nitrate (NN) in the Illecillewaet River during these five years, 1997-2001. The onset of freshet occurred between early and mid-May. For example, in 1998 a large peak in freshet flow began at the start of May, while freshet was delayed toward the end of May in 2001. There is a corresponding variation in the timing of the decline in C25 (Figure 3.8b). The decline in nitrate occurs more gradually through May and June to very low values in July and August (Figure 3.8c). Overall, nitrate declined from 420-480 µg/L in May to 50-100 µg/L in mid-summer. A similar decline in nitrate is seen in other tributaries to the Arrow Reservoir (e.g. Pieters *et al.*, 2003).

## 5. Conclusions

Based on these data, and those of previous years, the tributaries to both Kinbasket and Revelstoke Reservoirs are low in nutrients. Soluble reactive phosphorus (SRP) was very low in both basins, generally close to the detection limit. Total dissolved phosphorus (TDP) was also low, at ~ 5 µg/L. Total phosphorus (TP) was highly variable, reflecting the glacial origin of many of the tributaries, and much of the TP is likely of inorganic origin with low biological availability. In the presence of glacial inflow, TDP is preferred over TP as a measure of available phosphorus.

In the presence of oxygen, concentrations of nitrate and nitrite (NN) are typically dominated by nitrate. Nitrate in the outflow from Kinbasket and Revelstoke Reservoirs was approximately 100 µg/L. For comparison, nitrate in the outflow from Arrow Reservoir was 200 µg/L (Pieters *et al.*, 2003).

For an N:P ratio greater than 10 (by weight), phosphorus is expected to limit phytoplankton productivity (Horne and Goldman, 1994). The N:P ratio, based on nitrate and TDP, is greater than 10 for the reference tributaries, which suggests phosphorus limitation, with the notable exception of Columbia River at Donald in some summers, when the N:P ratio declined below 10, suggesting phosphorus and nitrogen co-limitation. The N:P ratio was well above 10 for the outflow from both reservoirs.

## Acknowledgements

Samples were collected by B. Manson, P. Bourget, and K. Bray. Funding was gratefully provided by BC Hydro. We thank J. Bowman, A. Sharp, K. Lywe, A. Quainoo, A. Law, C. Huang, T. Rodgers and A. Law for assistance, and for support from the UBC Work-Learn program. G. Lawrence is grateful for the support of the Canada Research Chair program.

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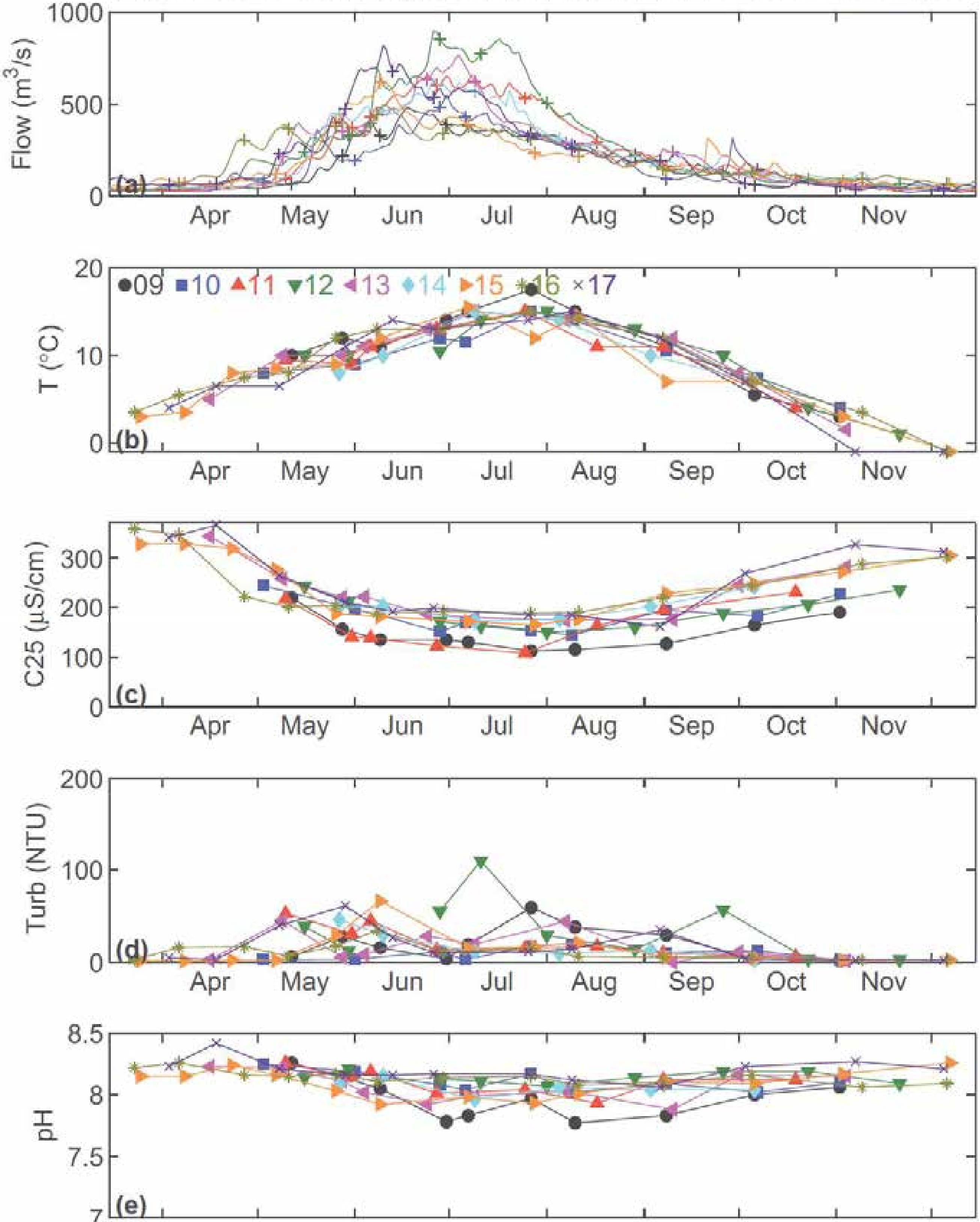
**Figure 3.1** Columbia R. at Donald: 09, 10, 11, 12, 13, 14 15 16 & 17




/ocean/rpieters/kr/chem/trib/plot/plotreftrib08to17all.m fig= 1 2019-Feb-12

**Figure 3.1 con't** Columbia R. at Donald: 09, 10, 11, 12, 13, 14 15 16 & 17

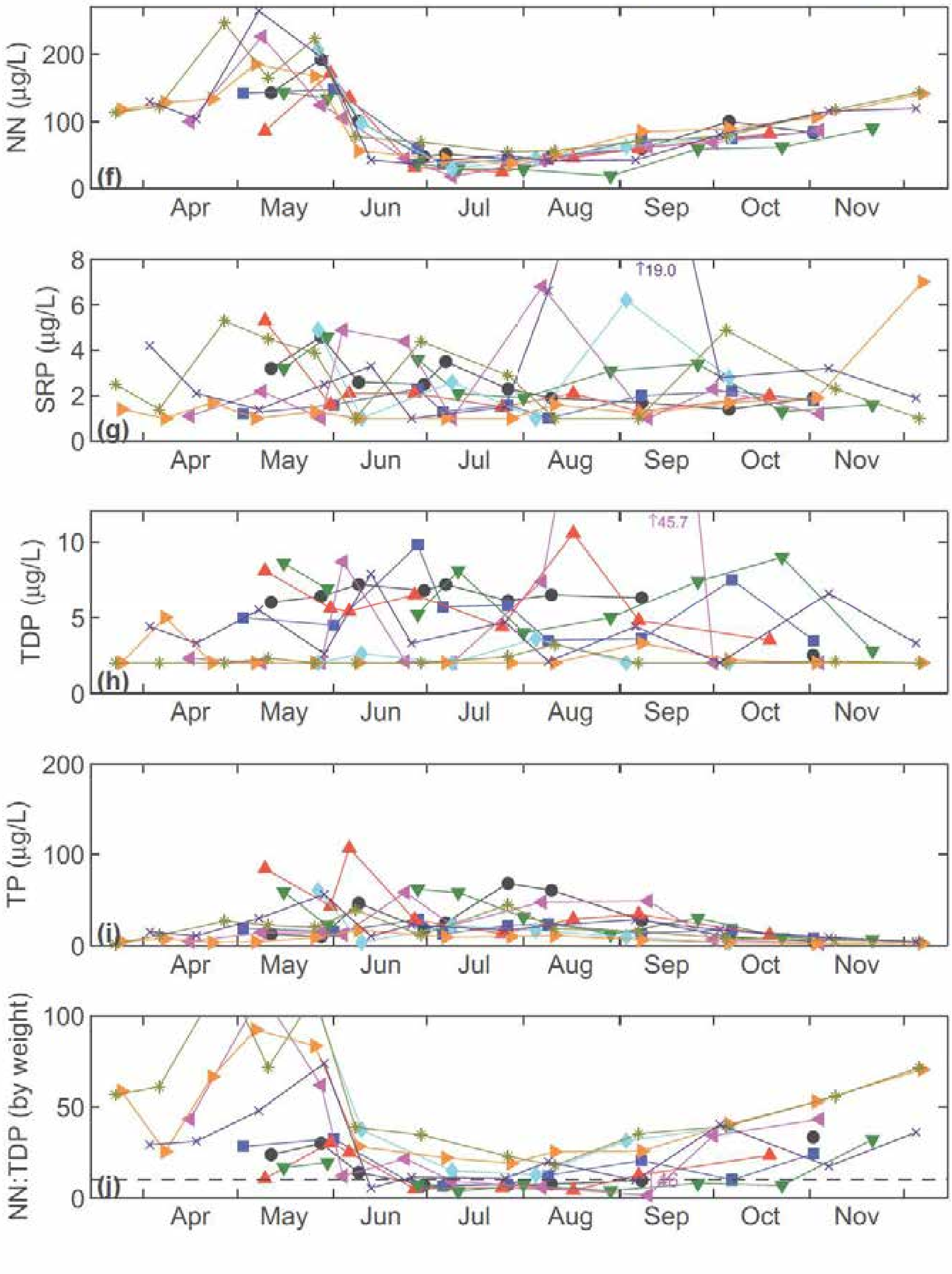



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**Figure 3.2** Goldstream River: 09, 10, 11, 12, 13, 14 15 16 & 17

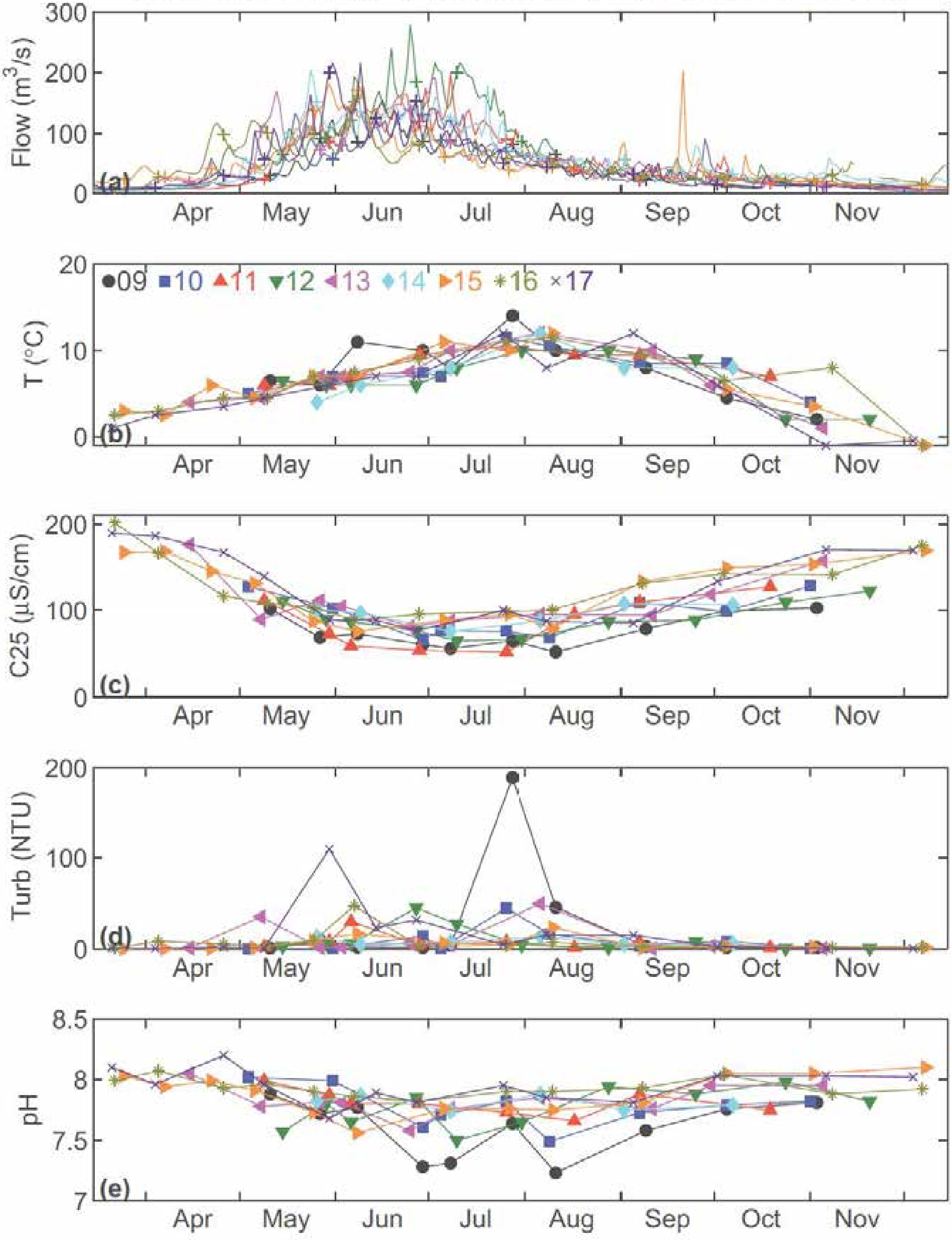


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**Figure 3.2 con't** Goldstream River: 09, 10, 11, 12, 13, 14 15 16 & 17

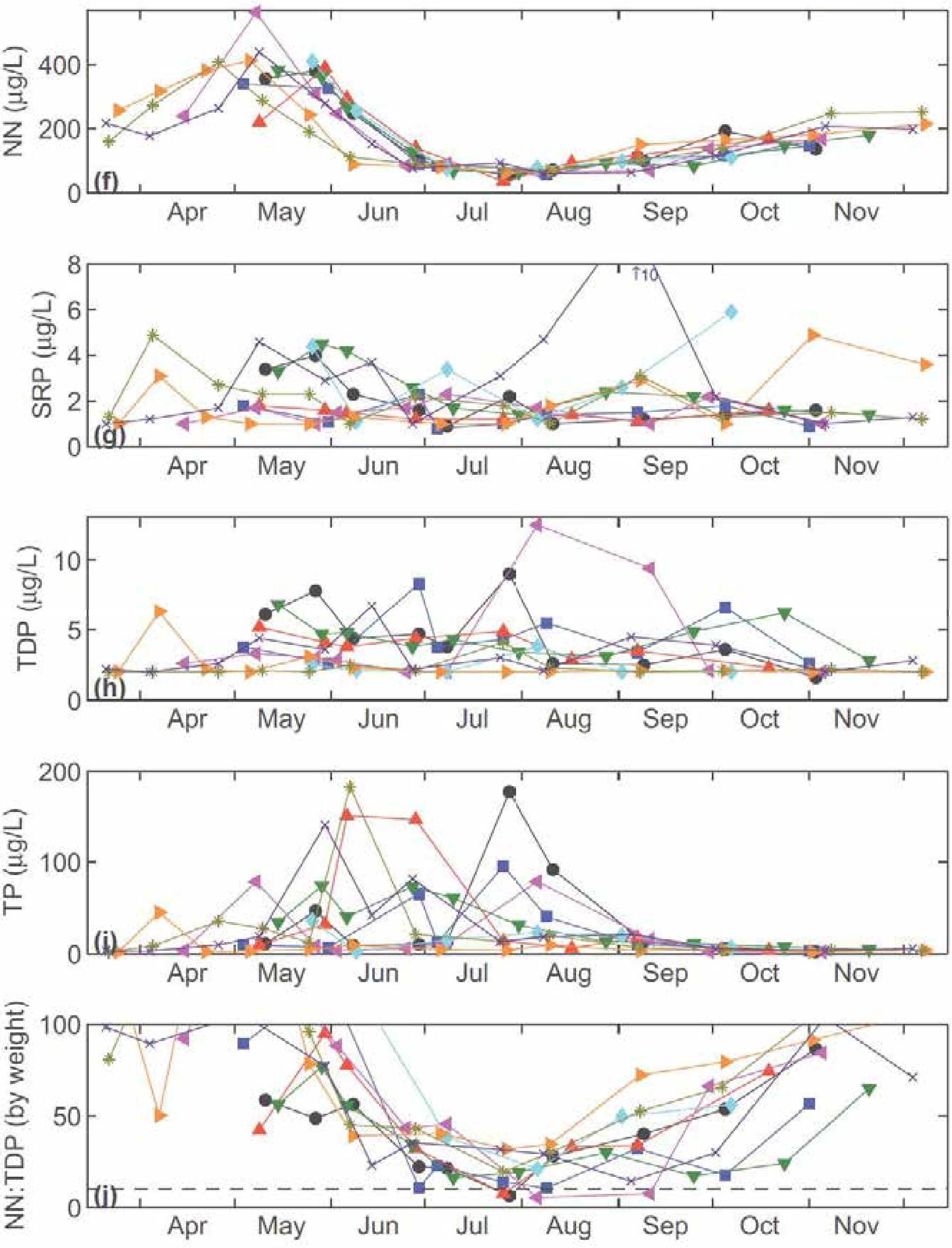


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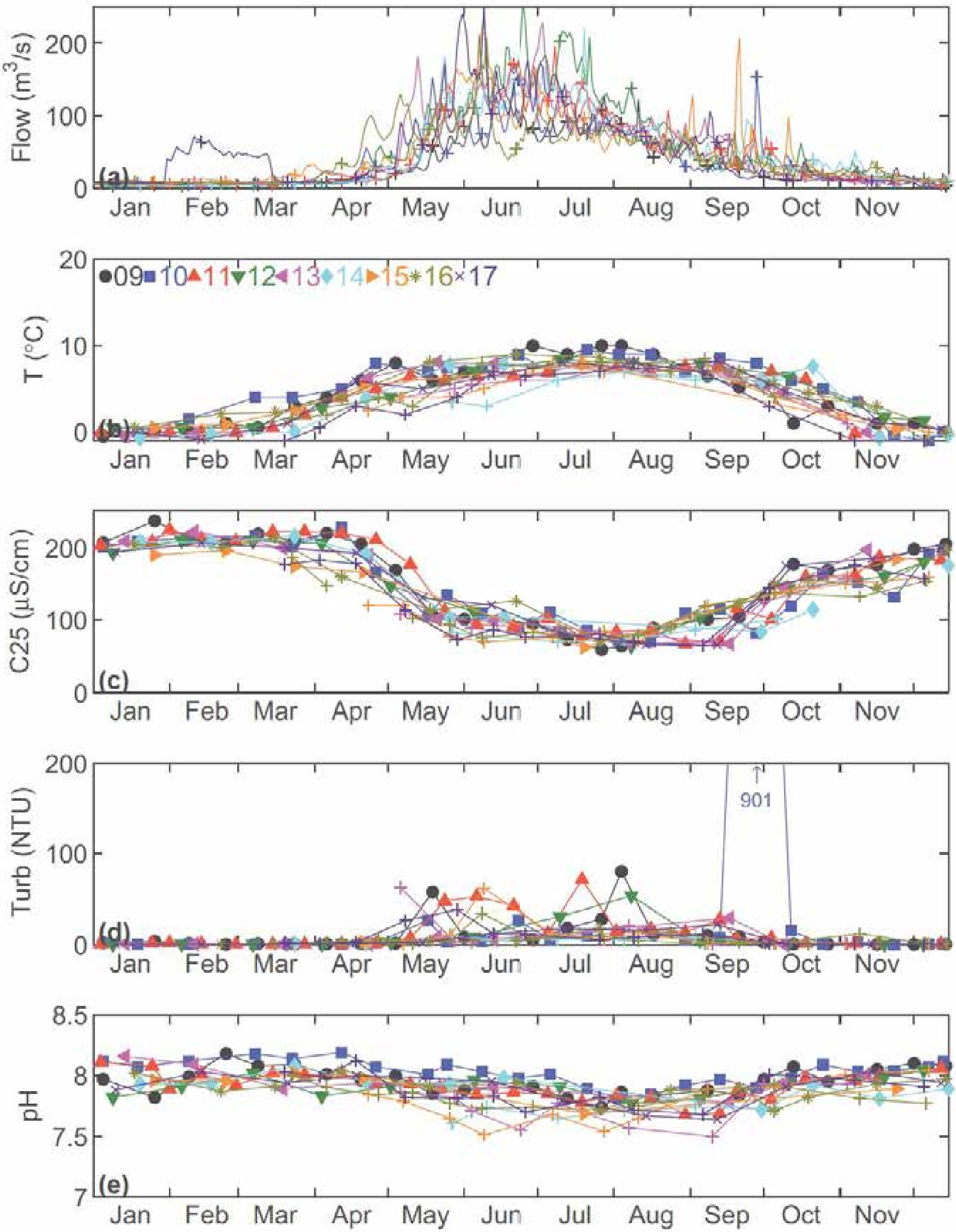
**Figure 3.3** Beaver River: 09, 10, 11, 12, 13, 14 15 16 & 17
all near East Park Gate except (+) near confluence

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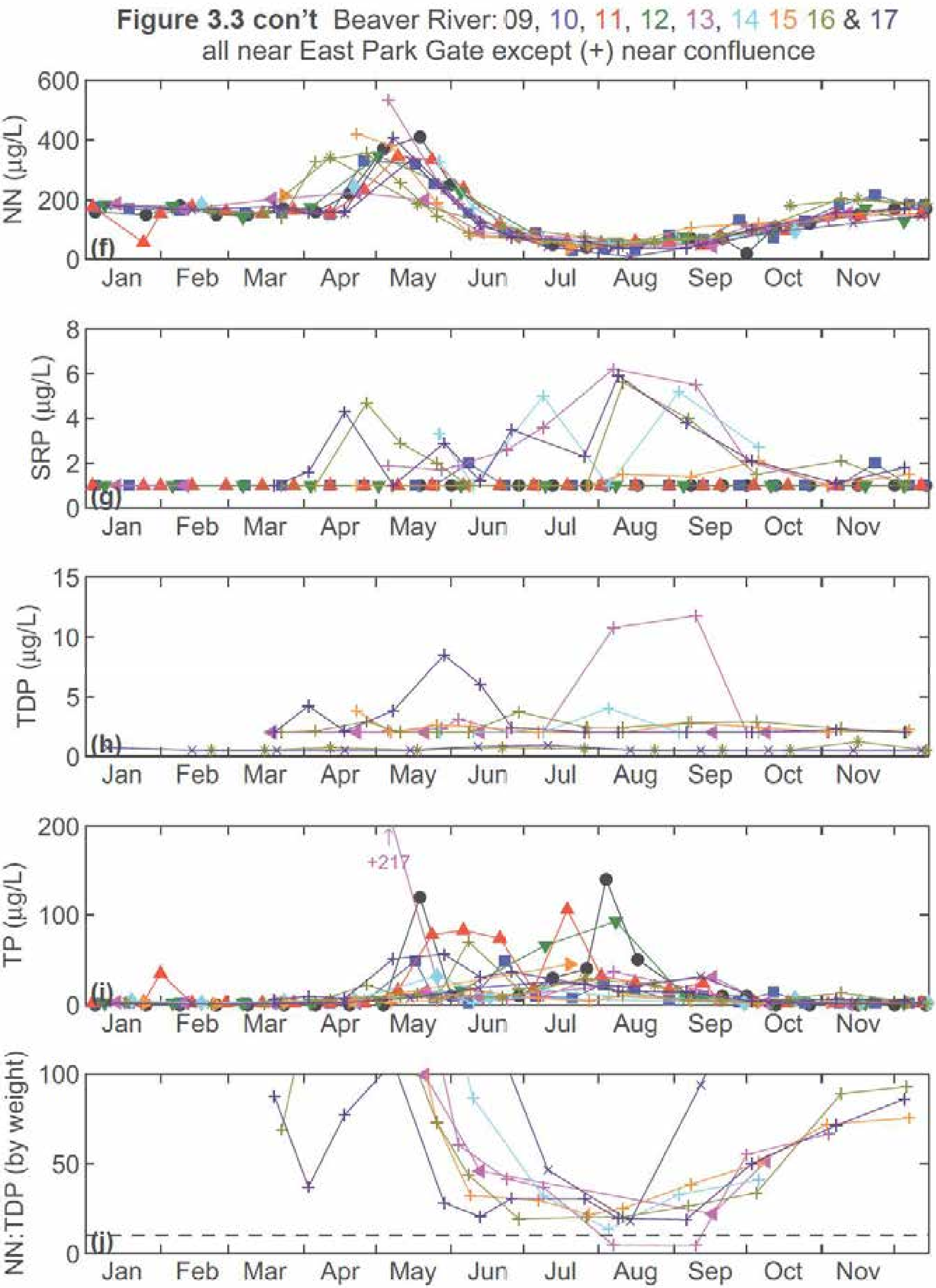


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**Figure 3.4** Kinbasket Outflow: 09, 10, 11, 12, 13, 14 15 16 & 17

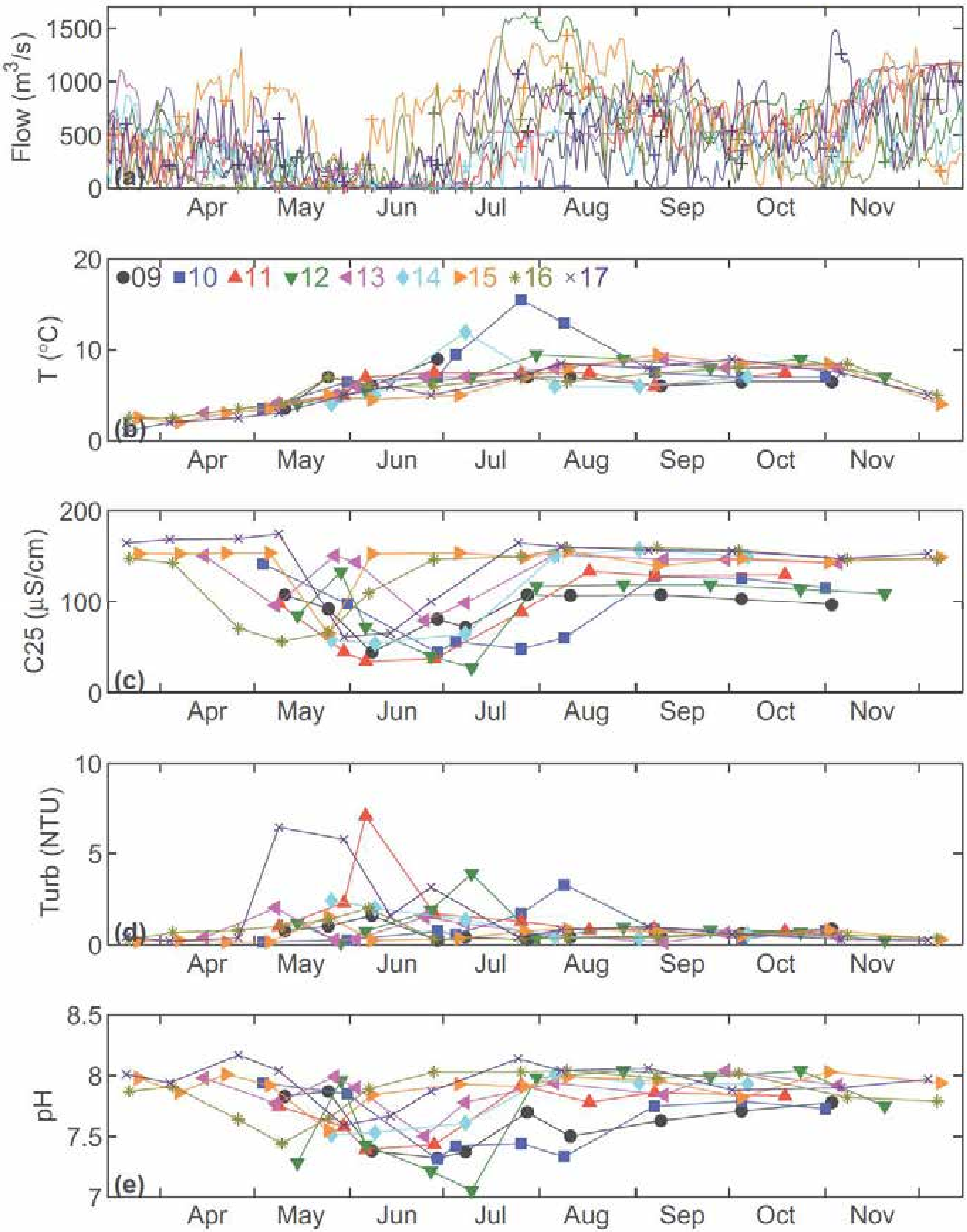


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**Figure 3.4 con't** Kinbasket Outflow: 09, 10, 11, 12, 13, 14 15 16 & 17

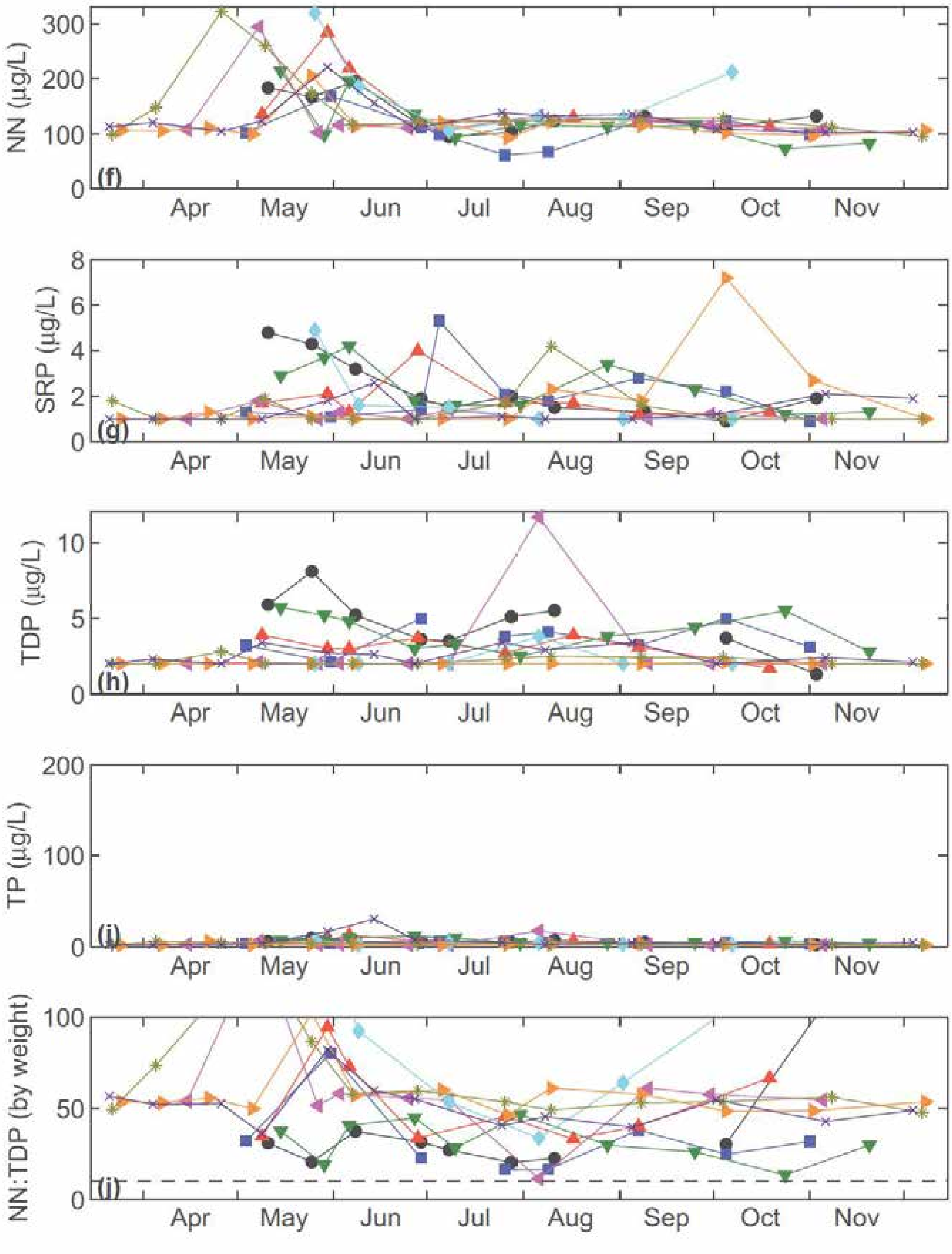


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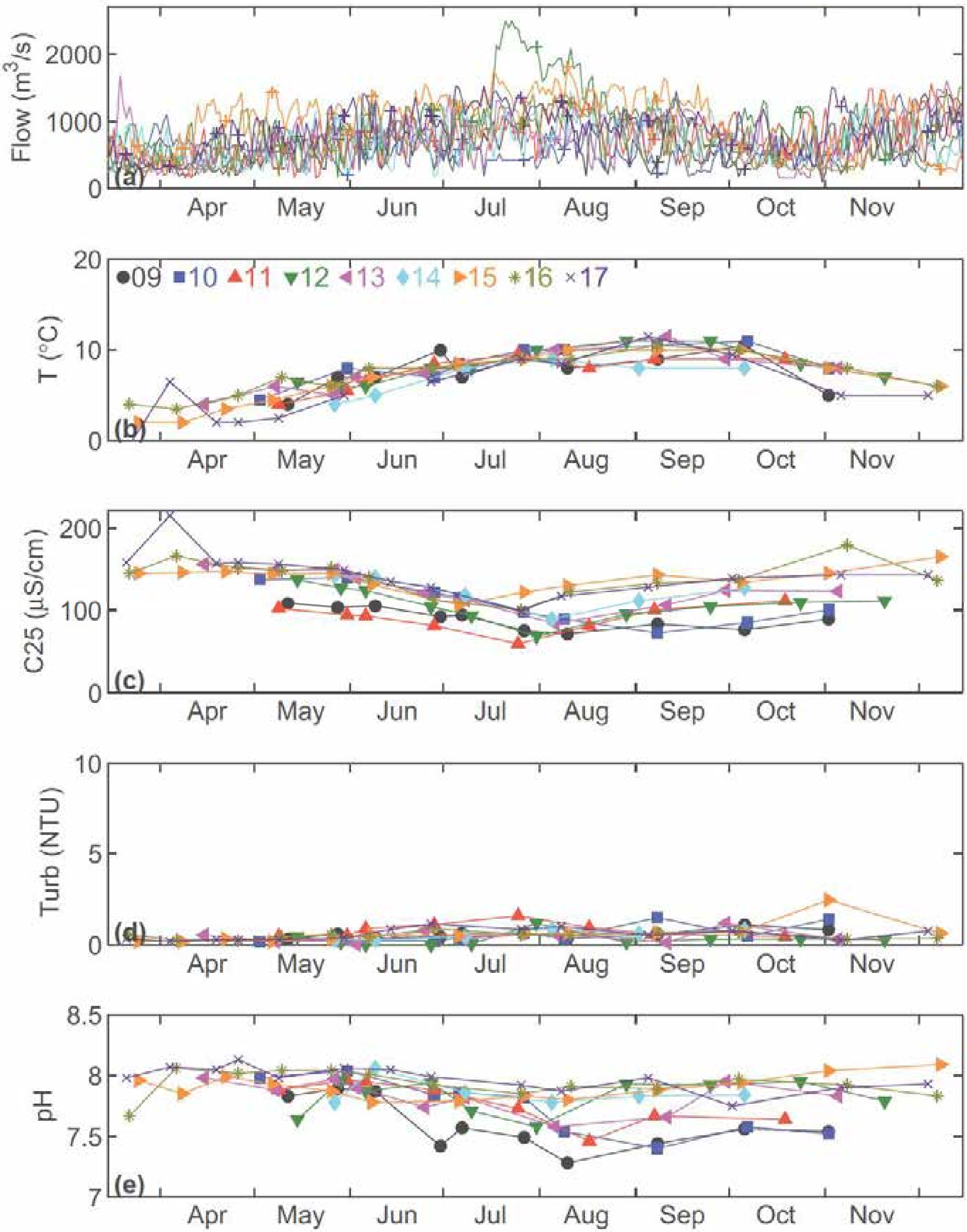
**Figure 3.5** Revelstoke Outflow: 09, 10, 11, 12, 13, 14 15 16 & 17

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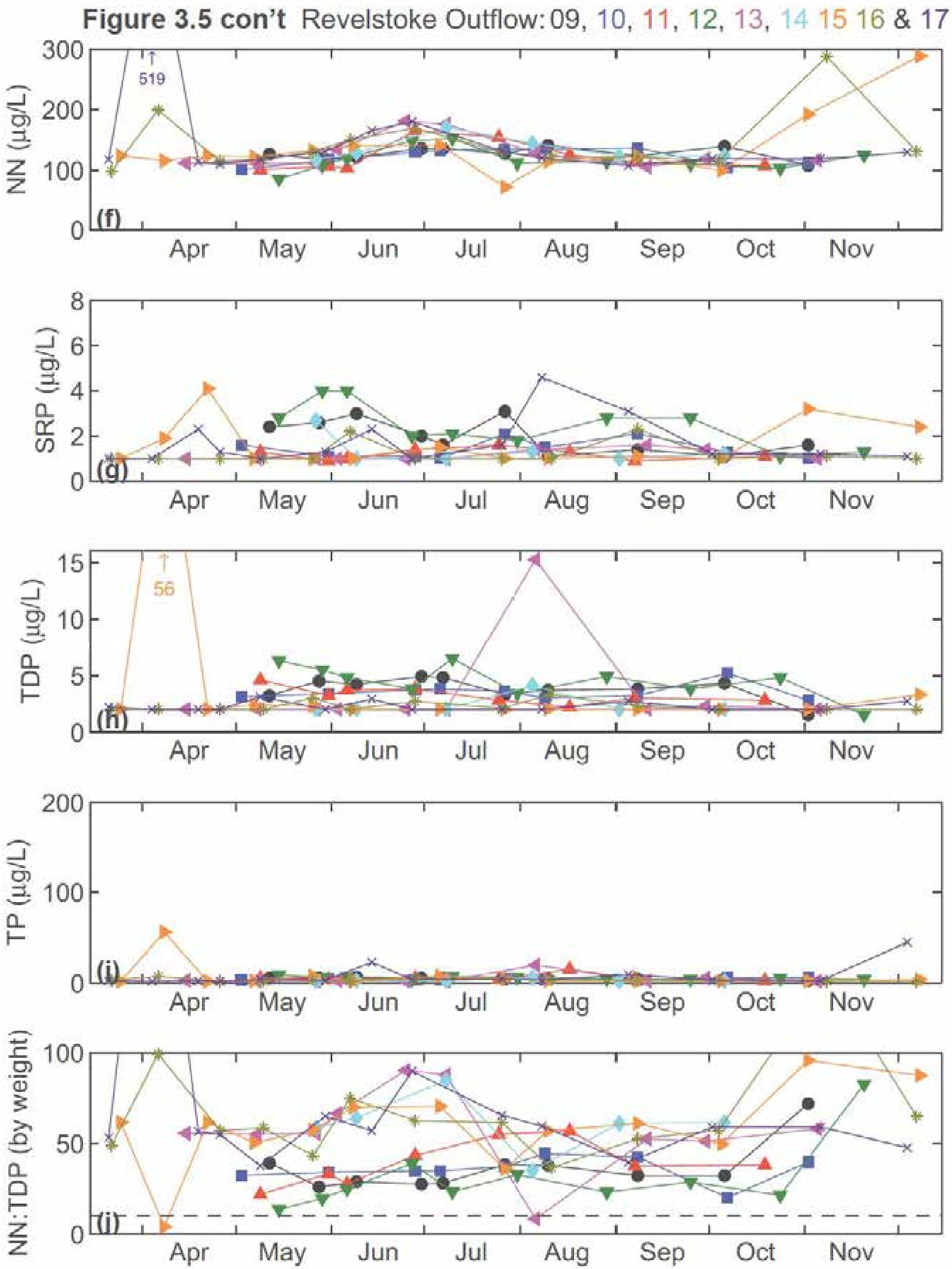
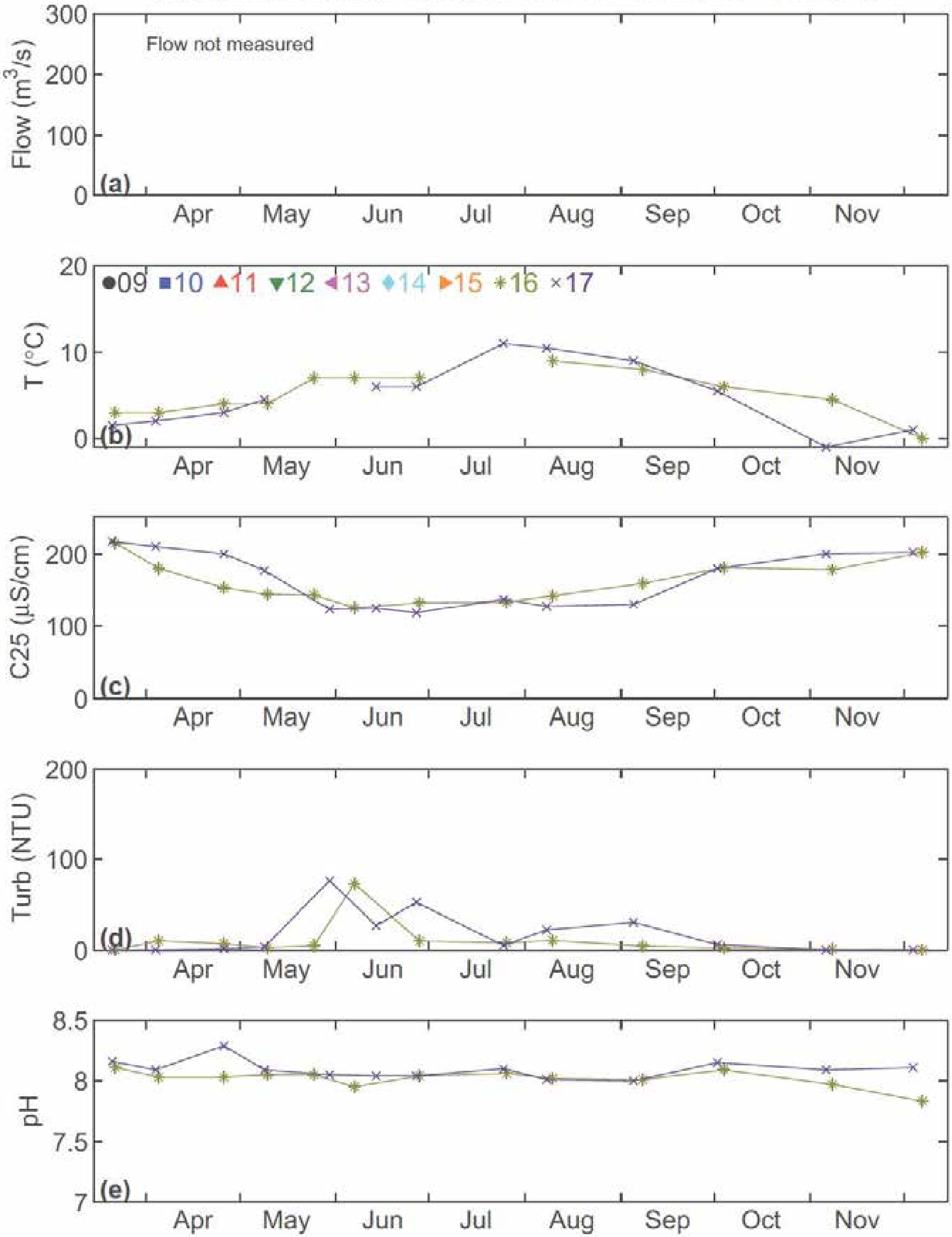


Figure 3.5 con't Revelstoke Outflow: 09, 10, 11, 12, 13, 14 15 16 & 17
NN (µg/L)
519
(f)
SRP (µg/L)
(g)
TDP (µg/L)
56
(h)
TP (µg/L)
(i)
NN:TDP (by weight)
(j)
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov

**Figure 3.6** Downie Creek: 09, 10, 11, 12, 13, 14 15 16 & 17

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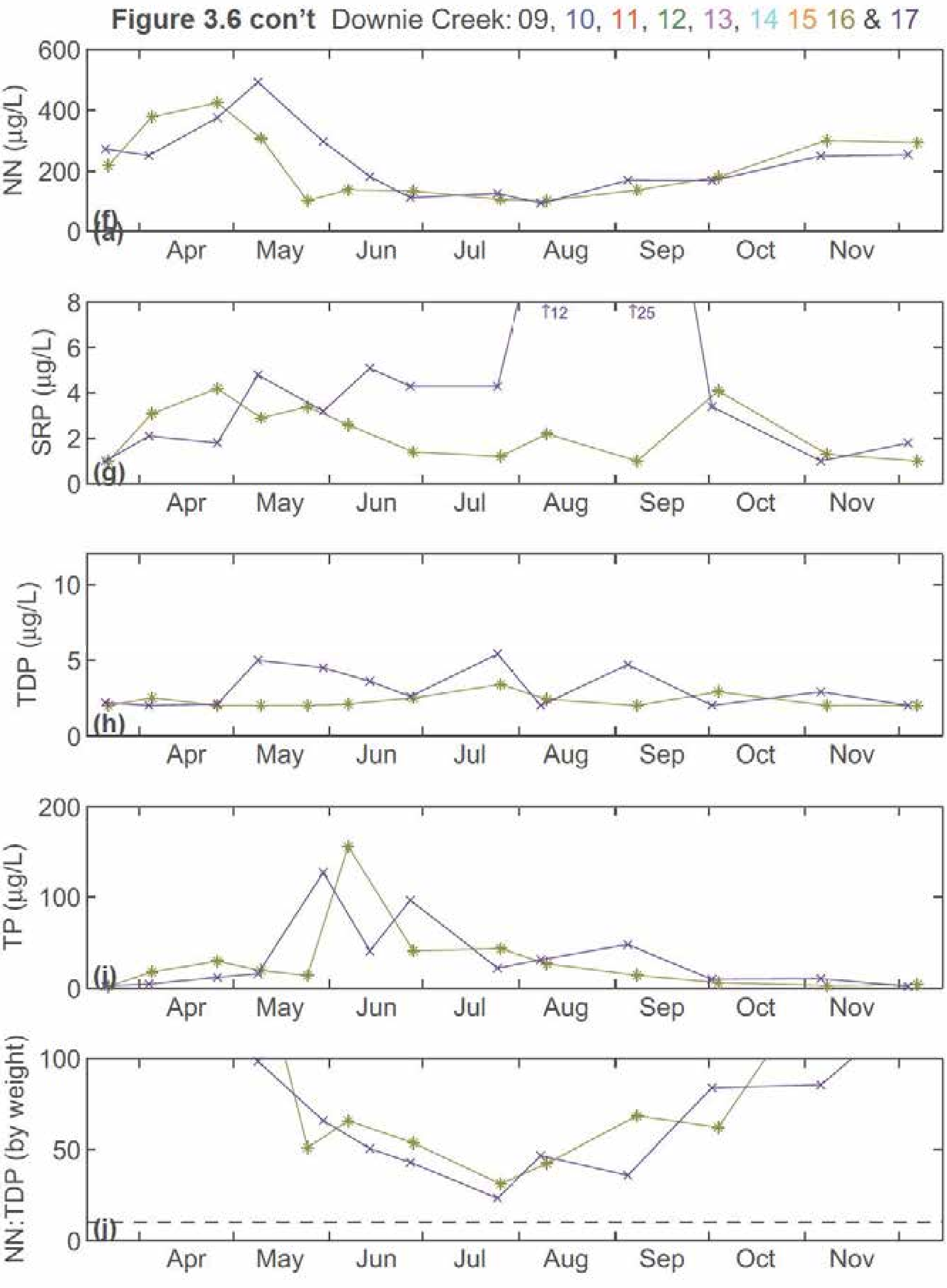


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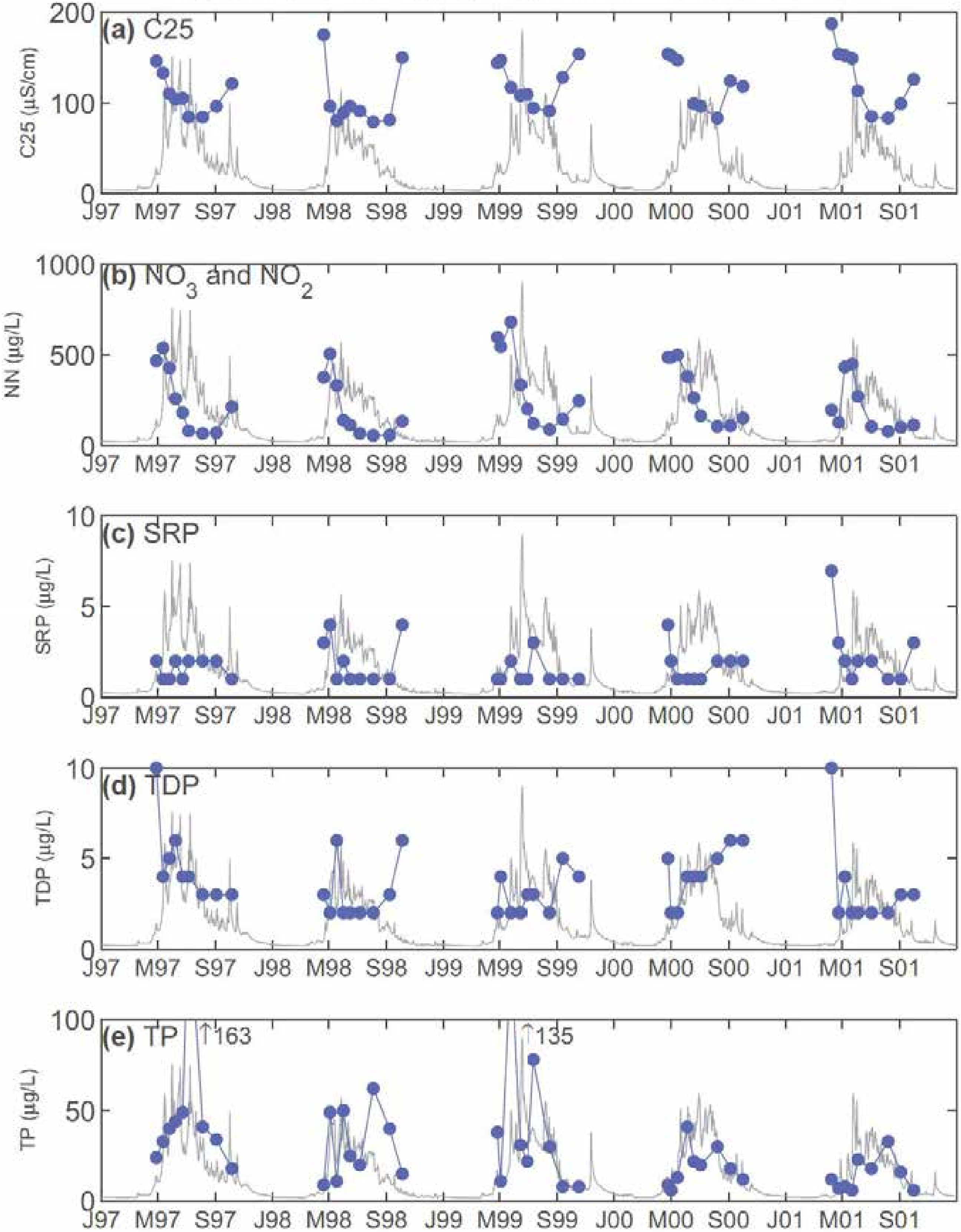
**Figure 3.7** Water quality of Illecillewaet River, 1997−2001




/ocean/rpieters/al97/chem/stream/plotillKINREV08.m fig= 1 2019−Mar−08

**Figure 3.7** Water quality of Illecillewaet River, 1997−2001

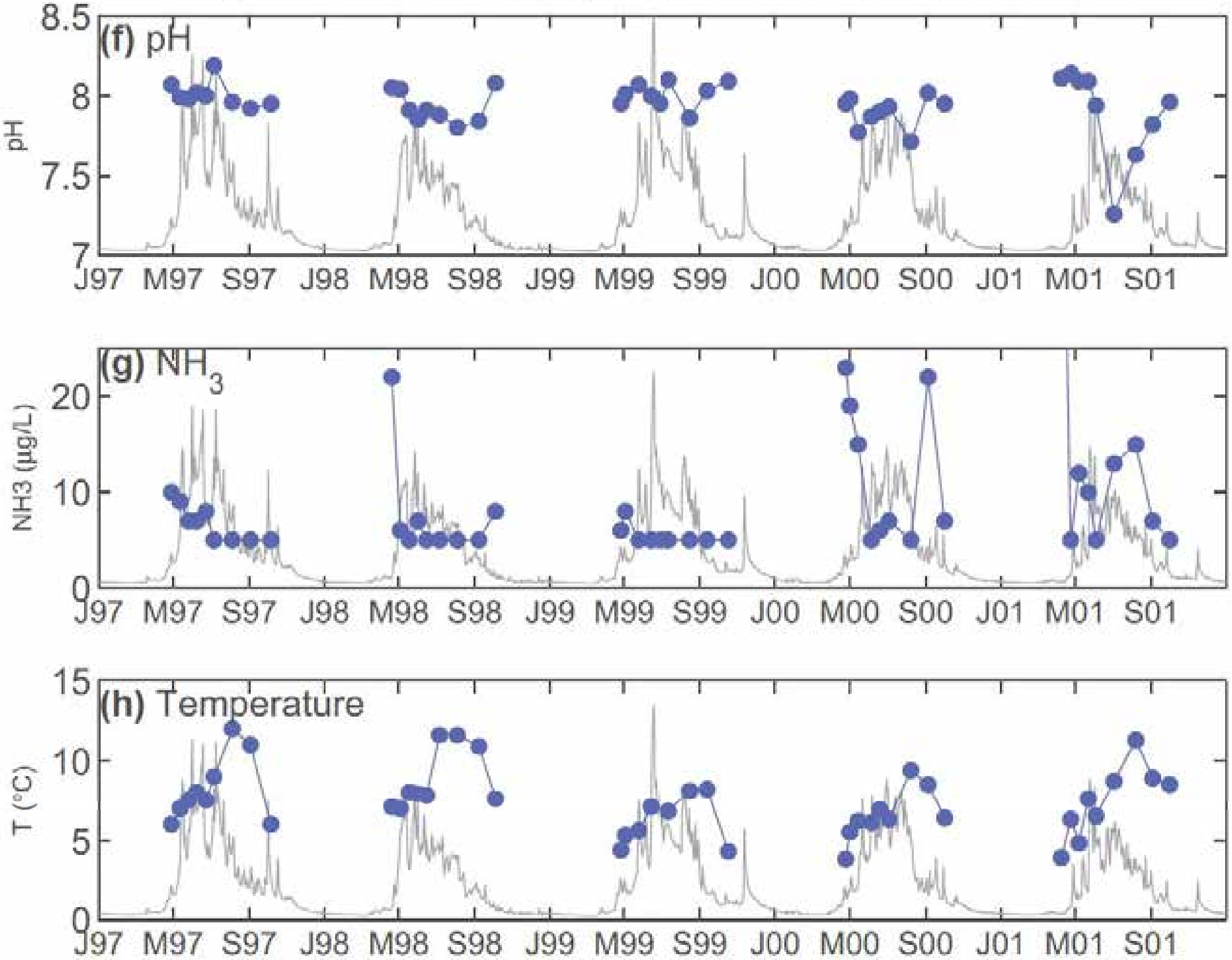



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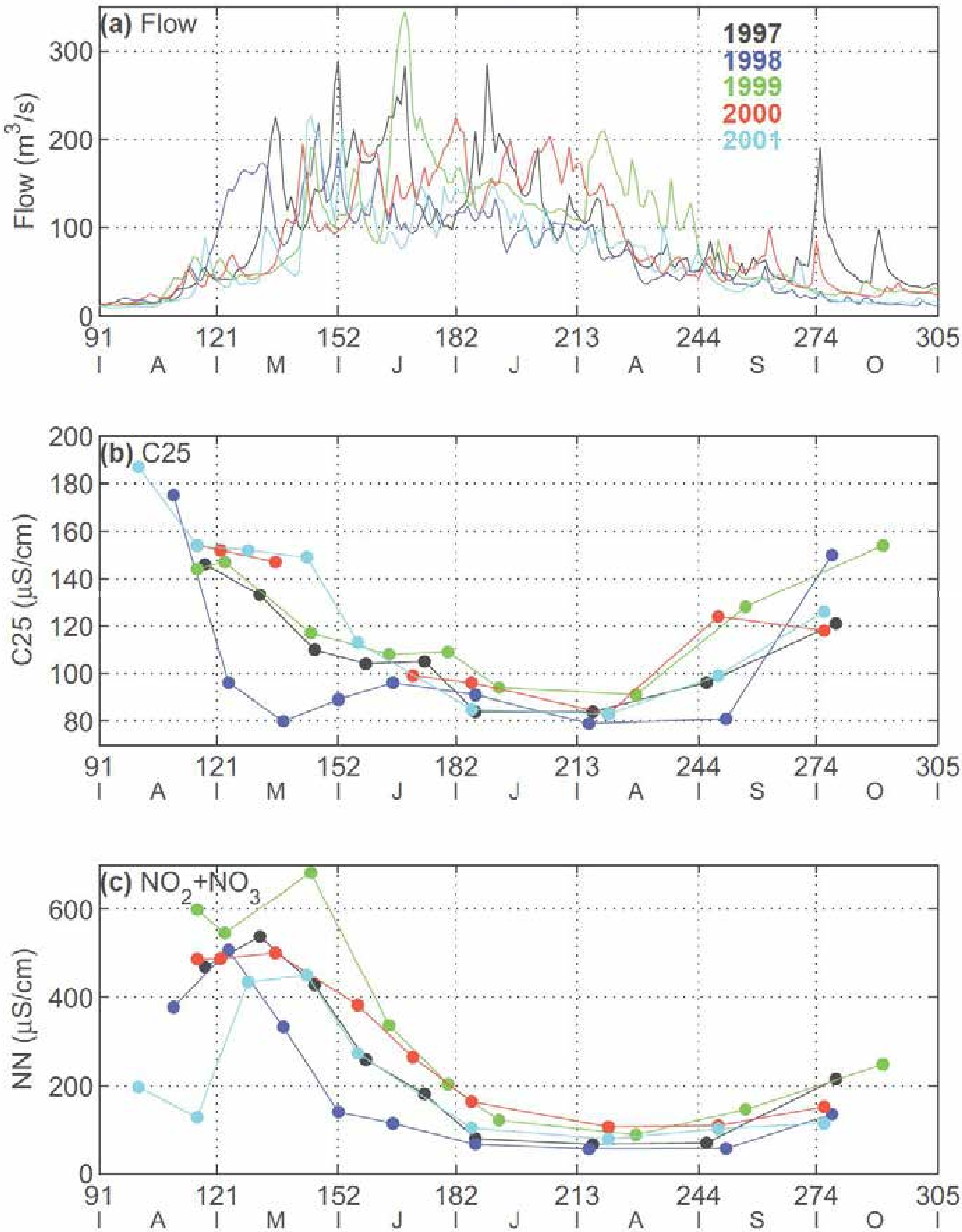
**Figure 3.8** Flow, C25 and NN in the Illecillewaet River, 1997−2001

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## Appendix 1
## Summary of Methods, Maxxam Analytics

Samples for $NO_3$+$NO_2$, SRP and TDP required filtration. Filtration was done using a 47 mm Swinnex holder with 60 cc syringe. Filters were 0.8 µm glass-fiber (GFF), ashed and washed with distilled/ deionized water before use. The samples for $NO_3$+$NO_2$ and SRP were frozen.

A summary of selected laboratory methods were abstracted from Maxxam method summaries as follows.

**Phosphorus** Standard Methods 22nd Edition, Method 2580 B

Total Phosphorus is the term used to describe the sum of all of the phosphorus present in a sample regardless of form, as measured by the persulphate digestion procedure.

Total orthophosphate is the phosphate that responds to colorimetric tests without preliminary hydrolysis or oxidative digestion of the sample; however a small fraction of condensed phosphates is usually hydrolyzed unavoidably. This form is termed 'reactive phosphorus'.

Phosphorus analysis involves two general steps: a) conversion of the phosphorus form of interest to dissolved orthophosphate, and b) colourimetric determination of dissolved orthophosphate. The sample is divided and the subsamples are prepared for determination of orthophosphate or total phosphate, which are determined sequentially in the Konelab. Ammonium molybdate and antimony potassium tartrate react in an acidic medium with dilute solutions of phosphorus to form an antimony-phospho-molybdate complex. This complex is reduced to an intensely blue coloured complex by ascorbic acid. The colour is proportional to the phosphorus concentration and is measured colorimetrically at 880 nm.

**Nitrate and Nitrite Plus Nitrate by Automated Colourimetric Method** Standard Methods 22nd Edition, Method 4500-NO3 – I

This method incorporates a split manifold used to determine both nitrite singly and nitrite and nitrate combined. The nitrite (that was originally present, plus reduced nitrate) is determined by diazotizing with sulphanilamide and coupling with N-(1-naphthyl)-ethylenediamine to form an azo dye, measured colourimetrically at 520 nm. For nitrite and nitrate combined, the nitrate in a portion of the sample is quantitatively reduced to nitrite in a reductor column containing amalgamated copperized cadmium filings. The nitrite yielded by the reduction plus the nitrite already present in the sample is then determined as for nitrite. Nitrate is determined by subtraction of the nitrite result from the nitrate + nitrite value.

**Conductivity, pH and Alkalinity** Standard Methods 22nd Edition, Methods 2510B (Conductivity), 4500B (pH), 2320B (Alkalinity)

Conductivity, pH, and alkalinity are determined sequentially on a sample using a fully automated instrument. Electrometric methods are calibrated daily to account for probe drift and fluctuations in temperature.

A multipoint calibration using standards of known conductivity and the measured cell constant is used to verify system performance. EC is calibrated daily because the cell constant may change over time.

pH measurement is the determination of the activity of the hydrogen ions by potentiometric measurement between electrodes. Combination electrodes, where both electrodes are contained in a single body with a saturated KCl filling solution are most commonly employed. The reference electrode is usually Ag/AgCl or calomel.

Alkalinity is determined by pH end-point titration of a sample aliquot with a standard solution of strong acid. The amount of acid added to the aliquot to bring the pH to 8.3 is used to calculate the phenolphthalein alkalinity. The amount of acid added to the aliquot to bring the pH to 4.5 is used to calculate the total alkalinity. For samples less than 20 mg/L CaCO3, low-level alkalinity is determined by carefully measuring the volume of acid required to lower the total alkalinity end point by exactly 0.3 pH units (doubling the H+ concentration) to pH 4.2.

**Turbidity** Standard Methods 22nd Edition, Method 2130B
A light source from a tungsten filament lamp is passed through a sample in order to measure the light scattered by the particles suspended in the sample. The intensity of the scattered light is measured by a 90° detector, a forward scatter light detector and a transmitted light detector. The intensity of the scattered light and the transmitted light is mathematically calculated to determine the concentration of the turbidity in the sample.

**Correction of Alkalinity data, 2008-2012**
Samples analyzed by the Cultus Lake lab were assessed using the low alkalinity method, and these values were given in all previous reports. However, only a few of the samples had alkalinity < 20 mg CaCO3/L for which the low level method is suitable (APHA 1975). The laboratory provided the spreadsheet from which it was possible to re-calculate the appropriate alkalinity, examples of which are shown in Table A1-1. Note that the first end point was not exactly pH 4.5 but ranged from pH 4.3 to 4.7; unfortunately the specific pH end point for each sample was not recorded. The alkalinity was recalculated assuming the end point pH was 4.5. The resulting error was estimated by adding 2/3 of the second end point, which was 0.3 pH units below the first. The resulting errors are less than 10% (Table A1-1). In summary, for alkalinity > 20 mg CaCO3/L, the recalculated values are approximately half of the uncorrected values.

**Table A1-1** Example of recalculation of alkalinity, August 5, 2008

| Tributary | pH | A or B mls acid to first pH[1] | C mls acid to 0.3 pH lower | N Norm-ality of acid | Low Level Alk [2] mg CaCO3 /L | Regular Alk [3] mg CaCO3 /L | Revised Alk mg CaCO3 /L | Estimated Error % |
|---|---|---|---|---|---|---|---|---|
| Beaver R | 7.51 | 3.20 | 0.170 | 0.02 | 62.3 | 32 | 32 | 3.5 |
| Bush R | 8.16 | 8.20 | 0.290 | 0.02 | 161.1 | 82 | 82 | 2.4 |
| Canoe R | 6.86 | 0.70 | 0.120 | 0.02 | 12.8 | 7 | 12.8 | - |
| Cummins R | 7.68 | 3.60 | 0.150 | 0.02 | 70.5 | 36 | 36 | 2.8 |
| Dave Henry Cr | 7.30 | 1.80 | 0.160 | 0.02 | 34.4 | 18 | 18 | 5.9 |
| Foster Cr | 7.05 | 1.10 | 0.150 | 0.02 | 20.5 | 11 | 11 | 9.1 |
| Gold R | 7.71 | 3.00 | 0.200 | 0.02 | 58.0 | 30 | 30 | 4.4 |
| Hugh Allen Cr | 7.44 | 2.50 | 0.170 | 0.02 | 48.3 | 25 | 25 | 4.5 |
| Kinbasket R | 8.03 | 5.90 | 0.220 | 0.02 | 115.8 | 59 | 59 | 2.5 |
| Molson Cr | 7.81 | 4.30 | 0.170 | 0.02 | 84.3 | 43 | 43 | 2.6 |
| Ptarmigan Cr | 7.28 | 1.70 | 0.160 | 0.02 | 32.4 | 17 | 17 | 6.3 |
| Sullivan R | 8.15 | 6.50 | 0.320 | 0.02 | 126.8 | 65 | 65 | 3.3 |
| Windy Cr | 7.31 | 1.60 | 0.150 | 0.02 | 30.5 | 16 | 16 | 6.3 |
| Wood R | 8.10 | 6.90 | 0.250 | 0.02 | 135.5 | 69 | 69 | 2.4 |

All sample volumes V = 100 mL.

(1) First pH = 4.5 (4.3 - 4.7)

(2) Low level alkalinity ((2*B-C)*N*50000)/V

(3) Regular alkalinity (A*N*50000)/V

**Appendix 2**
**Tributaries**

**Table A2-1 Tributaries to Kinbasket Reservoir**

| Name | Lat (N)/Long (W) | Drainage Area (1) (km$^2$) |
|---|---|---|
| Columbia R. at Donald Station | 51° 29.0 117° 10.5 | 9710 |
| Waitabit Creek (new in 2013) | 51°30.201 117°11.796 | *~400* |
| Bluewater Creek (new in 2013) | 51°30.164 117°13.571 | *~400* |
| Quartz Creek (new in 2013) | 51°31.310 117°23.947 | *~100* |
| Beaver River at confluence during low pool, ~800 m below confluence at full pool (accessed by helicopter during 2013 survey) | 51°32.105 117°25.592 | |
| Beaver River near confluence at full pool (Kinbasket Lake Resort) | 51°31.668 117°26.012 | |
| Beaver River at WSC gauge 08NB019 (just above railroad bridge and ~2.5 km above confluence at full pool) | 51° 30.58 117° 27.70 | 1150 |
| Beaver River above Cupola Cr (near Roger's Road bridge and ~6 km above confluence at full pool) | 51°29.264 117°29.503 | |
| Beaver River near East Park Gate (at Highway 1 bridge and ~18 km above confluence at full pool)(2) | 51°23 / 117°27 | *~600* |
| Gold River | 51° 41.5 117° 42.5 | 542 |
| **Bush Arm** | | |
| Bush River | 51° 47.5 117° 22.4 | 1032 |
| Prattle Creek | 51 ° 47.3 117 ° 25.4 | 199 |
| Chatter Creek | 51 ° 47.1 117 ° 26.3 | 102 |
| Succour Creek (new in 2013) | 51°45.014 117°35.631 | *~50* |
| **Columbia Reach** | | |
| Windy Creek | 51° 52.5 118° 01.2 | 243 |
| Sullivan River | 51° 57.2 117° 51.4 | 593 |
| Kinbasket River | 51° 58.5 117° 57.5 | *160* |
| Cummins | 52° 03.1 118° 09.5 | 268 |
| **Wood Arm** | | |
| Wood River | 52° 12.2 118° 10.3 | 451 |
| **Canoe Reach** | | |
| Canoe River | 52° 46.4 119° 09.6 | 611 |

| | | |
|---|---|---|
| Dave Henry Creek | 52° 44.4 119° 05.6 | 96 |
| Yellowjacket Creek | 52 ° 42.1 119 ° 03.1 | 104 |
| Bulldog Creek | 52 ° 38.4 118 ° 58.5 | 107 |
| Ptarmigan Creek | 52° 35.0 118° 39.5 | 295 |
| Hugh Allan Creek | 52° 26.4 118° 39.5 | 626 |
| Foster Creek | 52° 15.2 118° 38.1 | 187 |
| Dawson Creek | 52 ° 15.6 118 °29.5 | 108 |
| Molson Creek | 52° 10.4 118° 21.8 | 77 |

[1] From Water Survey Canada and BC Hydro; estimated values in italics

[2] Beaver River near the mouth (WSC 08NB019 at 51° 30.58 N and 117° 27.70 W) drains 1,150 km$^2$. Tributary sampling by Environment Canada was upstream at Beaver River near East Park Gate (BC08NB00002) with approximately half the drainage.

**Table A2-2 Tributaries to Revelstoke Reservoir**

| Name | Lat Long | Drainage Area[2] ($km^2$) |
|---|---|---|
| **Upper** | | |
| Columbia River at Mica (Kinbasket Reservoir/Mica Dam Outflow) | 52° 02.6 118° 35.3 | 21500[1] |
| Nagle Creek | 52° 03.1 118° 35.4 | 157 |
| Soards Creek | 52° 03.5 118° 37.3 | 161 |
| Mica Creek | 52° 00.4 118° 34.0 | 84 |
| Pat Creek (new in 2013) | 51°57.0 118°34.7 | *200* |
| Pitt Creek | 51° 57.3 118° 33.5 | *5* |
| Birch Creek | 51° 55.2 118° 33.5 | 27 |
| Bigmouth Creek | 51° 49.4 118° 32.4 | 588 |
| Scrip Creek | 51° 49.4 118° 39.2 | 160 |
| Horne Creek | 51° 46.4 118° 41.2 | 121 |
| Hoskins Creek | 51° 41.6 118° 40.1 | 101 |
| Goldstream River | 51° 40.0 118° 38.6 | 953 |
| Kirbyville Creek | 51° 39.1 118° 38.3 | 117 |
| **Lower** | | |
| Downie Creek | 51° 30.1 118° 22.1 | 657 |
| Bourne Creek | 51° 23.5 118° 27.5 | 69 |
| Big Eddy Creek | 51° 19.5 118° 23.2 | 57 |
| Carnes Creek | 51° 18.1 118° 17.1 | 188 |
| Martha Creek | 51° 09.2 118° 12.0 | 13 |
| Columbia R. above Jordan | 51° 01.0 118° 13.3 | 26700[1] |

[1] From Water Survey Canada
[2] Estimated values in italics

# Appendix 3
# Tributary Data

## Appendix 3.1 Reference Tributaries

| | | Date | pH | Cond | NN | TN | SRP | TDP | TP | TP Turb | TPc1 | Turb | Alk 2 | T | Color |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | (µS/cm) | (ug/L) | (ug/L) | (ug/L) | (ug/L) | (ug/L) | (ug/L) | (ug/L) | (NTU) | (mgCaCO3/L) | (°C) | |
| Columbia at Donald | 1 | 06/24/2008 | 8.06 | 160 | 63.2 | NaN | 2.7 | 10.7 | 43.0 | 25.5 | 17.5 | 19.2 | 83 | 11.5 | B |
| Columbia at Donald | 1 | 05/12/2009 | 8.26 | 220 | 142.3 | NaN | 3.2 | 6 | 12.8 | 3.1 | 9.7 | 6.08 | 132 | 10.0 | TM |
| Columbia at Donald | 1 | 05/28/2009 | 8.14 | 156 | 191.9 | NaN | 4.6 | 6.4 | 9.7 | 3.7 | 6 | 28 | 100 | 12.0 | TB |
| Columbia at Donald | 1 | 06/09/2009 | 8.05 | 135 | 100.6 | NaN | 2.6 | 7.2 | 46.5 | NaN | NaN | 15.8 | 83 | 11.0 | TB |
| Columbia at Donald | 1 | 06/30/2009 | 7.78 | 135 | 48 | NaN | 2.5 | 6.8 | 18 | 3.4 | 14.6 | 3.8 | 79.2 | 14.0 | TB |
| Columbia at Donald | 1 | 07/07/2009 | 7.83 | 130 | 51.8 | NaN | 3.5 | 7.2 | 25.4 | 5.8 | 19.6 | 19.2 | 77 | 15.0 | MB |
| Columbia at Donald | 1 | 07/27/2009 | 7.97 | 112 | 44.3 | NaN | 2.3 | 6.1 | 68.3 | 41.6 | 26.7 | 59 | 75.6 | 17.5 | TM |
| Columbia at Donald | 1 | 08/10/2009 | 7.77 | 115 | 49.1 | NaN | 1.9 | 6.5 | 60.6 | 33.8 | 26.8 | 38.1 | 73 | 15.0 | TM |
| Columbia at Donald | 1 | 09/08/2009 | 7.83 | 127 | 60 | NaN | 1.7 | 6.3 | 28 | 17 | 11 | 29.6 | 78.4 | 11.0 | MB |
| Columbia at Donald | 1 | 10/06/2009 | 8 | 164 | 99.6 | NaN | 1.4 | NaN | 9.5 | 5.8 | 3.7 | 3.31 | 103.5 | 5.5 | C |
| Columbia at Donald | 1 | 11/02/2009 | 8.06 | 190 | 83.7 | NaN | 1.9 | 2.5 | 4.8 | 1.9 | 2.9 | 1.7 | 114.2 | 3.0 | C |
| Columbia at Donald | 1 | 05/03/2010 | 8.25 | 244 | 141.5 | NaN | 1.2 | 5.0 | 19.2 | 6.7 | 12.5 | 2.56 | 115 | 8.0 | MG |
| Columbia at Donald | 1 | 06/01/2010 | 8.19 | 197 | 147.1 | NaN | 1.6 | 4.5 | 15.3 | <0.1 | 15.2 | 3.35 | 93.4 | 9.0 | TGB |
| Columbia at Donald | 1 | 06/28/2010 | 8.08 | 151 | 59.7 | NaN | 2.3 | 9.8 | 28.7 | 12.3 | 16.4 | 11.55 | 77.5 | 12.0 | TB |
| Columbia at Donald | 1 | 07/06/2010 | 8.04 | 169 | 36.8 | NaN | 1.3 | 5.7 | 12.9 | 2.9 | 10.1 | 2.72 | 79.5 | 11.5 | TGB |
| Columbia at Donald | 1 | 07/27/2010 | 8.17 | 154 | 43.3 | NaN | 1.6 | 5.8 | 22.3 | 12.0 | 10.4 | 18.15 | 74 | 15.0 | M |
| Columbia at Donald | 1 | 08/09/2010 | 8.02 | 144 | 43.7 | NaN | 1.0 | 3.5 | 23.4 | 17.2 | 6.3 | 20.05 | 70.1 | 14.0 | TB |
| Columbia at Donald | 1 | 09/08/2010 | 8.09 | 195 | 74.0 | NaN | 2.0 | 3.6 | 13.7 | 7.1 | 6.6 | 10.59 | 95.5 | 10.5 | T |
| Columbia at Donald | 1 | 10/07/2010 | 8.02 | 182 | 74.9 | NaN | 2.2 | 7.5 | 17.8 | 9.0 | 8.7 | 12.45 | 91.5 | 7.5 | TGB |
| Columbia at Donald | 1 | 11/02/2010 | 8.10 | 227 | 85.1 | NaN | 1.8 | 3.5 | 7.9 | 3.8 | 4.1 | 2.11 | 113 | 4.0 | C |
| Columbia at Donald | 1 | 05/10/2011 | 8.26 | 218 | 85.9 | NaN | 5.3 | 8.1 | 84.5 | 65.5 | 19.0 | 52.5 | 145 | 9.5 | TB |
| Columbia at Donald | 1 | 05/31/2011 | 8.14 | 141 | 171.4 | NaN | 1.6 | 5.6 | 43.3 | 17.7 | 25.6 | 31.0 | 102 | 9.0 | TB |
| Columbia at Donald | 1 | 06/06/2011 | 8.19 | 139 | 135.0 | NaN | 2.1 | 5.4 | 107.1 | 73.5 | 33.6 | 45.0 | 106 | 11.0 | TB |
| Columbia at Donald | 1 | 06/27/2011 | 8.01 | 122 | 32.1 | NaN | 2.1 | 6.5 | 28.5 | 3.5 | 25.1 | 13.5 | 86 | 13.0 | TB |
| Columbia at Donald | 1 | 07/25/2011 | 8.04 | 108 | 25.0 | NaN | 1.5 | 4.4 | 13.1 | 3.5 | 9.6 | 15.0 | 78.6 | 15.0 | TB |
| Columbia at Donald | 1 | 08/17/2011 | 7.93 | 163 | 46.2 | NaN | 2.1 | 10.6 | 29.4 | 9.7 | 19.7 | 17.5 | 79.5 | 11.0 | TB |
| Columbia at Donald | 1 | 09/07/2011 | 8.12 | 195 | 60.0 | NaN | 1.3 | 4.8 | 34.4 | 8.7 | 25.6 | 9.8 | 95.5 | 11.0 | TB |
| Columbia at Donald | 1 | 10/19/2011 | 8.12 | 231 | 82.3 | NaN | 2.0 | 3.5 | 11.9 | ** | NaN | 5.9 | 108.5 | 4.0 | TB |
| Columbia at Donald | 1 | 05/15/2012 | 8.14 | 243 | 143.0 | NaN | 3.2 | 8.6 | 58.7 | 16.4 | 42.3 | 39.0 | 125.5 | 10.0 | M |
| Columbia at Donald | 1 | 05/29/2012 | 8.21 | 213 | 134.0 | NaN | 4.6 | 6.9 | 22.4 | 2.3 | 20.0 | 12.5 | 112.5 | 10.0 | TB |
| Columbia at Donald | 1 | 06/05/2012 | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | n/a |
| Columbia at Donald | 1 | 06/27/2012 | 8.13 | 171 | 38.0 | NaN | 3.6 | 5.2 | 61.8 | 21.5 | 40.3 | 55.0 | 112.2 | 10.5 | TB |
| Columbia at Donald | 1 | 07/10/2012 | 8.11 | 162 | 29.3 | NaN | 2.1 | 8.1 | 58.1 | 23.8 | 34.3 | 110.0 | 114.9 | 14.0 | TB |
| Columbia at Donald | 1 | 07/31/2012 | 8.07 | 150 | 28.9 | NaN | 1.9 | 4.0 | 31.3 | 17.6 | 13.7 | 29.1 | 87.9 | 15.0 | TB |
| Columbia at Donald | 1 | 08/28/2012 | 8.14 | 160 | 19.3 | NaN | 3.1 | 5.0 | 12.5 | 6.3 | 6.1 | 14.0 | 90.7 | 13.0 | LTB |
| Columbia at Donald | 1 | 09/25/2012 | 8.19 | 188 | 59.4 | NaN | 3.4 | 7.4 | 30.5 | 23.0 | 7.4 | 56.6 | 108.5 | 10.0 | TB |
| Columbia at Donald | 1 | 10/22/2012 | 8.19 | 206 | 62.1 | NaN | 1.3 | 9.0 | 9.0 | 1.6 | 7.4 | 3.18 | 109 | 4.0 | C |
| Columbia at Donald | 1 | 11/20/2012 | 8.09 | 236 | 90.2 | NaN | 1.6 | 2.8 | 6.6 | 1.7 | 4.9 | 2.78 | 124 | 1.0 | C |
| Columbia at Donald | 1 | 04/16/2013 | 8.23 | 344 | 99.8 | NaN | 1.1 | 2.3 | 4.7 | NaN | NaN | 2.6 | 145 | 5.0 | GC |
| Columbia at Donald | 1 | 05/09/2013 | 8.22 | 258 | 226 | NaN | 2.2 | <2.00 | 14.4 | NaN | NaN | 45.2 | 114 | 10.0 | B |
| Columbia at Donald | 1 | 05/28/2013 | 8.11 | 221 | 124 | NaN | 1.0 | <2.00 | 14.4 | NaN | NaN | 5.46 | 94 | 10.0 | MG |
| Columbia at Donald | 1 | 06/04/2013 | 8.02 | 222 | 105 | NaN | 4.9 | 8.7 | 12.4 | NaN | NaN | 8.49 | 95.8 | 11.0 | GB |
| Columbia at Donald | 1 | 06/24/2013 | 7.92 | 186 | 45.3 | NaN | 4.4 | 2.1 | 58.3 | NaN | NaN | 28.4 | 79.7 | 13.0 | B |
| Columbia at Donald | 1 | 07/09/2013 | 7.99 | 179 | 18.5 | NaN | <1.00 | <2.00 | 22.5 | NaN | NaN | 19.7 | 77.8 | 15.0 | B |
| Columbia at Donald | 1 | 08/07/2013 | 8.03 | 174 | 42.5 | NaN | 6.8 | 7.4 | 47.6 | NaN | NaN | 44 | 74.6 | 14.0 | MB |
| Columbia at Donald | 1 | 09/10/2013 | 7.88 | 176 | 62.9 | NaN | <1.00 | 45.7 | 48.8 | NaN | NaN | 0.13 | 71.1 | 12.0 | B |

| | | Date | pH | Cond | NN | TN | SRP | TDP | TP | TP Turb | TPc1 | Turb | Alk 2 | T | Color |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | (µS/cm) | (ug/L) | (ug/L) | (ug/L) | (ug/L) | (ug/L) | (ug/L) | (ug/L) | (NTU) | (mgCaCO3/L) | (°C) | |
| Columbia at Donald | 1 | 10/01/2013 | 8.16 | 245 | 68.5 | NaN | 2.3 | <2.00 | 6.9 | NaN | NaN | 11.1 | 97.8 | 8.0 | B |
| Columbia at Donald | 1 | 11/04/2013 | 8.15 | 282 | 86.8 | NaN | 1.2 | <2.00 | 2.4 | NaN | NaN | 1.74 | 112 | 1.5 | C |
| Columbia at Donald | 1 | 05/27/2014 | 8.08 | 201 | 206.0 | NaN | 4.9 | <2.00 | 60.5 | NaN | NaN | 46.1 | 87.9 | 8.0 | B |
| Columbia at Donald | 1 | 06/10/2014 | 8.15 | 203 | 97.6 | NaN | <1.00 | 3.5* | 2.6 | NaN | NaN | 29.8 | 87.3 | 10.0 | B |
| Columbia at Donald | 1 | 07/09/2014 | 7.96 | 172 | 29.9 | NaN | 2.6 | <2.00 | 22.3 | NaN | NaN | 11.6 | 72.0 | 15.0 | B |
| Columbia at Donald | 1 | 08/05/2014 | 8.06 | 176 | 45.8 | NaN | <1.00 | 3.6 | 16.7 | NaN | NaN | 9.3 | 72.0 | 14.0 | B |
| Columbia at Donald | 1 | 09/03/2014 | 8.04 | 202 | 62.9 | NaN | 6.2 | <2.00 | 9.5 | NaN | NaN | 13.4 | 78.5 | 10.0 | MG |
| Columbia at Donald | 1 | 10/06/2014 | 8.04 | 242 | 78.2 | NaN | 2.8 | <2.00 | 3.0 | NaN | NaN | 2.89 | 93.8 | 7.0 | GC |
| Columbia at Donald | 1 | 03/25/2015 | 8.15 | 328 | 117.0 | NaN | 1.4 | <2.00 | 4.4 | NaN | NaN | 1.91 | 136.0 | 3.0 | MG |
| Columbia at Donald | 1 | 04/08/2015 | 8.15 | 329 | 128.0 | NaN | <1.00 | 5.0 | 7.7 | NaN | NaN | 1.33 | 131.0 | 3.5 | GC |
| Columbia at Donald | 1 | 04/23/2015 | 8.24 | 319 | 133.0 | NaN | 1.7 | <2.00 | 3.4 | NaN | NaN | 2.43 | 135.0 | 8.0 | GC |
| Columbia at Donald | 1 | 05/07/2015 | 8.16 | 277 | 185.0 | NaN | <1.00 | <2.00 | 4.2 | NaN | NaN | 2.01 | 112.0 | 8.5 | GB |
| Columbia at Donald | 1 | 05/26/2015 | 8.03 | 187 | 167.0 | NaN | 1.3 | <2.00 | 8.8 | NaN | NaN | 28.9 | 80.9 | 9.0 | B |
| Columbia at Donald | 1 | 06/09/2015 | 7.92 | 181 | 56.6 | NaN | <1.00 | <2.00 | 17.1 | NaN | NaN | 66.2 | 76.1 | 12.0 | B |
| Columbia at Donald | 1 | 07/07/2015 | 7.98 | 171 | 44.0 | NaN | <1.00 | 2.0 | 9.5 | NaN | NaN | 15.4 | 68.7 | 15.5 | B |
| Columbia at Donald | 1 | 07/28/2015 | 7.93 | 165 | 38.3 | NaN | <1.00 | <2.00 | 10.0 | NaN | NaN | 16.9 | 66.6 | 12.0 | GB |
| Columbia at Donald | 1 | 08/11/2015 | 8.01 | 176 | 50.9 | NaN | 1.6 | <2.00 | 11.2 | NaN | NaN | 21.1 | 72.0 | 14.5 | GB |
| Columbia at Donald | 1 | 09/08/2015 | 8.10 | 229 | 85.2 | NaN | 1.2 | 3.3 | 6.3 | NaN | NaN | 5.39 | 87.9 | 7.0 | MG |
| Columbia at Donald | 1 | 10/06/2015 | 8.09 | 248 | 89.3 | NaN | 1.7 | 2.2 | 3.4 | NaN | NaN | 4.35 | 93.9 | 7.0 | M |
| Columbia at Donald | 1 | 11/03/2015 | 8.17 | 272 | 106.0 | NaN | 1.9 | <2.00 | 2.3 | NaN | NaN | 2.05 | 108.0 | 3.0 | GC |
| Columbia at Donald | 1 | 12/07/2015 | 8.26 | 305 | 141.0 | NaN | 7.0 | <2.00 | 2.9 | NaN | NaN | 2.37 | 128.0 | -1.0 | C 3/4F |
| Columbia at Donald | 1 | 03/22/2016 | 8.22 | 359 | 113 | NaN | 2.5 | <2.0 | <2.0 | NaN | NaN | 2.52 | 146.0 | 3.5 | C |
| Columbia at Donald | 1 | 04/05/2016 | 8.26 | 347 | 122 | NaN | 1.4 | 2.0 | 11.4 | NaN | NaN | 16.10 | 108.0 | 5.5 | MG |
| Columbia at Donald | 1 | 04/26/2016 | 8.16 | 222 | 246 | 342 | 5.3 | <2.0 | 26.9 | NaN | NaN | 16.80 | 99.6 | 7.5 | 8i |
| Columbia at Donald | 1 | 05/10/2016 | 8.15 | 201 | 165 | 258 | 4.5 | 2.3 | 22.7 | NaN | NaN | 6.87 | 86.7 | 8 | TB |
| Columbia at Donald | 1 | 05/25/2016 | 8.17 | 204 | 223 | 246 | 3.9 | <2.0 | 20.5 | NaN | NaN | 17.80 | 87.2 | 12 | GB |
| Columbia at Donald | 1 | 06/07/2016 | 8.11 | 187 | 77.6 | 167 | <1.0 | <2.0 | 39.1 | NaN | NaN | 34.80 | 80.4 | 13 | MB |
| Columbia at Donald | 1 | 06/28/2016 | 8.14 | 192 | 69.5 | 121 | 4.4 | <2.0 | 11.7 | NaN | NaN | 11.00 | 77.7 | 13 | MG |
| Columbia at Donald | 1 | 07/26/2016 | 8.15 | 189 | 55.1 | 108 | 2.9 | 2.4 | 44.9 | NaN | NaN | 14.90 | 73.3 | 15 | TB |
| Columbia at Donald | 1 | 08/10/2016 | 8.08 | 190 | 57 | 228 | <1.0 | 3.2 | 18.8 | NaN | NaN | 6.48 | 74.0 | 14 | MG |
| Columbia at Donald | 1 | 09/06/2016 | 8.10 | 220 | 70.6 | 232 | <1.0 | <2.0 | 15.6 | NaN | NaN | 5.30 | 83.4 | 12 | M |
| Columbia at Donald | 1 | 10/04/2016 | 8.16 | 244 | 78.9 | 201 | 4.9 | <2.0 | 8.2 | NaN | NaN | 5.83 | 91.8 | 7 | M |
| Columbia at Donald | 1 | 11/08/2016 | 8.06 | 288 | 117 | 244 | 2.3 | 2.1 | 5.7 | NaN | NaN | 2.66 | 116.0 | 3.5 | C |
| Columbia at Donald | 1 | 12/05/2016 | 8.09 | 302 | 143 | 249 | <1.0 | <2.0 | 4.7 | NaN | NaN | 3.05 | 127.0 | -1 | C/I |
| Columbia at Donald | 1 | 04/03/2017 | 8.23 | 341 | 129 | 333 | 4.2 | 4.4 | 15.1 | NaN | NaN | 4.87 | 142 | 4.00 | GB |
| Columbia at Donald | 1 | 04/18/2017 | 8.42 | 366 | 103 | 193 | 2.1 | 3.3 | 10.9 | NaN | NaN | 2.91 | 161 | 6.50 | GB |
| Columbia at Donald | 1 | 05/08/2017 | 8.21 | 265 | 264 | 637 | 1.4 | 5.5 | 30.0 | NaN | NaN | 39.7 | 123 | 6.50 | BT |
| Columbia at Donald | 1 | 05/29/2017 | 8.16 | 211 | 192 | 295 | 2.5 | 2.6 | 55.9 | NaN | NaN | 60.9 | 94.5 | 11.00 | BT |
| Columbia at Donald | 1 | 06/13/2017 | 8.16 | 192 | 42.8 | 140 | 3.3 | 7.9 | 10.5 | NaN | NaN | 26.6 | 82.8 | 14.00 | GB |
| Columbia at Donald | 1 | 06/26/2017 | 8.17 | 199 | 37.6 | 103 | <1.00 | 3.3 | 22.8 | NaN | NaN | 10.5 | 83.8 | 13.00 | MGT |
| Columbia at Donald | 1 | 07/26/2017 | 8.17 | 184 | 50.3 | 160 | 1.5 | 4.7 | 17.2 | NaN | NaN | 11.3 | 75.2 | 14.00 | GB |
| Columbia at Donald | 1 | 08/09/2017 | 8.12 | 184 | 41.6 | 68 | 6.6 | 2.1 | 22.3 | NaN | NaN | 14.2 | 74.2 | 15.00 | BT |
| Columbia at Donald | 1 | 09/06/2017 | 8.06 | 161 | 42.7 | 148 | 19.0 | 4.4 | 28.7 | NaN | NaN | 35.1 | 67.6 | 12.00 | MT |
| Columbia at Donald | 1 | 10/03/2017 | 8.23 | 269 | 80.7 | 157 | 2.8 | <2.00 | 17.2 | NaN | NaN | 3.46 | 112 | 7.00 | G |
| Columbia at Donald | 1 | 11/07/2017 | 8.27 | 327 | 115 | 256 | 3.2 | 6.6 | 9.2 | NaN | NaN | 2.55 | 134 | -1.00 | C |
| Columbia at Donald | 1 | 12/05/2017 | 8.21 | 313 | 119 | 172 | 1.9 | 3.3 | 4.1 | NaN | NaN | 2.48 | 124 | -1.00 | C |
| Columbia at Mica Outflow | 2 | 06/24/2008 | 7.80 | 108 | 114.0 | NaN | 2.9 | 5.8 | 8.7 | 0.9 | 7.8 | 0.74 | 52 | 7.0 | n/a |

| | | Date | pH | Cond | NN | TN | SRP | TDP | TP | TP Turb | TPc1 | Turb | Alk 2 | T | Color |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | (µS/cm) | (ug/L) | (ug/L) | (ug/L) | (ug/L) | (ug/L) | (ug/L) | (ug/L) | (NTU) | (mgCaCO3/L) | (°C) | |
| Columbia at Mica Outflow | 2 | 05/11/2009 | 7.83 | 108 | 183.2 | NaN | 4.8 | 6.1* | 5.9 | 0.1 | 5.9 | 0.77 | 58 | 3.5 | C |
| Columbia at Mica Outflow | 2 | 05/25/2009 | 7.87 | 92 | 166.9 | NaN | 4.3 | 8.1 | 9.8 | 0.1 | 9.8 | 1.02 | 55 | 7.0 | C |
| Columbia at Mica Outflow | 2 | 06/08/2009 | 7.38 | 44 | 194.6 | NaN | 3.2 | 5.2 | 6.2 | 0.1 | 6.2 | 1.62 | 22 | 6.0 | TB |
| Columbia at Mica Outflow | 2 | 06/29/2009 | 7.32 | 81 | 113.6 | NaN | 1.9 | 3.6 | 4.5 | 0.1 | 4.5 | 0.25 | 48.1 | 9.0 | C |
| Columbia at Mica Outflow | 2 | 07/08/2009 | 7.37 | 72 | 95.1 | NaN | 1.5 | 3.5 | 5.7 | 0.1 | 5.7 | 0.42 | 44 | NaN | n/a |
| Columbia at Mica Outflow | 2 | 07/28/2009 | 7.7 | 108 | 103.3 | NaN | 2 | 5.1 | 5.4 | 0.1 | 5.4 | 0.29 | 71 | 7.0 | C |
| Columbia at Mica Outflow | 2 | 08/11/2009 | 7.5 | 107 | 123.6 | NaN | 1.5 | 5.5 | 7.1 | 0.1 | 7.1 | 0.42 | 70 | 7.0 | C |
| Columbia at Mica Outflow | 2 | 09/09/2009 | 7.63 | 108 | 130.7 | NaN | 1.3 | NaN | 5.1 | 0.1 | 5.1 | 0.48 | 70 | 6.0 | C |
| Columbia at Mica Outflow | 2 | 10/05/2009 | 7.71 | 103 | 112.5 | NaN | 0.9 | 4* | 3.7 | 0.3 | 3.4 | 0.62 | 65.9 | 6.5 | C |
| Columbia at Mica Outflow | 2 | 11/03/2009 | 7.78 | 97 | 131.3 | NaN | 1.9 | 1.3 | 2.1 | 0.1 | 2.1 | 0.88 | 62 | 6.5 | C |
| Columbia at Mica Outflow | 2 | 05/04/2010 | 7.94 | 142 | 103.0 | NaN | 1.3 | 3.2 | 3.7 | <0.1 | 3.6 | 0.15 | 69 | 3.5 | C |
| Columbia at Mica Outflow | 2 | 05/31/2010 | 7.85 | 98 | 168.6 | NaN | 1.1 | 2.1 | 4.2 | <0.1 | 4.1 | 0.27 | 44.1 | 6.5 | C |
| Columbia at Mica Outflow | 2 | 06/29/2010 | 7.31 | 44 | 113.6 | NaN | 1.4 | 5.0 | 5.6 | 1.4 | 4.2 | 0.75 | 17.7 | 7.0 | T |
| Columbia at Mica Outflow | 2 | 07/05/2010 | 7.42 | 56 | 99.5 | NaN | 5.3 | ** | 5.7 | <0.1 | 5.6 | 0.57 | 23 | 9.5 | C |
| Columbia at Mica Outflow | 2 | 07/26/2010 | 7.44 | 48 | 61.8 | NaN | 2.1 | 3.8 | 5.7 | 1.7 | 4.1 | 1.71 | 20 | 15.5 | C |
| Columbia at Mica Outflow | 2 | 08/09/2010 | 7.33 | 60 | 67.5 | NaN | 1.8 | 4.1 | 5.1 | 0.8 | 4.3 | 3.30 | 26.4 | 13.0 | C |
| Columbia at Mica Outflow | 2 | 09/07/2010 | 7.75 | 128 | 122.2 | NaN | 2.8 | 3.2 | 4.0 | <0.1 | 3.9 | 0.86 | 64.7 | 7.5 | C |
| Columbia at Mica Outflow | 2 | 10/05/2010 | 7.79 | 126 | 123.7 | NaN | 2.2 | 5.0 | 5.2 | <0.1 | 5.1 | 0.35 | 64 | 7.0 | C |
| Columbia at Mica Outflow | 2 | 11/01/2010 | 7.73 | 116 | 99.0 | NaN | 0.9 | 3.1 | 3.1 | <0.1 | 3.0 | 0.78 | 60 | 7.0 | C |
| Columbia at Mica Outflow | 2 | 05/09/2011 | 7.75 | 98 | 135.0 | NaN | 1.7 | 3.9 | 4.8 | <0.1 | 4.7 | 1.00 | 60.9 | 4.0 | C |
| Columbia at Mica Outflow | 2 | 05/30/2011 | 7.58 | 45 | 283.9 | NaN | 2.1 | 3.0 | 7.5 | 2.4 | 5.1 | 2.30 | 26 | 5.0 | TLB |
| Columbia at Mica Outflow | 2 | 06/06/2011 | 7.39 | 34 | 218.6 | NaN | 1.3 | 3.0 | 12.9 | 4.2 | 8.7 | 7.10 | 20 | 7.0 | TSM |
| Columbia at Mica Outflow | 2 | 06/28/2011 | 7.43 | 37 | 125.2 | NaN | 4.0 | 3.7 | 6.2 | <0.1 | 6.1 | 1.70 | 22.2 | 7.5 | C |
| Columbia at Mica Outflow | 2 | 07/26/2011 | 7.92 | 89 | 123.3 | NaN | 1.7 | 2.7 | 4.0 | 0.5 | 3.5 | 1.30 | 61.4 | 7.5 | C |
| Columbia at Mica Outflow | 2 | 08/17/2011 | 7.78 | 134 | 129.5 | NaN | 1.7 | 3.9 | 6.9 | 0.4 | 6.5 | 0.80 | 66 | 7.5 | C |
| Columbia at Mica Outflow | 2 | 09/07/2011 | 7.86 | 129 | 125.1 | NaN | 1.2 | 3.7* | 3.1 | ** | NaN | 0.88 | 63.5 | 6.0 | C |
| Columbia at Mica Outflow | 2 | 10/19/2011 | 7.83 | 130 | 113.1 | NaN | 1.3 | 1.7 | 3.4 | <0.1 | 3.3 | 0.75 | 63 | 7.5 | C |
| Columbia at Mica Outflow | 2 | 05/14/2012 | 7.28 | 85 | 213.9 | NaN | 2.9 | 5.7 | 7.2 | 1.1 | 6.1 | 1.20 | 37.3 | 4.0 | C |
| Columbia at Mica Outflow | 2 | 05/28/2012 | 7.96 | 133 | 98.9 | NaN | 3.7 | 5.2 | 7.3 | 1.0 | 6.3 | 0.10 | 53.65 | 5.0 | C |
| Columbia at Mica Outflow | 2 | 06/05/2012 | 7.43 | 72 | 195.5 | NaN | 4.2 | 4.8 | 9.9 | 1.9 | 8.0 | 0.75 | 33.25 | 5.5 | TB |
| Columbia at Mica Outflow | 2 | 06/26/2012 | 7.21 | 40 | 134.6 | NaN | 1.8 | 3.0 | 12.0 | 5.2 | 6.8 | 1.90 | 17.5 | 6.5 | TB |
| Columbia at Mica Outflow | 2 | 07/09/2012 | 7.05 | 27 | 93.5 | NaN | 1.6 | 3.3 | 9.6 | 2.3 | 7.3 | 3.90 | 11.1 | 7.0 | TB |
| Columbia at Mica Outflow | 2 | 07/30/2012 | 7.98 | 117 | 116.5 | NaN | 1.6 | 2.5 | 4.3 | <0.1 | 4.2 | 0.37 | 64.5 | 9.5 | C |
| Columbia at Mica Outflow | 2 | 08/27/2012 | 8.04 | 119 | 113.5 | NaN | 3.4 | 3.8 | 4.6 | 1.9 | 2.7 | 0.98 | 67.7 | 9.0 | C |
| Columbia at Mica Outflow | 2 | 09/24/2012 | 7.99 | 119 | 114.9 | NaN | 2.3 | 4.4 | 4.8 | <0.1 | 4.7 | 0.81 | 64.2 | 8.0 | C |
| Columbia at Mica Outflow | 2 | 10/23/2012 | 8.04 | 114 | 73.5 | NaN | 1.2 | 6.5* | 5.5 | <0.1 | 5.4 | 0.69 | 61.3 | 9.0 | C |
| Columbia at Mica Outflow | 2 | 11/19/2012 | 7.75 | 109 | 83.5 | NaN | 1.3 | 2.8 | 3.8 | <0.1 | 3.7 | 0.24 | 60.2 | 7.0 | C |
| Columbia at Mica Outflow | 2 | 04/15/2013 | 7.98 | 151 | 108 | NaN | <1.00 | 2.0 | 2.9 | NaN | NaN | 0.4 | 66 | 3.0 | C |
| Columbia at Mica Outflow | 2 | 05/08/2013 | 7.77 | 95.9 | 294 | NaN | 1.8 | 2.1 | 6.1 | NaN | NaN | 2.03 | 40.2 | 4.0 | LB |
| Columbia at Mica Outflow | 2 | 05/27/2013 | 7.99 | 151 | 103 | NaN | <1.00 | 2.4* | <2.00 | NaN | NaN | 0.27 | 62.9 | 5.0 | C |
| Columbia at Mica Outflow | 2 | 06/03/2013 | 7.9 | 144 | 116 | NaN | 1.3 | <2.00 | 2.6 | NaN | NaN | 0.3 | 59.6 | 6.0 | C |
| Columbia at Mica Outflow | 2 | 06/25/2013 | 7.5 | 79.4 | 111 | NaN | <1.00 | <2.00 | <2.00 | NaN | NaN | 1.54 | 29 | 7.0 | C |
| Columbia at Mica Outflow | 2 | 07/08/2013 | 7.78 | 99 | 109 | NaN | 1.4 | <2.00 | <2.00 | NaN | NaN | 1.17 | 39.4 | 7.0 | C |
| Columbia at Mica Outflow | 2 | 08/06/2013 | 7.94 | 152 | 132 | NaN | 1.0 | 11.7 | 17.5 | NaN | NaN | 0.51 | 66.4 | 8.0 | C |
| Columbia at Mica Outflow | 2 | 09/10/2013 | 7.84 | 147 | 122 | NaN | <1.00 | <2.00 | <2.00 | NaN | NaN | 0.12 | 62.8 | 9.0 | C |
| Columbia at Mica Outflow | 2 | 09/30/2013 | 8.04 | 147 | 115 | NaN | 1.2 | <2.00 | <2.00 | NaN | NaN | 0.65 | 62.8 | 8.0 | C |
| Columbia at Mica Outflow | 2 | 11/05/2013 | 7.92 | 143 | 109 | NaN | <1.00 | <2.00 | <2.00 | NaN | NaN | 0.44 | 58.9 | 8.0 | C |

| | | Date | pH | Cond | NN | TN | SRP | TDP | TP | TP Turb | TPc1 | Turb | Alk 2 | T | Color |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | (µS/cm) | (ug/L) | (ug/L) | (ug/L) | (ug/L) | (ug/L) | (ug/L) | (ug/L) | (NTU) | (mgCaCO3/L) | (°C) | |
| Columbia at Mica Outflow | 2 | 05/26/2014 | 7.51 | 58 | 319.0 | NaN | 4.9 | <2.00 | 7.4 | NaN | NaN | 2.43 | 17.2 | 4.0 | C |
| Columbia at Mica Outflow | 2 | 06/09/2014 | 7.53 | 54 | 185.0 | NaN | 1.6 | <2.00 | <2.00 | NaN | NaN | 2.02 | 16.7 | 5.0 | LB |
| Columbia at Mica Outflow | 2 | 07/08/2014 | 7.61 | 65 | 107.0 | NaN | 1.5 | <2.00 | 4.2 | NaN | NaN | 1.38 | 25.5 | 12.0 | C |
| Columbia at Mica Outflow | 2 | 08/06/2014 | 8.01 | 151 | 128.0 | NaN | <1.00 | 3.8 | 4.2 | NaN | NaN | 0.42 | 63.8 | 6.0 | C |
| Columbia at Mica Outflow | 2 | 09/02/2014 | 7.94 | 158 | 128.0 | NaN | <1.00 | <2.00 | 2.6 | NaN | NaN | 0.38 | 64.0 | 6.0 | C |
| Columbia at Mica Outflow | 2 | 10/07/2014 | 7.93 | 150 | 212.0 | NaN | <1.00 | <2.00 | <2.00 | NaN | NaN | 0.59 | 63.1 | 7.0 | C |
| Columbia at Mica Outflow | 2 | 03/25/2015 | 7.98 | 153.0 | 107.0 | NaN | <1.00 | <2.00 | <2.00 | NaN | NaN | 0.20 | 63.0 | 2.5 | C |
| Columbia at Mica Outflow | 2 | 04/07/2015 | 7.86 | 153.0 | 106.0 | NaN | <1.00 | <2.00 | <2.00 | NaN | NaN | 0.25 | 60.9 | 2.0 | C |
| Columbia at Mica Outflow | 2 | 04/22/2015 | 8.01 | 154.0 | 111.0 | NaN | 1.3 | <2.00 | 6.4 | NaN | NaN | 0.16 | 63.7 | 3.0 | C |
| Columbia at Mica Outflow | 2 | 05/06/2015 | 7.92 | 154.0 | 99.8 | NaN | <1.00 | <2.00 | <2.00 | NaN | NaN | 0.16 | 63.1 | 3.5 | C |
| Columbia at Mica Outflow | 2 | 05/25/2015 | 7.55 | 65.3 | 205.0 | NaN | 1.1 | 2.0 | 2.7 | NaN | NaN | 1.56 | 22.5 | 5.0 | C |
| Columbia at Mica Outflow | 2 | 06/08/2015 | 7.84 | 153 | 114.0 | NaN | <1.00 | <2.00 | <2.00 | NaN | NaN | 0.24 | 63.3 | 4.5 | LB |
| Columbia at Mica Outflow | 2 | 07/06/2015 | 7.93 | 154 | 120.0 | NaN | <1.00 | <2.00 | <2.00 | NaN | NaN | 0.36 | 64.1 | 5.0 | C |
| Columbia at Mica Outflow | 2 | 07/27/2015 | 7.91 | 149 | 92.9 | NaN | <1.00 | <2.00 | 2.5 | NaN | NaN | 0.75 | 60.9 | 7.0 | C |
| Columbia at Mica Outflow | 2 | 08/10/2015 | 7.99 | 156 | 122.0 | NaN | 2.3 | <2.00 | 2.5 | NaN | NaN | 0.88 | 67.1 | 8.0 | C |
| Columbia at Mica Outflow | 2 | 09/08/2015 | 7.96 | 140 | 115.0 | NaN | 1.8 | 2.0 | 3.1 | NaN | NaN | 0.72 | 57.4 | 9.5 | C |
| Columbia at Mica Outflow | 2 | 10/05/2015 | 7.82 | 148 | 102.0 | NaN | 7.2 | 2.1 | 2.3 | NaN | NaN | 0.49 | 58.0 | 8.5 | C |
| Columbia at Mica Outflow | 2 | 11/02/2015 | 8.03 | 144 | 97.6 | NaN | 2.7 | <2.00 | <2.00 | NaN | NaN | 0.81 | 59.6 | 8.5 | C |
| Columbia at Mica Outflow | 2 | 12/08/2015 | 7.94 | 149 | 107.0 | NaN | <1.00 | <2.00 | 2.1 | NaN | NaN | 0.29 | 62.6 | 4.0 | C |
| Columbia at Mica Outflow | 2 | 03/21/2016 | 7.87 | 148 | 99.3 | NaN | 1.8 | <2.0 | <2.0 | NaN | NaN | 0.29 | 62.5 | 2.5 | C |
| Columbia at Mica Outflow | 2 | 04/04/2016 | 7.91 | 143 | 147 | NaN | <1.0 | <2.0 | 6.0 | NaN | NaN | 0.68 | 59.3 | 2.5 | C |
| Columbia at Mica Outflow | 2 | 04/25/2016 | 7.64 | 70.7 | 322 | 344 | <1.0 | 4.6 | 2.8 | NaN | NaN | 0.80 | 25.7 | 3.5 | C |
| Columbia at Mica Outflow | 2 | 05/09/2016 | 7.44 | 56.2 | 259 | 297 | 1.9 | <2.0 | 3.8 | NaN | NaN | 1.03 | 16.7 | 4 | C |
| Columbia at Mica Outflow | 2 | 05/24/2016 | 7.65 | 66.2 | 173 | 268 | <1.0 | <2.0 | 3.5 | NaN | NaN | 1.39 | 24.0 | 7 | C |
| Columbia at Mica Outflow | 2 | 06/06/2016 | 7.89 | 110 | 116 | 154 | <1.0 | <2.0 | 4.0 | NaN | NaN | 2.01 | 45.1 | 6 | C |
| Columbia at Mica Outflow | 2 | 06/27/2016 | 8.03 | 147 | 119 | 156 | <1.0 | <2.0 | 3.1 | NaN | NaN | 0.33 | 61.5 | 6 | C |
| Columbia at Mica Outflow | 2 | 07/25/2016 | 8.03 | 150 | 123 | 176 | 1.7 | 2.3 | 3.8 | NaN | NaN | 0.33 | 59.9 | 7 | C |
| Columbia at Mica Outflow | 2 | 08/09/2016 | 8.04 | 160 | 123 | 201 | 4.2 | 2.5 | 3.0 | NaN | NaN | 0.35 | 66.5 | 6.5 | C |
| Columbia at Mica Outflow | 2 | 09/07/2016 | 7.98 | 160 | 127 | 535 | 1.6 | 2.4 | 2.4 | NaN | NaN | 0.41 | 63.9 | 7.5 | C |
| Columbia at Mica Outflow | 2 | 10/03/2016 | 8.02 | 157 | 129 | 280 | <1.0 | 2.4 | 3.4 | NaN | NaN | 0.60 | 62.8 | 8 | C |
| Columbia at Mica Outflow | 2 | 11/07/2016 | 7.82 | 147 | 112 | 178 | <1.0 | 2.2 | <2.0 | NaN | NaN | 0.54 | 61.3 | 8.5 | C |
| Columbia at Mica Outflow | 2 | 12/06/2016 | 7.79 | 147 | 95.4 | 167 | <1.0 | <2.0 | <2.0 | NaN | NaN | 0.34 | 61.8 | 5 | C |
| Columbia at Mica Outflow | 2 | 03/21/2017 | 8.01 | 165 | 113 | 216 | <1.00 | 2.0 | <2.00 | NaN | NaN | 0.44 | 66.50 | 1.00 | C100 |
| Columbia at Mica Outflow | 2 | 04/04/2017 | 7.94 | 169 | 120 | 165 | <1.00 | 2.3 | 2.6 | NaN | NaN | 0.2 | 68.90 | 2.00 | C |
| Columbia at Mica Outflow | 2 | 04/26/2017 | 8.17 | 170 | 105 | 203 | <1.00 | <2.00 | 2.2 | NaN | NaN | 0.37 | 70.50 | 2.50 | C |
| Columbia at Mica Outflow | 2 | 05/09/2017 | 8.04 | 175 | 123 | 317 | <1.00 | 3.4 | 3.9 | NaN | NaN | 6.45 | 74.50 | 3.00 | C |
| Columbia at Mica Outflow | 2 | 05/30/2017 | 7.59 | 61.3 | 221 | 261 | 1.8 | 2.7 | 16.7 | NaN | NaN | 5.78 | 22.90 | 5.00 | BT |
| Columbia at Mica Outflow | 2 | 06/14/2017 | 7.67 | 65.7 | 155 | 233 | 2.6 | 2.6 | 30.8 | NaN | NaN | 1.6 | 24.20 | 6.00 | C |
| Columbia at Mica Outflow | 2 | 06/27/2017 | 7.87 | 100 | 110 | 129 | <1.00 | <2.00 | 7.9 | NaN | NaN | 3.16 | 41.10 | 5.00 | C |
| Columbia at Mica Outflow | 2 | 07/25/2017 | 8.14 | 165 | 138 | 217 | 1.1 | 4.6 | 3.4 | NaN | NaN | 0.42 | 70.10 | 7.00 | C |
| Columbia at Mica Outflow | 2 | 08/08/2017 | 8.04 | 161 | 132 | 300 | <1.00 | 2.9 | 2.9 | NaN | NaN | 0.82 | 68.70 | 8.50 | C |
| Columbia at Mica Outflow | 2 | 09/05/2017 | 8.06 | 157 | 135 | 312 | <1.00 | 3.4 | 4.0 | NaN | NaN | 1.01 | 66.40 | 8.00 | C |
| Columbia at Mica Outflow | 2 | 10/02/2017 | 7.88 | 156 | 109 | 134 | 1.2 | <2.00 | 3.3 | NaN | NaN | 0.6 | 65.70 | 9.00 | C |
| Columbia at Mica Outflow | 2 | 11/06/2017 | 7.90 | 148 | 103 | 157 | 2.1 | 2.4 | 3.1 | NaN | NaN | 0.3 | 63.60 | 7.50 | C |
| Columbia at Mica Outflow | 2 | 12/04/2017 | 7.97 | 153 | 103 | 183 | 1.9 | 4.7 | 2.1 | NaN | NaN | 0.25 | 65.00 | 5.00 | C |
| Goldstream River | 3 | 06/24/2008 | 7.73 | 75 | 1172.5 | NaN | 2.0 | 18.3 | 22.9 | 2.2 | 20.7 | 1.01 | 38 | 9.5 | n/a |
| Goldstream River | 3 | 08/05/2008 | 7.69 | 78 | 71.8 | NaN | 2.1 | 0.0 | 20.8 | 7.5 | 13.3 | 2.71 | 41 | 13.0 | n/a |

| | | Date | pH | Cond | NN | TN | SRP | TDP | TP | TP Turb | TPc1 | Turb | Alk 2 | T | Color |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | (µS/cm) | (ug/L) | (ug/L) | (ug/L) | (ug/L) | (ug/L) | (ug/L) | (ug/L) | (NTU) | (mgCaCO3/L) | (°C) | |
| Goldstream River | 3 | 05/11/2009 | 7.88 | 102 | 357.1 | NaN | 3.4 | 6.1 | 11.2 | 0.7 | 10.5 | 0.76 | 63 | 6.5 | C |
| Goldstream River | 3 | 05/27/2009 | 7.72 | 69 | 380.7 | NaN | 4 | 7.8 | 46.6 | 3.1 | 43.5 | 9.26 | 45 | 6.0 | TB |
| Goldstream River | 3 | 06/08/2009 | 7.77 | 73 | 247.7 | NaN | 2.3 | 4.4 | 9.1 | 0.6 | 8.5 | 1.86 | 46 | 11.0 | TB |
| Goldstream River | 3 | 06/29/2009 | 7.28 | 61 | 104.2 | NaN | 1.6 | 4.7 | 10.4 | 0.8 | 9.6 | 1.38 | 40 | 10.0 | TB |
| Goldstream River | 3 | 07/08/2009 | 7.31 | 56 | 81.2 | NaN | 0.9 | 3.8 | 13.1 | 1.6 | 11.5 | 4.11 | 37.5 | 8.0 | C |
| Goldstream River | 3 | 07/28/2009 | 7.64 | 65 | 57.2 | NaN | 2.2 | 9 | 177.3 | 116 | 61.3 | 189 | 40.5 | 14.0 | TB |
| Goldstream River | 3 | 08/11/2009 | 7.23 | 52 | 72.5 | NaN | 1 | 2.6 | 91.9 | 33 | 58.9 | 45.6 | 35 | 10.0 | TB |
| Goldstream River | 3 | 09/09/2009 | 7.58 | 79 | 100.8 | NaN | 1.2 | 2.5 | 13.3 | 3.7 | 9.6 | 2.55 | 51 | 8.0 | C |
| Goldstream River | 3 | 10/05/2009 | 7.76 | 100 | 193.4 | NaN | 1.4 | 4.9* | 3.6 | 0.6 | 3 | 1.72 | 64.5 | 4.5 | C |
| Goldstream River | 3 | 11/03/2009 | 7.81 | 103 | 138.6 | NaN | 1.6 | 1.6 | 2.2 | 0.1 | 2.2 | 1.35 | 67 | 2.0 | C |
| Goldstream River | 3 | 05/04/2010 | 8.02 | 128 | 340.4 | NaN | 1.8 | 3.8 | 9.9 | 0.5 | 9.4 | 0.20 | 65 | 5.0 | C |
| Goldstream River | 3 | 05/31/2010 | 7.99 | 103 | 325.3 | NaN | 1.1 | 2.6 | 7.0 | <0.1 | 6.9 | 0.44 | 51 | 7.0 | C |
| Goldstream River | 3 | 06/29/2010 | 7.61 | 66 | 90.8 | NaN | 2.3 | 8.3 | 65.3 | 6.7 | 58.6 | 14.10 | 33.5 | 7.5 | TB |
| Goldstream River | 3 | 07/05/2010 | 7.71 | 77 | 85.7 | NaN | 0.8 | 3.8 | 12.4 | 1.3 | 11.1 | 1.05 | 37 | 7.0 | TB |
| Goldstream River | 3 | 07/26/2010 | 7.82 | 76 | 60.0 | NaN | 1.0 | 4.3 | 95.6 | 24.9 | 70.7 | 44.75 | 36.9 | 11.5 | TB |
| Goldstream River | 3 | 08/09/2010 | 7.49 | 69 | 57.6 | NaN | 1.4 | 5.5 | 40.3 | 10.3 | 30.0 | 16.55 | 34.1 | 10.5 | T |
| Goldstream River | 3 | 09/07/2010 | 7.73 | 109 | 109.8 | NaN | 1.5 | 3.4 | 10.3 | 1.1 | 9.1 | 3.20 | 55.4 | 8.5 | C |
| Goldstream River | 3 | 10/05/2010 | 7.79 | 99 | 116.7 | NaN | 1.8 | 6.6 | 6.7 | 3.8 | 3.0 | 8.66 | 51 | 8.5 | MGB |
| Goldstream River | 3 | 11/01/2010 | 7.82 | 129 | 147.4 | NaN | 0.9 | 2.6 | 3.2 | <0.1 | 3.1 | 0.46 | 68 | 4.0 | C |
| Goldstream River | 3 | 05/09/2011 | 7.99 | 112 | 220.3 | NaN | 1.8 | 5.2 | 9.5 | <0.1 | 9.4 | 2.15 | 76 | 6.0 | TGB |
| Goldstream River | 3 | 05/30/2011 | 7.87 | 73 | 390.3 | NaN | 1.6 | 4.1 | 32.3 | 2.4 | 29.8 | 8.20 | 51 | 6.0 | TB |
| Goldstream River | 3 | 06/06/2011 | 7.80 | 59 | 295.2 | NaN | 1.5 | 3.8 | 151.0 | 13.7 | 137.3 | 30.0 | 40 | 7.0 | TB |
| Goldstream River | 3 | 06/28/2011 | 7.80 | 54 | 142.1 | NaN | 1.2 | 4.4 | 146.9 | ** | NaN | 4.50 | 38.5 | 9.5 | TB |
| Goldstream River | 3 | 07/26/2011 | 7.73 | 52 | 37.2 | NaN | 1.2 | 4.9 | 14.0 | 1.9 | 12.2 | 8.15 | 37.5 | 10.5 | TLB |
| Goldstream River | 3 | 08/17/2011 | 7.66 | 96 | 96.2 | NaN | 1.4 | 2.9 | 6.3 | 0.9 | 5.5 | 1.60 | 47 | 9.5 | C |
| Goldstream River | 3 | 09/07/2011 | 7.88 | 110 | 118.7 | NaN | 1.1 | 3.5 | 17.6 | ** | NaN | 7.10 | 55.5 | 9.5 | TB |
| Goldstream River | 3 | 10/19/2011 | 7.75 | 128 | 170.9 | NaN | 1.6 | 2.3 | 4.0 | <0.1 | 3.9 | 1.20 | 64 | 7.0 | C |
| Goldstream River | 3 | 05/14/2012 | 7.57 | 111 | 382.1 | NaN | 3.3 | 6.8 | 34.4 | 2.2 | 32.3 | 2.80 | 55.4 | 6.5 | M |
| Goldstream River | 3 | 05/28/2012 | 7.80 | 90 | 361.5 | NaN | 4.5 | 4.7 | 73.9 | 4.9 | 69.1 | 6.25 | 47 | 6.0 | TB |
| Goldstream River | 3 | 06/05/2012 | 7.65 | 87 | 267.3 | NaN | 4.2 | 4.8 | 40.1 | 4.3 | 35.8 | 5.80 | 46.5 | 6.0 | TB |
| Goldstream River | 3 | 06/26/2012 | 7.85 | 77 | 130.4 | NaN | 2.6 | 3.8 | 73.3 | 14.1 | 59.2 | 45.00 | 42.1 | 6.0 | TB |
| Goldstream River | 3 | 07/09/2012 | 7.50 | 65 | 69.4 | NaN | 1.7 | 4.3 | 60.6 | 7.9 | 52.6 | 27.50 | 37 | 8.0 | TB |
| Goldstream River | 3 | 07/30/2012 | 7.65 | 67 | 65.4 | NaN | 1.4 | 3.4 | 31.3 | 5.9 | 25.4 | 4.04 | 37.2 | 10.0 | TLB |
| Goldstream River | 3 | 08/27/2012 | 7.94 | 87 | 93.3 | NaN | 2.4 | 3.1 | 13.4 | 5.5 | 7.9 | 1.45 | 50 | 10.0 | C |
| Goldstream River | 3 | 09/24/2012 | 7.88 | 89 | 84.4 | NaN | 2.2 | 4.9 | 11.4 | 4.7 | 6.7 | 8.33 | 48 | 9.0 | M |
| Goldstream River | 3 | 10/23/2012 | 7.98 | 110 | 149.3 | NaN | 1.6 | 6.2 | 7.4 | <0.1 | 7.3 | 0.63 | 65 | 2.0 | C |
| Goldstream River | 3 | 11/19/2012 | 7.82 | 123 | 181.7 | NaN | 1.4 | 2.8 | 4.6 | <0.1 | 4.5 | 0.47 | 69.6 | 2.0 | C |
| Goldstream River | 3 | 04/15/2013 | 8.05 | 177 | 240 | NaN | <1.00 | 2.6 | 3.7 | NaN | NaN | 1.07 | 80.8 | 4.0 | GC |
| Goldstream River | 3 | 05/08/2013 | 7.78 | 89.7 | 564 | NaN | 1.7 | 3.3 | 78.7 | NaN | NaN | 35.3 | 37.5 | 4.5 | B |
| Goldstream River | 3 | 05/27/2013 | 7.81 | 112 | 309 | NaN | <1.00 | 3.0 | 8.5 | NaN | NaN | 1.3 | 50.2 | 7.0 | GC |
| Goldstream River | 3 | 06/03/2013 | 7.81 | 105 | 247 | NaN | 1.5 | 2.8 | 3.6 | NaN | NaN | 1.85 | 46.7 | 7.0 | GC |
| Goldstream River | 3 | 06/25/2013 | 7.58 | 81.5 | 86.7 | NaN | 1.7 | <2.00 | 5.9 | NaN | NaN | 6.4 | 33.9 | 7.5 | BG |
| Goldstream River | 3 | 07/08/2013 | 7.76 | 88.2 | 91.2 | NaN | 2.3 | <2.00 | 10.9 | NaN | NaN | 4.57 | 37.8 | 10.0 | MG |
| Goldstream River | 3 | 08/06/2013 | 7.85 | 95.7 | 66.9 | NaN | 1.7 | 12.5 | 78.7 | NaN | NaN | 49.5 | 43.7 | 12.0 | MB |
| Goldstream River | 3 | 09/11/2013 | 7.76 | 94.9 | 70.5 | NaN | <1.00 | 9.4 | 16.0 | NaN | NaN | 0.24 | 39.8 | 10.0 | B |
| Goldstream River | 3 | 09/30/2013 | 7.95 | 119 | 139 | NaN | 2.2 | 2.1 | 2.7 | NaN | NaN | 3.4 | 51.2 | 6.0 | GC |
| Goldstream River | 3 | 11/05/2013 | 7.95 | 158 | 169 | NaN | <1.00 | <2.00 | <2.00 | NaN | NaN | 0.61 | 68.7 | 1.0 | C |

| | | Date | pH | Cond | NN | TN | SRP | TDP | TP | TP Turb | TPc1 | Turb | Alk 2 | T | Color |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | (µS/cm) | (ug/L) | (ug/L) | (ug/L) | (ug/L) | (ug/L) | (ug/L) | (ug/L) | (NTU) | (mgCaCO3/L) | (°C) | |
| Goldstream River | 3 | 05/26/2014 | 7.82 | 101 | 411.0 | NaN | 4.4 | 2.5 | 36.0 | NaN | NaN | 13.40 | 42.1 | 4.0 | B |
| Goldstream River | 3 | 06/09/2014 | 7.87 | 97 | 255.0 | NaN | 1.1 | 2.1 | 2.2 | NaN | NaN | 4.85 | 41.3 | 6.0 | B |
| Goldstream River | 3 | 07/08/2014 | 7.74 | 76 | 76.9 | NaN | 3.4 | <2.00 | 14.9 | NaN | NaN | 7.48 | 33.3 | 8.0 | MG |
| Goldstream River | 3 | 08/06/2014 | 7.88 | 88 | 79.8 | NaN | 1.2 | 3.8 | 23.4 | NaN | NaN | 13.60 | 40.4 | 12.0 | MG |
| Goldstream River | 3 | 09/02/2014 | 7.75 | 108 | 99.7 | NaN | 2.6 | <2.00 | 19.9 | NaN | NaN | 5.20 | 41.6 | 8.0 | MG |
| Goldstream River | 3 | 10/07/2014 | 7.79 | 107 | 112.0 | NaN | 5.9 | 2.0 | 6.7 | NaN | NaN | 6.22 | 41.6 | 8.0 | MG |
| Goldstream River | 3 | 03/25/2015 | 8.03 | 168 | 257.0 | NaN | <1.00 | <2.00 | <2.00 | NaN | NaN | 0.36 | 75.2 | 3.0 | VC |
| Goldstream River | 3 | 04/07/2015 | 7.94 | 169 | 317.0 | NaN | 3.1 | 6.3 | 45.1 | NaN | NaN | 0.33 | 73.7 | 2.5 | C |
| Goldstream River | 3 | 04/22/2015 | 7.99 | 146 | 383.0 | NaN | 1.3 | 2.5* | 2.2 | NaN | NaN | 0.66 | 65.0 | 6.0 | GC |
| Goldstream River | 3 | 05/06/2015 | 7.91 | 132 | 413.0 | NaN | <1.00 | <2.00 | 2.8 | NaN | NaN | 0.91 | 56.8 | 4.5 | MG |
| Goldstream River | 3 | 05/25/2015 | 7.73 | 87.8 | 243.0 | NaN | <1.00 | 3.1 | 4.8 | NaN | NaN | 9.33 | 36.5 | 7.0 | B |
| Goldstream River | 3 | 06/08/2015 | 7.56 | 76.0 | 90.2 | NaN | 1.3 | 2.3 | 9.6 | NaN | NaN | 17.00 | 32.7 | 7.0 | B |
| Goldstream River | 3 | 07/06/2015 | 7.76 | 89.0 | 81.0 | NaN | <1.00 | <2.00 | 4.5 | NaN | NaN | 6.58 | 36.3 | 11.0 | MG |
| Goldstream River | 3 | 07/27/2015 | 7.76 | 95.8 | 63.8 | NaN | <1.00 | <2.00 | 3.9 | NaN | NaN | 4.44 | 38.2 | 10.0 | MG |
| Goldstream River | 3 | 08/10/2015 | 7.75 | 79.8 | 69.1 | NaN | 1.8 | <2.00 | 9.8 | NaN | NaN | 23.70 | 34.1 | 12.0 | GB |
| Goldstream River | 3 | 09/08/2015 | 7.81 | 134 | 152.0 | NaN | 2.9 | 2.1 | 3.3 | NaN | NaN | 0.96 | 52.5 | ot Tak | C |
| Goldstream River | 3 | 10/05/2015 | 8.05 | 150 | 167.0 | NaN | <1.00 | 2.1 | 4.3 | NaN | NaN | 2.89 | 62.8 | 5.5 | GC |
| Goldstream River | 3 | 11/02/2015 | 8.05 | 154 | 183.0 | NaN | 4.9 | <2.00 | 2.0 | NaN | NaN | 2.37 | 66.6 | 3.5 | C |
| Goldstream River | 3 | 12/08/2015 | 8.10 | 170 | 215.0 | NaN | 3.6 | 2.0 | 3.7 | NaN | NaN | 1.77 | 76.8 | -1.0 | C 1/2F |
| Goldstream River | 3 | 03/21/2016 | 7.99 | 202 | 162 | NaN | 1.3 | <2.0 | <2.0 | NaN | NaN | 0.69 | 90.7 | 2.5 | C |
| Goldstream River | 3 | 04/04/2016 | 8.07 | 167 | 273 | NaN | 4.9 | <2.0 | 8.6 | NaN | NaN | 8.65 | 77.1 | 3 | MGB |
| Goldstream River | 3 | 04/25/2016 | 7.93 | 117 | 408 | 483 | 2.7 | <2.0 | 35.9 | NaN | NaN | 5.12 | 52.8 | 4.5 | TB |
| Goldstream River | 3 | 05/09/2016 | 7.96 | 109 | 288 | 332 | 2.3 | 2.1 | 28.0 | NaN | NaN | 3.81 | 47.4 | 4.5 | GB |
| Goldstream River | 3 | 05/24/2016 | 7.90 | 103 | 192 | 273 | 2.3 | <2.0 | 12.5 | NaN | NaN | 9.15 | 44.9 | 7 | T |
| Goldstream River | 3 | 06/06/2016 | 7.86 | 89.3 | 113 | 310 | <1.0 | 2.5 | 183.0 | NaN | NaN | 47.40 | 42.1 | 7.5 | TB |
| Goldstream River | 3 | 06/27/2016 | 7.82 | 95.9 | 90.8 | 144 | 2.2 | 2.1 | 21.6 | NaN | NaN | 2.71 | 40.1 | 9 | G |
| Goldstream River | 3 | 07/25/2016 | 7.90 | 98.7 | 79.5 | 121 | 1.8 | 4.1 | 13.3 | NaN | NaN | 4.08 | 41.0 | 11 | M |
| Goldstream River | 3 | 08/09/2016 | 7.90 | 101 | 68.8 | 145 | <1.0 | 2.3 | 20.5 | NaN | NaN | 7.21 | 42.2 | 11.5 | TB |
| Goldstream River | 3 | 09/07/2016 | 7.93 | 132 | 105 | 253 | 3.1 | <2.0 | 6.5 | NaN | NaN | 2.37 | 52.4 | 9.5 | C |
| Goldstream River | 3 | 10/03/2016 | 8.04 | 143 | 138 | 286 | 1.3 | 2.1 | 3.4 | NaN | NaN | 1.55 | 59.2 | 6.5 | C |
| Goldstream River | 3 | 11/07/2016 | 7.88 | 142 | 248 | 404 | 1.5 | 2.2 | 4.4 | NaN | NaN | 1.58 | 63.1 | 8 | C |
| Goldstream River | 3 | 12/06/2016 | 7.92 | 176 | 252 | 330 | 1.2 | <2.0 | 3.5 | NaN | NaN | 1.87 | 80.5 | -1 | C/I |
| Goldstream River | 3 | 03/21/2017 | 8.10 | 190 | 217 | 307 | <1.00 | 2.2 | 3.3 | NaN | NaN | 0.93 | 84.1 | 1.00 | C100 |
| Goldstream River | 3 | 04/04/2017 | 7.96 | 187 | 179 | 248 | 1.2 | <2.00 | 3.0 | NaN | NaN | 0.64 | 83.1 | 2.50 | C |
| Goldstream River | 3 | 04/26/2017 | 8.20 | 168 | 264 | 370 | 1.7 | 2.6 | 9.8 | NaN | NaN | 1.97 | 77.2 | 3.50 | GC |
| Goldstream River | 3 | 05/09/2017 | 7.96 | 140 | 440 | 547 | 4.6 | 4.4 | 18.9 | NaN | NaN | 0.5 | 64.8 | 4.50 | GB |
| Goldstream River | 3 | 05/30/2017 | 7.68 | 89.4 | 278 | 421 | 2.9 | 3.6 | 141.0 | NaN | NaN | 110 | 42.4 | 6.00 | BT |
| Goldstream River | 3 | 06/14/2017 | 7.89 | 88.9 | 154 | 203 | 3.7 | 6.7 | 42.1 | NaN | NaN | 23.3 | 39.2 | 7.00 | MBT |
| Goldstream River | 3 | 06/27/2017 | 7.81 | 76.9 | 78.1 | 162 | <1.00 | 2.2 | 81.8 | NaN | NaN | 31.8 | 36 | 7.00 | BT |
| Goldstream River | 3 | 07/25/2017 | 7.95 | 100 | 94.9 | 149 | 3.1 | 3.0 | 13.3 | NaN | NaN | 4.65 | 42.3 | 12.00 | C |
| Goldstream River | 3 | 08/08/2017 | 7.85 | 87.5 | 61.6 | 87 | 4.7 | 2.1 | 18.5 | NaN | NaN | 15.6 | 39.1 | 8.00 | T |
| Goldstream River | 3 | 09/05/2017 | 7.81 | 85.5 | 64.4 | 144 | 10.0 | 4.5 | 21.6 | NaN | NaN | 15.2 | 36 | 12.00 | T |
| Goldstream River | 3 | 10/02/2017 | 8.03 | 134 | 117 | 181 | 2.2 | 3.9 | 5.8 | NaN | NaN | 2.64 | 56.8 | 6.00 | C |
| Goldstream River | 3 | 11/06/2017 | 8.03 | 171 | 208 | 271 | <1.00 | <2.00 | 3.4 | NaN | NaN | 0.48 | 78.4 | -1.00 | C |
| Goldstream River | 3 | 12/04/2017 | 8.02 | 170 | 199 | 270 | 1.3 | 5.9 | 2.8 | NaN | NaN | 0.67 | 76.4 | -0.50 | C |
| Columbia above Jordan 4 | 4 | 06/24/2008 | 7.94 | 118 | 144.3 | NaN | 2.7 | 6.7 | 8.2 | 1.0 | 7.2 | 0.16 | 50 | 10.0 | n/a |
| Columbia above Jordan | 4 | 05/12/2009 | 7.83 | 108 | 125.7 | NaN | 2.4 | 5.6* | 3.2 | 0.1 | 3.2 | 0.32 | 64 | 4.0 | C |

| | | Date | pH | Cond | NN | TN | SRP | TDP | TP | TP Turb | TPc1 | Turb | Alk 2 | T | Color |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | (µS/cm) | (ug/L) | (ug/L) | (ug/L) | (ug/L) | (ug/L) | (ug/L) | (ug/L) | (NTU) | (mgCaCO3/L) | (°C) | |
| Columbia above Jordan | 4 | 05/28/2009 | 7.89 | 103 | 117.3 | NaN | 2.6 | 4.5 | 5.6 | 0.1 | 5.6 | 0.59 | 63 | 7.0 | C |
| Columbia above Jordan | 4 | 06/09/2009 | 7.87 | 105 | 121.2 | NaN | 3 | 6.7* | 4.2 | 0.1 | 4.2 | 0.37 | 64 | 7.0 | C |
| Columbia above Jordan | 4 | 06/30/2009 | 7.42 | 92 | 134.9 | NaN | 2 | 5.3* | 4.9 | 0.1 | 4.9 | 0.43 | 56 | 10.0 | C |
| Columbia above Jordan | 4 | 07/07/2009 | 7.57 | 94 | 134.9 | NaN | 1.6 | 4.8 | 5.2 | 0.1 | 5.2 | 0.63 | 58.4 | 7.0 | C |
| Columbia above Jordan | 4 | 07/27/2009 | 7.49 | 75 | 126.7 | NaN | 3.1 | 3.3 | 4.7 | 0.1 | 4.7 | 0.63 | 49 | 9.5 | C |
| Columbia above Jordan | 4 | 08/10/2009 | 7.28 | 71 | 140.5 | NaN | 1.1 | 3.7 | 4.3 | 0.1 | 4.3 | 0.36 | 45.4 | 8.0 | C |
| Columbia above Jordan | 4 | 09/08/2009 | 7.44 | 83 | 122.8 | NaN | 1.4 | 4.2* | 3.8 | 0.7 | 3.1 | 0.58 | 52.6 | 9.0 | C |
| Columbia above Jordan | 4 | 10/06/2009 | 7.56 | 76 | 138.9 | NaN | 1.1 | 4.4* | 4.3 | 0.8 | 3.5 | 1.09 | 50 | 10.5 | C |
| Columbia above Jordan | 4 | 11/02/2009 | 7.54 | 89 | 107.9 | NaN | 1.6 | 1.5 | 2.7 | 0.1 | 2.7 | 0.83 | 55.2 | 5.0 | C |
| Columbia above Jordan | 4 | 05/03/2010 | 7.98 | 137 | 100.5 | NaN | 1.6 | 3.1 | 3.5 | <0.1 | 3.4 | 0.17 | 63.7 | 4.5 | C |
| Columbia above Jordan | 4 | 05/31/2010 | 8.04 | 140 | 116.2 | NaN | 1.1 | 5.6* | 3.4 | <0.1 | 3.3 | 0.25 | 66.6 | 8.0 | C |
| Columbia above Jordan | 4 | 06/28/2010 | 7.84 | 121 | 128.7 | NaN | 1.1 | 4.4* | 3.7 | <0.1 | 3.6 | 0.22 | 59.5 | 7.0 | C |
| Columbia above Jordan | 4 | 07/06/2010 | 7.86 | 116 | 132.6 | NaN | 1.0 | 3.9* | 3.8 | <0.1 | 3.7 | 0.39 | 56 | 8.5 | C |
| Columbia above Jordan | 4 | 07/27/2010 | 7.82 | 97 | 134.2 | NaN | 2.1 | 3.6 | 4.6 | 0.8 | 3.9 | 0.62 | 46.7 | 10.0 | C |
| Columbia above Jordan | 4 | 08/09/2010 | 7.54 | 89 | 133.3 | NaN | 1.5 | 3.0 | 3.9 | <0.1 | 3.8 | 0.37 | 44.2 | 10.0 | C |
| Columbia above Jordan | 4 | 09/08/2010 | 7.40 | 72 | 136.2 | NaN | 2.1 | 3.2 | 3.2 | <0.1 | 3.1 | 1.49 | 34.7 | 10.5 | C |
| Columbia above Jordan | 4 | 10/07/2010 | 7.58 | 85 | 104.5 | NaN | 1.3 | 5.7* | 5.2 | <0.1 | 5.1 | 0.49 | 42 | 11.0 | C |
| Columbia above Jordan | 4 | 11/02/2010 | 7.52 | 100 | 111.2 | NaN | 1.0 | 2.8 | 6.2 | 4.0 | 2.2 | 1.40 | 51 | 8.0 | C |
| Columbia above Jordan | 4 | 05/09/2011 | 7.88 | 102 | 100.7 | NaN | 1.3 | 5.4* | 4.6 | <0.1 | 4.5 | 0.48 | 64 | 4.0 | C |
| Columbia above Jordan | 4 | 05/31/2011 | 7.96 | 94 | 106.4 | NaN | 0.9 | 3.2 | 3.9 | <0.1 | 3.8 | 0.50 | 61.7 | 5.5 | C |
| Columbia above Jordan | 4 | 06/06/2011 | 7.95 | 93 | 102.8 | NaN | 1.0 | 4.0* | 3.7 | <0.1 | 3.6 | 0.90 | 60 | 6.5 | C |
| Columbia above Jordan | 4 | 06/28/2011 | 7.88 | 81 | 165.1 | NaN | 1.4 | 3.8 | 5.2 | <0.1 | 5.1 | 1.10 | 55.5 | 8.5 | C |
| Columbia above Jordan | 4 | 07/25/2011 | 7.73 | 59 | 154.1 | NaN | 1.6 | 2.8 | 3.7 | 0.7 | 2.9 | 1.60 | 41.9 | 9.5 | C |
| Columbia above Jordan | 4 | 08/17/2011 | 7.46 | 81 | 124.9 | NaN | 1.3 | 15.3* | 2.2 | 0.3 | 1.9 | 0.95 | 38 | 8.0 | C |
| Columbia above Jordan | 4 | 09/07/2011 | 7.67 | 100 | 112.8 | NaN | 0.9 | 3.0 | 4.7 | ** | NaN | 0.60 | 47 | 9.0 | C |
| Columbia above Jordan | 4 | 10/19/2011 | 7.64 | 111 | 107.0 | NaN | 1.1 | 2.8* | 2.8 | <0.1 | 2.7 | 0.45 | 51.5 | 9.0 | C |
| Columbia above Jordan | 4 | 05/14/2012 | 7.64 | 137 | 85.5 | NaN | 2.8 | 6.3 | 9.0 | 1.0 | 8.0 | 0.45 | 64.55 | 6.5 | C |
| Columbia above Jordan | 4 | 05/28/2012 | 7.96 | 127 | 107.6 | NaN | 4.0 | 5.5 | 6.0 | 1.3 | 4.7 | 0.13 | 62.5 | 6.0 | C |
| Columbia above Jordan | 4 | 06/05/2012 | 7.87 | 124 | 119.3 | NaN | 4.0 | 4.8 | 6.9 | 0.7 | 6.2 | 0.00 | 63.6 | 6.0 | C |
| Columbia above Jordan | 4 | 06/26/2012 | 7.94 | 104 | 148.1 | NaN | 2.0 | 4.0 | 3.8 | 0.7 | 3.1 | 0.00 | 52.6 | 8.0 | C |
| Columbia above Jordan | 4 | 07/09/2012 | 7.71 | 93 | 151.8 | NaN | 2.1 | 6.5 | 7.1 | 0.8 | 6.3 | 0.05 | 48.2 | 8.0 | C |
| Columbia above Jordan | 4 | 07/30/2012 | 7.58 | 68 | 111.4 | NaN | 1.8 | 3.4 | 6.4 | 2.0 | 4.4 | 1.18 | 35.8 | 10.0 | C |
| Columbia above Jordan | 4 | 08/28/2012 | 7.93 | 95 | 113.6 | NaN | 2.8 | 4.9 | 4.9 | 1.3 | 3.6 | 0.15 | 52.6 | 11.0 | C |
| Columbia above Jordan | 4 | 09/24/2012 | 7.92 | 104 | 109.4 | NaN | 2.8 | 3.8 | 4.1 | <0.1 | 4.0 | 0.30 | 56.46 | 11.0 | C |
| Columbia above Jordan | 4 | 10/23/2012 | 7.95 | 109 | 102.8 | NaN | 1.1 | 4.8 | 5.5 | <0.1 | 5.4 | 0.32 | 61 | 8.5 | C |
| Columbia above Jordan | 4 | 11/19/2012 | 7.79 | 111 | 124.0 | NaN | 1.3 | 1.5 | 4.0 | <0.1 | 3.9 | 0.28 | 60.4 | 7.0 | C |
| Columbia above Jordan | 4 | 04/15/2013 | 7.98 | 156 | 111 | NaN | <1.00 | <2.00 | 3.2 | NaN | NaN | 0.53 | 67.7 | 4.0 | C |
| Columbia above Jordan | 4 | 05/08/2013 | 7.88 | 149 | 110 | NaN | <1.00 | <2.00 | 2.1 | NaN | NaN | 0.18 | 64.1 | 6.0 | C |
| Columbia above Jordan | 4 | 05/27/2013 | 7.97 | 149 | 111 | NaN | <1.00 | <2.00 | <2.00 | NaN | NaN | 0.21 | 64.4 | 5.0 | C |
| Columbia above Jordan | 4 | 06/03/2013 | 7.9 | 139 | 133 | NaN | <1.00 | <2.00 | 2.9 | NaN | NaN | 0.024 | 59.3 | 7.0 | C |
| Columbia above Jordan | 4 | 06/25/2013 | 7.74 | 121 | 181 | NaN | <1.00 | <2.00 | <2.00 | NaN | NaN | 0.79 | 48.7 | 7.5 | C |
| Columbia above Jordan | 4 | 07/08/2013 | 7.82 | 112 | 176 | NaN | <1.00 | <2.00 | <2.00 | NaN | NaN | 0.37 | 48.2 | 8.0 | C |
| Columbia above Jordan | 4 | 08/06/2013 | 7.58 | 83.9 | 128 | NaN | 1.4 | 15.3 | 19.9 | NaN | NaN | 0.62 | 35.2 | 10.0 | C |
| Columbia above Jordan | 4 | 09/11/2013 | 7.66 | 106 | 105 | NaN | 1.6 | 2.0 | 2.3 | NaN | NaN | 0.11 | 42.6 | 11.5 | C |
| Columbia above Jordan | 4 | 09/30/2013 | 7.95 | 124 | 118 | NaN | 1.4 | 2.3 | 5.5 | NaN | NaN | 1.19 | 51.6 | 9.0 | C |
| Columbia above Jordan | 4 | 11/05/2013 | 7.83 | 123 | 116 | NaN | <1.00 | <2.00 | <2.00 | NaN | NaN | 0.3 | 50.3 | 8.0 | C |
| Columbia above Jordan | 4 | 05/27/2014 | 7.78 | 142 | 117.0 | NaN | 2.7 | <2.00 | <2.00 | NaN | NaN | 0.27 | 56.2 | 4.0 | C |

| | | Date | pH | Cond | NN | TN | SRP | TDP | TP | TP Turb | TPc1 | Turb | Alk 2 | T | Color |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | (µS/cm) | (ug/L) | (ug/L) | (ug/L) | (ug/L) | (ug/L) | (ug/L) | (ug/L) | (NTU) | (mgCaCO3/L) | (°C) | |
| Columbia above Jordan | 4 | 06/09/2014 | 8.06 | 140 | 128.0 | NaN | <1.00 | <2.00 | 2.7 | NaN | NaN | 0.28 | 59.3 | 5.0 | C |
| Columbia above Jordan | 4 | 07/08/2014 | 7.86 | 118 | 170.0 | NaN | <1.00 | <2.00 | 2.2 | NaN | NaN | 0.45 | 50.0 | 8.0 | C |
| Columbia above Jordan | 4 | 08/05/2014 | 7.78 | 89 | 144.0 | NaN | 1.3 | 4.1 | 6.1 | NaN | NaN | 0.89 | 35.7 | 9.0 | C |
| Columbia above Jordan | 4 | 09/02/2014 | 7.83 | 111 | 122.0 | NaN | 1.0 | <2.00 | <2.00 | NaN | NaN | 0.61 | 45.6 | 8.0 | C |
| Columbia above Jordan | 4 | 10/06/2014 | 7.84 | 127 | 123.0 | NaN | 1.2 | <2.00 | <2.00 | NaN | NaN | 0.82 | 52.0 | 8.0 | C |
| Columbia above Jordan | 4 | 03/25/2015 | 7.96 | 145 | 123.0 | NaN | <1.00 | <2.00 | <2.00 | NaN | NaN | 0.19 | 61.5 | 2.0 | C |
| Columbia above Jordan | 4 | 04/08/2015 | 7.85 | 146 | 115.0 | NaN | 1.9 | 29.3 | 56.0 | NaN | NaN | 0.18 | 60.3 | 2.0 | C |
| Columbia above Jordan | 4 | 04/22/2015 | 7.99 | 147 | 123.0 | NaN | 4.1 | <2.00 | <2.00 | NaN | NaN | 0.32 | 63.0 | 3.5 | C |
| Columbia above Jordan | 4 | 05/07/2015 | 7.93 | 144 | 121.0 | NaN | <1.00 | 2.5* | 2.4 | NaN | NaN | 0.18 | 58.7 | 4.5 | C |
| Columbia above Jordan | 4 | 05/26/2015 | 7.87 | 145 | 132.0 | NaN | <1.00 | 2.3 | 7.9 | NaN | NaN | 0.33 | 60.7 | 6.0 | C |
| Columbia above Jordan | 4 | 06/08/2015 | 7.78 | 131 | 140.0 | NaN | <1.00 | <2.0 | <2.00 | NaN | NaN | 0.53 | 54.4 | 7.0 | C |
| Columbia above Jordan | 4 | 07/06/2015 | 7.79 | 106 | 141.0 | NaN | 1.5 | 7.8* | <2.00 | NaN | NaN | 0.49 | 41.6 | 8.5 | C |
| Columbia above Jordan | 4 | 07/27/2015 | 7.83 | 122 | 72.2 | NaN | <1.00 | 2.0 | 4.4 | NaN | NaN | 0.60 | 50.2 | 9.0 | C |
| Columbia above Jordan | 4 | 08/10/2015 | 7.80 | 130 | 114.0 | NaN | <1.00 | <2.00 | 2.2 | NaN | NaN | 0.64 | 55.1 | 10.0 | C |
| Columbia above Jordan | 4 | 09/08/2015 | 7.88 | 143 | 122.0 | NaN | 1.1 | <2.00 | 2.7 | NaN | NaN | 0.63 | 55.0 | 10.0 | C |
| Columbia above Jordan | 4 | 10/05/2015 | 7.94 | 134 | 99.2 | NaN | <1.00 | <2.00 | 2.3 | NaN | NaN | 0.72 | 54.7 | 10.0 | C |
| Columbia above Jordan | 4 | 11/02/2015 | 8.04 | 145 | 192.0 | NaN | 3.2 | <2.00 | 2.4 | NaN | NaN | 2.45 | 60.2 | 8.0 | C |
| Columbia above Jordan | 4 | 12/08/2015 | 8.09 | 165 | 289.0 | NaN | 2.4 | 3.9* | 3.3 | NaN | NaN | 0.63 | 72.8 | 6.0 | C |
| Columbia above Jordan | 4 | 03/21/2016 | 7.67 | 145 | 98 | NaN | <1.0 | 3.2 | <2.00 | NaN | NaN | 0.55 | 63.0 | 4.0 | C |
| Columbia above Jordan | 4 | 04/05/2016 | 8.06 | 166 | 199 | NaN | 1.0 | <2.0 | 7.2 | NaN | NaN | 0.26 | 72.5 | 3.5 | C |
| Columbia above Jordan | 4 | 04/25/2016 | 8.02 | 151 | 114 | 166 | <1.0 | <2.0 | <2.0 | NaN | NaN | 0.24 | 63.5 | 5.0 | C |
| Columbia above Jordan | 4 | 05/09/2016 | 8.04 | 148 | 117 | 186 | <1.0 | <2.0 | 2.6 | NaN | NaN | 0.43 | 63.3 | 7.0 | C |
| Columbia above Jordan | 4 | 05/25/2016 | 8.04 | 152 | 130 | 229 | <1.0 | 3.3 | 3.0 | NaN | NaN | 0.58 | 63.9 | 6.0 | C |
| Columbia above Jordan | 4 | 06/06/2016 | 8.01 | 140 | 150 | 221 | 2.2 | <2.0 | 2.1 | NaN | NaN | 0.42 | 60.3 | 8.0 | C |
| Columbia above Jordan | 4 | 06/27/2016 | 7.92 | 112 | 169 | 209 | 1.0 | 2.7 | 3.9 | NaN | NaN | 0.89 | 49.5 | 8.0 | C |
| Columbia above Jordan | 4 | 07/25/2016 | 7.85 | 100 | 129 | 191 | <1.0 | 4.6 | 2.1 | NaN | NaN | 0.58 | 39.4 | 9.0 | C |
| Columbia above Jordan | 4 | 08/10/2016 | 7.91 | 122 | 121 | 232 | <1.0 | 3.5 | 3.3 | NaN | NaN | 0.53 | 48.8 | 9.0 | C |
| Columbia above Jordan | 4 | 09/07/2016 | 7.89 | 133 | 121 | 162 | 2.3 | 2.3 | 2.9 | NaN | NaN | 0.67 | 50.8 | 10.5 | C |
| Columbia above Jordan | 4 | 10/03/2016 | 7.97 | 137 | 114 | 319 | <1.0 | 2.0 | 2.7 | NaN | NaN | 0.73 | 56.3 | 10.0 | C |
| Columbia above Jordan | 4 | 11/07/2016 | 7.92 | 179 | 288 | 325 | 1.1 | <2.0 | <2.00 | NaN | NaN | 0.32 | 76.0 | 8.0 | C |
| Columbia above Jordan | 4 | 12/06/2016 | 7.83 | 136 | 130 | 211 | <1.0 | <2.0 | <2.00 | NaN | NaN | 0.35 | 57.0 | 6.0 | C |
| Columbia above Jordan | 4 | 03/21/2017 | 7.98 | 158 | 117 | 217 | <1.00 | 2.5 | 2.2 | NaN | NaN | 0.33 | 63.90 | -1.00 | C |
| Columbia above Jordan | 4 | 04/04/2017 | 8.07 | 215 | 519 | 427 | <1.00 | <2.00 | <2.00 | NaN | NaN | 0.18 | 94.00 | 6.50 | C |
| Columbia above Jordan | 4 | 04/19/2017 | 8.05 | 157 | 113 | 188 | 2.3 | <2.00 | 2.5 | NaN | NaN | 0.28 | 63.50 | 2.00 | C |
| Columbia above Jordan | 4 | 04/26/2017 | 8.13 | 158 | 110 | 310 | 1.3 | 2.0 | <2.00 | NaN | NaN | 0.26 | 66.80 | 2.00 | C |
| Columbia above Jordan | 4 | 05/09/2017 | 7.98 | 156 | 117 | 265 | 1.0 | 3.1 | 3.9 | NaN | NaN | 0.28 | 65.90 | 2.50 | C |
| Columbia above Jordan | 4 | 05/30/2017 | 8.06 | 149 | 130 | 183 | 1.3 | <2.00 | 3.1 | NaN | NaN | 0.38 | 63.60 | 5.00 | C |
| Columbia above Jordan | 4 | 06/14/2017 | 8.05 | 135 | 165 | 198 | 2.3 | 2.9 | 23.0 | NaN | NaN | 0.85 | 59.40 | NaN | C |
| Columbia above Jordan | 4 | 06/27/2017 | 7.99 | 128 | 180 | 247 | <1.00 | <2.00 | 3.9 | NaN | NaN | 1.15 | 53.30 | 6.50 | C |
| Columbia above Jordan | 4 | 07/26/2017 | 7.92 | 98.6 | 131 | 218 | 1.6 | <2.00 | 4.3 | NaN | NaN | 0.85 | 42.40 | 9.00 | C |
| Columbia above Jordan | 4 | 08/08/2017 | 7.87 | 117 | 119 | 122 | 4.6 | <2.00 | 3.4 | NaN | NaN | 1.01 | 46.70 | 8.50 | C |
| Columbia above Jordan | 4 | 09/05/2017 | 7.98 | 128 | 107 | 152 | 3.1 | 9.4 | 2.7 | NaN | NaN | 0.52 | 54.60 | 11.50 | C |
| Columbia above Jordan | 4 | 10/02/2017 | 7.75 | 139 | 118 | 116 | 1.2 | <2.00 | 3.4 | NaN | NaN | 0.78 | 59.20 | 9.50 | C |
| Columbia above Jordan | 4 | 11/06/2017 | 7.90 | 143 | 118 | 152 | 1.2 | <2.00 | 2.4 | NaN | NaN | 0.25 | 59.10 | 5.00 | C |
| Columbia above Jordan | 4 | 12/04/2017 | 7.93 | 143 | 129 | 204 | 1.1 | 2.7 | 45.0 | NaN | NaN | 0.76 | 61.70 | 5.00 | C |
| Beaver River | 6 | 05/06/2013 | 7.87 | 108 | 533 | NaN | 1.9 | 2.1 | 217.0 | NaN | NaN | 62.6 | 44.9 | 4.0 | B |
| Beaver River | 6 | 05/28/2013 | 7.82 | 100 | 239 | NaN | 1.7 | 2.3 | 8.1 | NaN | NaN | 3.33 | 39.5 | 5.0 | C |

| | | Date | pH | Cond | NN | TN | SRP | TDP | TP | TP Turb | TPc1 | Turb | Alk 2 | T | Color |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | (µS/cm) | (ug/L) | (ug/L) | (ug/L) | (ug/L) | (ug/L) | (ug/L) | (ug/L) | (NTU) | (mgCaCO3/L) | (°C) | |
| Beaver River | 6 | 06/04/2013 | 7.71 | 88.2 | 187 | NaN | 1.9 | 3.1 | 6.4 | NaN | NaN | 3.16 | 36.2 | 5.5 | C |
| Beaver River | 6 | 06/24/2013 | 7.55 | 81.7 | 83.2 | NaN | 2.6 | <2.00 | 5.8 | NaN | NaN | 9.14 | 30.7 | 6.0 | TG |
| Beaver River | 6 | 07/09/2013 | 7.77 | 85.1 | 74.1 | NaN | 3.6 | <2.00 | 9.7 | NaN | NaN | 8.03 | 34.1 | 6.0 | C |
| Beaver River | 6 | 08/07/2013 | 7.57 | 66.4 | 47.2 | NaN | 6.2 | 10.8 | 37.1 | NaN | NaN | 20.8 | 28 | 8.0 | M |
| Beaver River | 6 | 09/10/2013 | 7.5 | 71.4 | 49.7 | NaN | 5.5 | 11.8 | 17.0 | NaN | NaN | 0.23 | 28.5 | 7.0 | M |
| Beaver River | 6 | 10/01/2013 | 7.93 | 125 | 110 | NaN | 2.1 | <2.00 | <2.00 | NaN | NaN | 2.33 | 50.9 | 5.0 | C |
| Beaver River | 6 | 11/04/2013 | 7.93 | 159 | 133 | NaN | <1.00 | <2.00 | 2.5 | NaN | NaN | 0.74 | 64 | 1.0 | C |
| Beaver River | 6 | 05/27/2014 | 7.61 | 83 | 327.0 | NaN | 3.3 | <2.00 | 15.2 | NaN | NaN | 10.70 | 31.6 | 3.5 | GB |
| Beaver River | 6 | 06/10/2014 | 7.74 | 77 | 173.0 | NaN | <1.00 | <2.00 | 2.2 | NaN | NaN | 6.53 | 29.7 | 3.0 | MG |
| Beaver River | 6 | 07/09/2014 | 7.65 | 70 | 64.1 | NaN | 5.0 | <2.00 | 17.4 | NaN | NaN | 6.25 | 28.7 | 6.0 | MG |
| Beaver River | 6 | 08/05/2014 | 7.71 | 73 | 53.9 | NaN | <1.00 | 4.0 | 9.7 | NaN | NaN | 5.14 | 28.8 | 7.0 | MG |
| Beaver River | 6 | 09/03/2014 | 7.74 | 86 | 65.5 | NaN | 5.2 | <2.00 | 6.9 | NaN | NaN | 8.12 | 34.2 | 6.0 | MG |
| Beaver River | 6 | 10/06/2014 | 7.73 | 101 | 82.2 | NaN | 2.7 | <2.00 | 3.8 | NaN | NaN | 2.02 | 38.7 | 6.0 | C |
| Beaver River | 6 | 04/23/2015 | 7.84 | 120 | 420.0 | NaN | <1.00 | 4.9* | 3.8 | NaN | NaN | 1.39 | 49.1 | 2.5 | B |
| Beaver River | 6 | 05/07/2015 | 7.79 | 119 | 381.0 | NaN | <1.00 | <2.00 | 2.5 | NaN | NaN | 0.77 | 46.7 | 4.0 | C |
| Beaver River | 6 | 05/26/2015 | 7.65 | 77.6 | 189.0 | NaN | <1.00 | 2.6 | 4.8 | NaN | NaN | 10.20 | 30.0 | 4.0 | B |
| Beaver River | 6 | 06/09/2015 | 7.51 | 69.7 | 81.0 | NaN | <1.00 | 2.5 | 16.6 | NaN | NaN | 61.60 | 27.4 | 5.0 | B |
| Beaver River | 6 | 07/07/2015 | 7.68 | 75.8 | 59.4 | NaN | <1.00 | <2.00 | 7.4 | NaN | NaN | 11.60 | 31.6 | 8.0 | MG |
| Beaver River | 6 | 07/28/2015 | 7.54 | 84.5 | 43.3 | NaN | <1.00 | <2.00 | 4.2 | NaN | NaN | 5.63 | 31.1 | 7.0 | M |
| Beaver River | 6 | 08/11/2015 | 7.65 | 70.7 | 50.0 | NaN | 1.5 | <2.00 | 10.2 | NaN | NaN | 12.90 | 30.1 | 8.0 | M |
| Beaver River | 6 | 09/08/2015 | 7.89 | 120 | 108.0 | NaN | 1.4 | 2.8 | 4.0 | NaN | NaN | 1.84 | 45.6 | 7.0 | C |
| Beaver River | 6 | 10/06/2015 | 7.90 | 137 | 121.0 | NaN | 2.1 | 2.4 | 2.5 | NaN | NaN | 1.83 | 51.9 | 4.0 | C |
| Beaver River | 6 | 11/03/2015 | 8.01 | 150 | 144.0 | NaN | <1.00 | 2.7* | <2.00 | NaN | NaN | 1.74 | 58.7 | 2.0 | C |
| Beaver River | 6 | 12/07/2015 | 8.04 | 159 | 166.0 | NaN | 1.5 | 2.2 | 2.7 | NaN | NaN | 1.07 | 65.8 | 0.0 | C |
| Beaver River | 6 | 03/22/2016 | 8.00 | 186 | 138 | NaN | <1.0 | <2.0 | <2.00 | NaN | NaN | 1.07 | 78.8 | 1.5 | C |
| Beaver River | 6 | 04/05/2016 | 7.90 | 147 | 326 | NaN | <1.0 | 2.1 | 3.5 | NaN | NaN | 2.37 | 59.4 | 2 | LB |
| Beaver River | 6 | 04/26/2016 | 7.84 | NaN | 356 | 420 | 4.7 | 2.9 | 22.2 | NaN | NaN | 7.22 | 40.7 | 4 | TB |
| Beaver River | 6 | 05/10/2016 | 7.86 | 103 | 254 | 330 | 2.9 | <2.0 | 10.1 | NaN | NaN | 2.10 | 40.2 | 3 | G |
| Beaver River | 6 | 05/25/2016 | 7.77 | 93.5 | 146 | 225 | 2.0 | <2.0 | 7.5 | NaN | NaN | 3.56 | 37.5 | 6 | C |
| Beaver River | 6 | 06/07/2016 | 7.73 | 75.1 | 87.6 | 195 | <1.0 | 2.0 | 70.4 | NaN | NaN | 34.60 | 31.6 | 8 | C |
| Beaver River | 6 | 06/28/2016 | 7.74 | 83 | 71.1 | 110 | <1.0 | 3.7 | 17.1 | NaN | NaN | 6.46 | 33.8 | 7.5 | MG |
| Beaver River | 6 | 07/26/2016 | 7.72 | 72.9 | 48.6 | 107 | <1.0 | 2.4 | 28.7 | NaN | NaN | 9.45 | 27.7 | 8 | MG |
| Beaver River | 6 | 08/10/2016 | 7.75 | 78.7 | 48.8 | 102 | 5.6 | 2.4 | 13.4 | NaN | NaN | 4.44 | 30.7 | 8 | M |
| Beaver River | 6 | 09/06/2016 | 7.82 | 118 | 73.5 | 181 | 4.0 | 2.8 | 5.6 | NaN | NaN | 1.55 | 42.1 | 8.5 | C |
| Beaver River | 6 | 10/04/2016 | 7.92 | 138 | 98.2 | 269 | 1.5 | 2.9 | 3.2 | NaN | NaN | 1.51 | 50.4 | 4 | C |
| Beaver River | 6 | 11/08/2016 | 7.81 | 132 | 205 | 324 | 2.1 | 2.3 | 13.3 | NaN | NaN | 12.10 | 53.4 | 3.5 | TB |
| Beaver River | 6 | 12/05/2016 | 7.77 | 154 | 186 | 272 | <1.0 | <2.0 | 3.6 | NaN | NaN | 1.44 | 63.8 | -1 | C/I |
| Beaver River | 6 | 03/20/2017 | 8.03 | 177 | 175 | 257 | <1.00 | <2.00 | 5.7 | NaN | NaN | 2.35 | 73.20 | -1.00 | C |
| Beaver River | 6 | 04/03/2017 | 7.99 | 183 | 156 | 259 | 1.6 | 9.5 | 4.2 | NaN | NaN | 1.33 | 73.10 | 0.50 | C |
| Beaver River | 6 | 04/18/2017 | 8.12 | 178 | 162 | 307 | 4.3 | 2.1 | 7.2 | NaN | NaN | 2.57 | 71.80 | 3.00 | BT |
| Beaver River | 6 | 05/08/2017 | 7.82 | 113 | 407 | 637 | <1.00 | 3.8 | 51.1 | NaN | NaN | 26.6 | 47.00 | 2.00 | BT |
| Beaver River | 6 | 05/29/2017 | 7.81 | 73 | 239 | 310 | 2.9 | 8.5 | 56.0 | NaN | NaN | 38.4 | 31.90 | 4.00 | BT |
| Beaver River | 6 | 06/13/2017 | 7.83 | 86.9 | 123 | 149 | 1.2 | 6.0 | 31.1 | NaN | NaN | 12.1 | 34.60 | 7.00 | MGT |
| Beaver River | 6 | 06/26/2017 | 7.70 | 75.9 | 73.7 | 153 | 3.5 | 2.4 | 36.7 | NaN | NaN | 11.7 | 30.60 | 6.50 | MT |
| Beaver River | 6 | 07/26/2017 | 7.82 | 80.6 | 60.9 | 157 | 2.3 | <2.00 | 22.7 | NaN | NaN | 5.39 | 32.30 | 7.00 | MT |
| Beaver River | 6 | 08/09/2017 | 7.72 | 69.4 | 39 | 24 | 5.9 | <2.00 | 15.8 | NaN | NaN | 8.23 | 28.70 | 8.00 | MT |
| Beaver River | 6 | 09/06/2017 | 7.68 | 64.7 | 37.6 | 92 | 3.8 | <2.00 | 14.4 | NaN | NaN | 11.6 | 26.70 | 7.00 | MT |

| | | Date | pH | Cond | NN | TN | SRP | TDP | TP | TP Turb | TPc1 | Turb | Alk 2 | T | Color |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | (µS/cm) | (ug/L) | (ug/L) | (ug/L) | (ug/L) | (ug/L) | (ug/L) | (ug/L) | (NTU) | (mgCaCO3/L) | (°C) | |
| Beaver River | 6 | 10/03/2017 | 8.01 | 144 | 100 | 126 | 2.1 | <2.00 | 4.0 | NaN | NaN | 1.3 | 59.70 | 3.00 | C |
| Beaver River | 6 | 11/07/2017 | 7.96 | 176 | 157 | 199 | 1.1 | 2.2 | 6.0 | NaN | NaN | 0.78 | 72.60 | -1.00 | C |
| Beaver River | 6 | 12/05/2017 | 7.91 | 157 | 172 | 218 | 1.8 | 4.6 | <2.00 | NaN | NaN | 0.89 | 65.90 | -1.00 | C |
| Downie Creek | 7 | 03/21/2016 | 8.11 | 215 | 217 | NaN | <1.0 | <2.0 | <2.0 | NaN | NaN | 0.36 | 99.1 | 3 | C |
| Downie Creek | 7 | 04/04/2016 | 8.03 | 180 | 378 | NaN | 3.1 | 2.5 | 18.1 | NaN | NaN | 10.40 | 85.1 | 3 | GB |
| Downie Creek | 7 | 04/25/2016 | 8.03 | 153 | 424 | 455 | 4.2 | <2.0 | 29.8 | NaN | NaN | 7.20 | 70.1 | 4 | M |
| Downie Creek | 7 | 05/09/2016 | 8.05 | 144 | 307 | 369 | 2.9 | <2.0 | 19.5 | NaN | NaN | 2.78 | 64.2 | 4 | M |
| Downie Creek | 7 | 05/24/2016 | 8.05 | 143 | 102 | 279 | 3.4 | <2.0 | 14.1 | NaN | NaN | 5.03 | 63.0 | 7 | T |
| Downie Creek | 7 | 06/06/2016 | 7.95 | 125 | 138 | 243 | 2.6 | 2.1 | 156.0 | NaN | NaN | 73.20 | 56.7 | 7 | TB |
| Downie Creek | 7 | 06/27/2016 | 8.04 | 132 | 134 | 186 | 1.4 | 2.5 | 40.9 | NaN | NaN | 10.20 | 55.4 | 7 | M |
| Downie Creek | 7 | 07/25/2016 | 8.06 | 133 | 106 | 141 | 1.2 | 3.4 | 43.4 | NaN | NaN | 8.20 | 57.6 | NaN | MB |
| Downie Creek | 7 | 08/09/2016 | 8.02 | 142 | 102 | 146 | 2.2 | 2.4 | 26.9 | NaN | NaN | 10.80 | 61.1 | 9 | M |
| Downie Creek | 7 | 09/07/2016 | 8.01 | 159 | 137 | 201 | <1.0 | <2.0 | 14.2 | NaN | NaN | 4.64 | 65.0 | 8 | LT |
| Downie Creek | 7 | 10/03/2016 | 8.09 | 181 | 180 | 336 | 4.1 | 2.9 | 6.3 | NaN | NaN | 2.38 | 74.6 | 6 | C |
| Downie Creek | 7 | 11/07/2016 | 7.97 | 178 | 300 | 395 | 1.3 | <2.0 | 3.0 | NaN | NaN | 1.11 | 79.3 | 4.5 | C |
| Downie Creek | 7 | 12/06/2016 | 7.83 | 202 | 292 | 359 | <1.0 | <2.0 | 4.1 | NaN | NaN | 0.64 | 92.2 | 0 | C/I |
| Downie Creek | 7 | 03/21/2017 | 8.16 | 217 | 271 | 332 | <1.00 | 2.2 | 2.5 | NaN | NaN | 0.29 | 98.50 | 1.50 | C100 |
| Downie Creek | 7 | 04/04/2017 | 8.09 | 210 | 250 | 288 | 2.1 | <2.00 | 4.7 | NaN | NaN | 0.41 | 95.40 | 2.00 | C |
| Downie Creek | 7 | 04/26/2017 | 8.29 | 200 | 375 | 532 | 1.8 | 2.1 | 12.1 | NaN | NaN | 1.55 | 93.70 | 3.00 | G |
| Downie Creek | 7 | 05/09/2017 | 8.09 | 177 | 493 | 570 | 4.8 | 5.0 | 16.0 | NaN | NaN | 3.55 | 85.00 | 4.50 | MT |
| Downie Creek | 7 | 05/30/2017 | 8.05 | 123 | 296 | 500 | 3.2 | 4.5 | 127.0 | NaN | NaN | 76.3 | 55.70 | NaN | BT |
| Downie Creek | 7 | 06/14/2017 | 8.04 | 124 | 182 | 203 | 5.1 | 3.6 | 40.9 | NaN | NaN | 27.2 | 55.60 | 6.00 | MT |
| Downie Creek | 7 | 06/27/2017 | 8.04 | 118 | 112 | 161 | 4.3 | 2.6 | 96.6 | NaN | NaN | 52.5 | 54.00 | 6.00 | MT |
| Downie Creek | 7 | 07/25/2017 | 8.10 | 137 | 126 | 178 | 4.3 | 5.4 | 22.3 | NaN | NaN | 5.32 | 59.60 | 11.00 | MT |
| Downie Creek | 7 | 08/08/2017 | 8.01 | 127 | 93.5 | 88 | 12.0 | <2.00 | 31.5 | NaN | NaN | 22.4 | 57.20 | 10.50 | T |
| Downie Creek | 7 | 09/05/2017 | 8.00 | 130 | 169 | 169 | 25.0 | 4.7 | 47.8 | NaN | NaN | 30.7 | 57.80 | 9.00 | T |
| Downie Creek | 7 | 10/02/2017 | 8.15 | 180 | 168 | 168 | 3.4 | <2.00 | 9.9 | NaN | NaN | 6.23 | 80.70 | 5.50 | MT |
| Downie Creek | 7 | 11/06/2017 | 8.09 | 200 | 248 | 269 | <1.00 | 2.9 | 10.6 | NaN | NaN | 0.34 | 91.50 | -1.00 | C |
| Downie Creek | 7 | 12/04/2017 | 8.11 | 202 | 253 | 341 | 1.8 | <2.00 | <2.00 | NaN | NaN | 0.45 | 99.10 | 1.00 | C |

1 TP=TP-Tpturb Total phosphorus corrected for turbidity
2 Corrected Alkalinity 2008 - 2012
3 (C)lear, (T)urbid, (M)ilky, (G)reen, (B)rown, (S)lightly, (L)ight, (V)ery, (F)rozen
4 Columbia above Jordan is located just below Revelstoke Dam
* TDP > TP, values swapped in figures and analysis
** TPTurb not measured

Appendix 3.2

Station: Beaver River near East Park Gate (BC08NB0002)

Raw data from Environment Canada

| | ALK-T | Ca* | Cl-D | K* | Mg* | Na* | NH3 | NO2 | NO3 | pH | OP | TP | SO4 | COND | T | TURB | TN | TND | TDP | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MG/L | MG/L | MG/L | MG/L | MG/L | MG/L | MG/L | MG/L | MG/L | PH UNITS | MG/L | MG/L | MG/L | USIE/CM | DEG C | NTU | MG/L | MG/L | MG/L | |
| 18/01/2016 10:50 | 86.6 | 25.9 | 0.86 | 0.4 | 8.2 | 1.7 | NaN | NaN | NaN | 8.02 | NaN | 0.0029 | 18.7 | 204 | 0.5 | NaN | 0.16 | 0.16 | NaN | |
| 22/02/2016 11:10 | 90.9 | 29 | 0.83 | 0.4 | 9 | 2 | NaN | 0.005 | 0.159 | 7.87 | NaN | 5.00E-04 | 17.2 | 201 | 2.1 | 0.41 | 0.19 | 0.14 | 5.00E-04 | |
| 15/03/2016 10:55 | 90 | 30.1 | 1.39 | 0.4 | 8.7 | 2.1 | NaN | 0.005 | 0.152 | 7.91 | NaN | 8.00E-04 | 18.8 | 213 | 2.3 | 0.39 | 0.15 | 0.15 | 5.00E-04 | |
| 11/04/2016 10:39 | 65.1 | 21 | 2.81 | 0.4 | 6 | 2.4 | NaN | 0.005 | 0.336 | 8.04 | NaN | 0.0054 | 13.7 | 160 | 4 | 2.68 | 0.38 | 0.37 | 7.00E-04 | |
| 17/05/2016 11:43 | 47.8 | 15.1 | 0.43 | 0.3 | 4.2 | 0.9 | NaN | 0.012 | 0.173 | 7.91 | NaN | 0.0112 | 9.16 | 113 | 8.1 | 4.16 | 0.28 | 0.22 | 5.00E-04 | |
| 21/06/2016 10:05 | 50 | 15.6 | 0.3 | 0.3 | 5.1 | 0.7 | NaN | 0.016 | 0.093 | 7.94 | NaN | 0.008 | 13 | 126 | 9 | 3.59 | 0.14 | 0.11 | 7.00E-04 | |
| 25/07/2016 10:57 | 29.9 | 10 | 0.11 | 0.3 | 2.8 | 0.5 | NaN | 0.036 | 0.04 | 7.72 | NaN | 0.0291 | 8.04 | 71.4 | 8.7 | 18 | 0.07 | 0.06 | 6.00E-04 | |
| 23/08/2016 9:40 | 36.5 | 12.1 | 0.19 | 0.3 | 3.2 | 0.4 | NaN | 0.005 | 0.053 | 7.88 | NaN | 0.0222 | 8.8 | 90.5 | 7 | 13.6 | 0.07 | 0.06 | 5.00E-04 | |
| 20/09/2016 10:40 | 46.8 | 18.5 | 0.29 | 0.3 | 5.3 | 0.8 | NaN | 0.005 | 0.071 | 7.9 | NaN | 0.0052 | 14.9 | 123 | 7 | 3.1 | 0.11 | 0.11 | 5.00E-04 | |
| 04/10/2016 14:20 | 0.5 | 0.1 | 0.05 | 0.1 | 0.1 | 0.2 | NaN | 0.005 | 0.002 | 5.77 | NaN | 5.00E-04 | 0.1 | 2 | 5.6 | 0.06 | 0.02 | 0.02 | 5.00E-04 | Note (1) |
| 04/10/2016 14:20 | 148 | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 7.71 | NaN | NaN | NaN | 150 | 5.6 | NaN | NaN | NaN | 0.1 | Note (2) |
| 18/10/2016 9:35 | 62.8 | 21.3 | 0.64 | 0.4 | 6.4 | 1.3 | NaN | 0.005 | 0.176 | 7.82 | NaN | 0.0033 | 18.1 | 156 | 4.5 | 1.01 | 0.19 | 0.19 | 5.00E-04 | |
| 15/11/2016 9:42 | 62 | 19.1 | 0.67 | 0.4 | 5.6 | 1.3 | NaN | 0.005 | 0.198 | 7.93 | NaN | 0.0019 | 13.7 | 145 | 3 | 1.11 | 0.23 | 0.22 | 0.0012 | |
| 13/12/2016 9:20 | 82.8 | 25.3 | 0.85 | 0.4 | 7.9 | 1.6 | NaN | 0.005 | 0.181 | 7.97 | NaN | 5.00E-04 | 18.5 | 197 | 0 | 0.44 | 0.2 | 0.21 | 5.00E-04 | |

* Jan-Apr, Extractable; May to December, Dissolved.

(1) This row is measurement of a blank

(2) TheTDP of 0.1 mg/L is judged erronous and was not used in the analysis.

# Appendix 3

## CTD Surveys
## Kinbasket and Revelstoke Reservoirs, 2017

**Roger Pieters and Greg Lawrence**
**University of British Columbia**

# CTD Surveys
# Kinbasket and Revelstoke Reservoirs, 2017

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[2] Civil Engineering, University of British Columbia, Vancouver, B.C. V6T 1Z4

Columbia Reach, Kinbasket Reservoir, 31 May 2018

Prepared for

Karen Bray
British Columbia Hydro and Power Authority
1200 Powerhouse Road
Revelstoke B.C. V0E 2S0

March 12, 2019

## Contents



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## 1. Introduction

This report examines CTD (conductivity-temperature-depth) profiles collected from Kinbasket and Revelstoke Reservoirs in 2017. These data were collected as part of year nine of the B.C. Hydro project "CLBMON-3 Kinbasket and Revelstoke Ecological Productivity Monitoring".*

## 2. Methods

### *Sampling stations*

Sampling Kinbasket and Revelstoke Reservoirs is challenging because of their size. The Columbia and Canoe Reaches of Kinbasket Reservoir stretch over 180 km (Figure A1). Revelstoke Reservoir is not quite as long, with 130 km between Mica and Revelstoke Dams. Kinbasket is particularly difficult to sample because of limited road access, the frequency and severity of wind storms, the presence of woody debris, and the absence of sheltered locations along much of the reservoir.

The location of the sampling stations is shown in Figure A1. Stations are numbered either from the dam or from the mouth of an arm. In Kinbasket there are five main stations: Forebay (K1fb), Middle (K2mi), Columbia Reach (K3co), Canoe Arm (Kca1), and Wood Arm (Kwo1). In Revelstoke there are three main stations: Forebay (R1fb), Middle (R2mi) and Upper (R3up). Station locations are given in Appendix 1.

Sampling was conducted in both reservoirs monthly from April to October 2017. A list of the profiles collected in 2017 is given in Appendix 2, and a summary is given in Tables 2.1 and 2.2.

In 2017, intensive CTD surveys were not undertaken in Kinbasket Reservoir, other than the occasional collection of a few additional casts in the main pool and Columbia Reach (Table 2.1). In Revelstoke Reservoir, intensive surveys focused on the reach between Revelstoke Dam and Downie Arm. A sequence of four intensive surveys was conducted between 29 August and 8 September 2017, and another sequence of six surveys between 29 September and 13 October 2017. Additional casts were collected during measurement of primary production, and these data are shown in Appendix 4.

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* Data collected prior to this program include profiles from Revelstoke Reservoir and the Mica Forebay (Watson 1984; Fleming and Smith 1988). Monthly profiles at four stations in Kinbasket Reservoir (2003, 2004 and 2005) and three stations in Revelstoke Reservoir (2003) were collected with an YSI multiparameter probe (K. Bray, personal communication).

### *Sea-Bird Profiler*

Profiles were collected using a Sea-Bird Electronics SBE 19plus V2 profiler with the following additional sensors:

- Turner SCUFA II fluorometer and optical back scatter (OBS) sensor,
- Biospherical QSP-2300L (4 pi) photosynthetically active radiation (PAR) sensor,
- Sea-Bird SBE 43 dissolved oxygen sensor, and
- Wetlabs CStar transmissometer (red with 25 cm path).

Secchi depths were collected with a 20 cm diameter black and white disk, lowered from the side of the boat away from the sun. The Secchi depth is given as the average of the depths at which the disk disappeared going down and reappeared going up. Multiplying the Secchi depth by 2.5 provides an estimate of the 1% light level (Figure A4).

***Pump problems*** From 2009 to 2011, the pump on the profiler did not turn on due to a problem with the setting of the parameter for the minimum conductivity frequency; for more detail see Appendix 3. The pump affects the temperature, conductivity, and dissolved oxygen readings. Even with the pump off, most of the temperature and conductivity data collected was satisfactory as the descent of the instrument forced water through the plumbing.

From 2012-2017, the minimum conductivity frequency was correctly set to zero. In 2012 casts were collected to evaluate the effect of having the pump turned off. For casts with the pump on and off, the temperature and conductivity data were very similar. However, having the pump off did affect the dissolved oxygen readings, and as a result the oxygen data for 2009-2011, other than confirming generally oxygenated conditions, were not accurate. The data for light transmission and fluorescence (Chla) are independent of the pump. For further detail see Pieters and Lawrence (2014a).

***Early descent*** After the Seabird is turned on:

- it is hung in the air for 60 sec,
- it is lowered into the water to soak for 90 sec, and
- at 150 sec from the start, the Seabird is lowered, beginning the descent.

The pump comes on half way through the soak at 105 sec (420 scans). However, in 2013, the descent had erroneously begun at 90 sec from the start, earlier than in previous years. As a result, the pump did not turn on until the Seabird was at a depth of 4-6 m. The data before the pump turned on was removed from the 2013 plots, and as a result most plots in 2013 began at 4-6 m depth. As observed in past years, the top 5 m is often relatively uniform, not unexpected given wind mixing in these large reservoirs. From 2014 to 2017, this problem did not occur as all casts were in the water before scan 420, and descent did not begin until after scan 420.

***Problem transmissometer data*** The transmissometer assesses the clarity of the water, returning a higher voltage when light transmission is higher (clearer water), and returning a lower voltage when less light is transmitted through the water (the water is more turbid). Other than lenses of turbidity, the readings in Kinbasket and Revelstoke Reservoir are generally fairly high (Figure F1e).

In 2016, the transmissometer data was observed to intermittently drop suddenly to very low readings (low voltage), or to have a low reading for the first part of the profile. This problem began in 2015, and service of the transmissometer in early 2016 did not resolve the problem. This intermittent change is likely the result of a mechanical fault in the cable between the transmissometer and the profiler. Line and contour plots of this data should be disregarded. No problems were observed in 2017.

**Table 2.1** Kinbasket surveys, 2017

| Date | FB K1 | K1.5 | MI K2 | CO K3 | CA Kcal | WO Kwol |
|---|---|---|---|---|---|---|
| 24-25 April | ✓ | | ✓ | ✓ | ✓ | ✓ |
| 15-16 May | ✓ | | ✓ | ✓ | ✓ | ✓ |
| 19-20 June | ✓ | ✓* | ✓✓ | ✓ | ✓ | ✓ |
| 10-11 July | ✓ | | ✓ | ✓ | ✓ | ✓ |
| 19 July | | ✓* | ✓✓ | | | |
| 14-15 August | ✓ | | ✓✓✓ | ✓✓ | ✓ | ✓ |
| 23 August | | ✓* | | | | |
| 11-12 September | ✓ | | | ✓ | ✓ | ✓ |
| 20 September | | ✓* | | | | |
| 16-18 October | ✓ | | | ✓ | ✓ | |

* Collected during measurement of primary production (See Appendix 3)

**Table 2.2** Revelstoke surveys, 2017

| Date | FB | MI | UP | Downie | |
|---|---|---|---|---|---|
| | | | | Rd0 | Rd1 |
| 18-19 April | ✓ | ✓ | ✓ | | |
| 23-24 May | ✓ | ✓ | ✓ | ✓ | ✓ |
| 12-13 June | ✓ | ✓ | ✓ | ✓ | ✓ |
| 21-22 June | ✓✓✓* | ✓✓*✓* | | ✓ | ✓ |
| 17-18 July | ✓* | ✓ | ✓ | ✓ | ✓ |
| 20 July | | ✓* | | | |
| 21-22 August | ✓* | ✓ | ✓ | ✓ | ✓ |
| 24 August | | ✓* | | | |
| 29 August | ✓+14 | ✓✓ | | | |
| 1 September | ✓+14 | ✓✓ | | ✓ | |
| 5 September | ✓+14 | ✓✓ | | ✓ | |
| 8 September | ✓+14 | ✓✓ | | ✓ | |
| 18-19 September | ✓* | ✓ | ✓ | | |
| 21 September | | ✓* | | | |
| 29 September | ✓+11 | | | | |
| 2 October | ✓+7 | | | | |
| 4 October | ✓+14 | ✓✓ | | ✓ | |
| 6 October | ✓+10 | | | | |
| 10 October | ✓+14 | ✓✓ | | ✓ | |
| 13 October | ✓+8 | | | | |
| 23-24 October | ✓ | ✓ | ✓ | | |

* Collected during measurement of primary production (See Appendix 3)

## 3. Results

We first look at the water levels and flows during 2017, shown in Figure A2, respectively. The first survey in Kinbasket Reservoir was undertaken on 24-25 April 2017 just before the time of minimum water level (4 May 2017, Figure A2a). The last survey was on 16-18 October 2017, when water level was beginning to decline from its peak in August and September. The center of the outlet from Kinbasket Reservoir is located 64.6 m below normal full pool.

In Revelstoke Reservoir there is normally little variation in water level (< 1.3 m), but from April to July 2017 the water level experienced many periods of below average level, though the water level did not go below normal minimum (Figure A2b). The mid-depth of the outlet at Revelstoke Dam is 28 m below full pool.

The major inflow and outflows to Kinbasket and Revelstoke Reservoirs are shown in Figures A2c and A2d, respectively. Inflow to Kinbasket is dominated by freshet, while inflow to Revelstoke alternates between inflow from Kinbasket Reservoir, and inflow from local freshet.

Next, consider the conductivity of the tributary inflows. For example, the main inflow to Kinbasket Reservoir, the Columbia River at Donald, was sampled under the Canada - British Columbia Water Quality Monitoring Agreement every two weeks from 1984-1995 including during ice-cover in winter. Water temperature, conductivity and flow for this period are shown in Figure A3. Water temperature varied from 12 to 19 °C in summer, and cooled to 0-5 °C in winter.

The conductivity of the Columbia River at Donald varied significantly over the year. In winter, the flow was more saline with a conductivity of 300-350 μS/cm. At the start of freshet in spring, the conductivity decreased rapidly to 150-200 μS/cm, about half of the winter value. During freshet, the contribution of more saline groundwater to the river is diluted by fresh snowmelt and rain. In the fall the conductivity gradually increased as the freshet flow declined. A similar pattern was seen for the Beaver, Goldstream and Illecillewaet rivers (Pieters et al. 2019b). This seasonal change in the conductivity of the inflow will assist in identifying water masses as discussed below.

### 3.1 Kinbasket Reservoir

***24-25 April 2017*** **(Figure B1)** Line plots for the surveys of Kinbasket Reservoir are shown in Figures B. In April 2017, the reservoir was slightly reverse stratified with temperature ranging from a low of 2.6 °C at the surface to approximately 4 °C at depth (Figure B1b). During this time, the outlet from Kinbasket Reservoir was 39 m below the surface, as marked with the dotted lines in Figure B1.

A slight increase in conductivity with depth was observed throughout the reservoir (Figure B1c). Note the Columbia Reach, K3co, had a higher conductivity of approximately 220 μS/cm (black, Figure B1c). The station at K3co is located at the former Kinbasket Lake, and the conductivity of the water below 80 m remained distinctly different (Figures B1c to B8c) and relatively unchanged (Figure B11c) throughout the summer, as observed in previous years.

In April 2017, the reservoir was generally very clear (high light transmission) with slightly reduced transmission at the bottom of Wood Arm (cyan, Figure B1d). Dissolved oxygen was high (>10 mg/L) throughout the reservoir (Figure B1e). The nominal concentration of chlorophyll was relatively low and uniform, not unexpected for this time of year (Figure B1g). The 1% light level determined from PAR is marked with dashed lines; the 1% light level varied between 25 and 35 m.

***15-16 May 2017* (Figure B2)** The temperature shows the start of seasonal stratification, with surface temperature ranging from 4 to 5.5 °C (Figure B2b). During this time, the outlet from Kinbasket Reservoir was 41 m below the surface, as marked with the dotted lines in Figure B2.

The conductivity in the top 50 m shows a slight reduction due to freshet inflow. Light transmission is beginning to decrease, particularly in Wood Arm (Figure B2d). Slight peaks (<1 μg/L) in nominal chlorophyll are observed at all sites, near the depth of the 1% light level (Figure B2g).

***19-20 June 2017* (Figure B3)** In June 2017 the reservoir finally shows signs of significant temperature stratification with surface temperature from 12 to 13 °C (Figure B3b), and showing the beginnings of a broad thermocline extending from the surface to 50 m depth. The conductivity in the top 60 m continued to decline, most noticeably in the Canoe Reach (green, Figure B3c).

The solubility of oxygen is sensitive to temperature, and decreases as temperature increases. As the surface water warms, it can hold less oxygen, and this is reflected in the slight decline in dissolved oxygen concentrations in the top 60 m (Figure B3e). To remove the effect of temperature, dissolved oxygen is also plotted as percent saturation (Figure B3f). The dissolved oxygen was close to 100% saturation near the surface and remained > 80% at depth, indicating that the water was well oxygenated as would be expected for an oligotrophic system (Figure B3f). Distinct peaks in chlorophyll occur ranging from 1 to 1.7 μg/L (Figure B3g). The peak at 25 m in Wood Arm (cyan, Figure B3g) is likely the fluorescence of the turbid inflow at this depth (cyan, Figure B3d).

***10-11 July 2017* (Figure B4)** In July, surface temperature varied from 13 to 17 °C (Figure B4b). As in June, there was a broad thermocline, extending from the surface to 60 m depth. For conductivity, the most notable feature is again the decline in the conductivity in the top 60 m, especially in the Canoe and Columbia Reaches (Figure B4c).

The turbidity showed layers of very high turbidity (low light transmission) in Wood Arm (cyan ), and the Columbia Reach (black, Figure B4d). In July, the chlorophyll layer was between 5 and 20 m depth, and similar in magnitude to that observed in previous months (Figure B4g).

***14-15 August 2017*** **(Figure B6)** The temperature at the surface was 16 - 18 °C at all stations, and the broad thermocline extended to about 60 m (Figure B6b). The stratification is slightly reduced in the top 5-10 m in several of the casts, suggesting some surface mixing. The conductivity of the surface layer continued to decline in the Columbia Reach (Figure B6c). All stations showed layers of turbidity between 20 and 50 m, with the highest turbidity in Wood Arm as usual (cyan, Figure B6d).

***Fall 2017*** **(Figures B7 and B8)** By mid-September the surface had cooled to 16 °C and some profiles showed a surface mixed layer up to 10 m depth (Figure B7b). By mid-October the surface had cooled to 12 °C, and a distinct surface mixed layer was observed to 40 m depth (Figure B8b).

***Seasonal changes*** Seasonal changes at the Forebay (K1fb), Middle (K2mi), Columbia (K3co), Canoe (Kca1) and Wood (Kwo1) stations, are shown respectively in Figures B9 to B13. To account for the increase in the water level, the casts are plotted relative to full pool, 754.4 mASL. There is a distinct increase in the deep conductivity from April and May to June 2017. After June 2017, changes in temperature and conductivity below 60 m are small. Oxygen below 60 m declined only slightly ($\leq$ 2 mg/L) over the summer.

***Contour plots*** The profiles along the length of Kinbasket Reservoir are shown as contour plots in Figures C1 to C7. Each contour shows from left to right: Canoe Reach (Kca1), the main pool (K2mi) and Columbia Arm (K3co). The exceptions were September and October 2017 when data at the forebay, K1fb, was shown to replace the missing data at K2mi (Figures C6 and C7).

Contour plots highlight variations along the reservoir; however, care must be taken when interpreting features between the stations marked. Note, the black line does not give the bathymetry along the thalweg, but simply connects the maximum depth from the sounder at each station. The approximate depth of the outlet is marked with a white circle. The 1% light level is given by black bars in the last panel of each figure.

After the reservoir stratified (June onward), the temperature was relatively uniform along the reservoir during each survey (Figure C3a to C7a). As the summer progressed, the conductivity was lowest in Canoe Reach (e.g. June 2017, Figure C3b), but a distinct layer of low conductivity also appeared in the top 60 m in the Columbia Reach (e.g. July 2017, Figure C4b). Light transmission was generally high (turbidity low) in the deep (> 60 m) water. Lenses of turbidity were observed in the thermocline at different times and locations along the reservoir (Figures C3c to C7c). Oxygen was generally high (e.g.

Figures C1d to C7d). Chlorophyll is generally low, with peaks well below 2 µg/L in the top 20 m, just above the 1% light level (marked by black bars, e.g. Figures C3e to C7e).

### 3.2 Revelstoke Reservoir

In 2017, the outflow from Kinbasket was low in May and June (blue, Figure A2d), the typical pattern seen in many of the study years. During this time the freshet from local tributaries dominated the inflow (black, Figure A2d).

***April to July 2017*** On 18-19 April 2017, Revelstoke Reservoir was unstratified or slightly reverse stratified with relative uniform temperature from top to bottom of 2 to 4 °C (Figure D1b). The conductivity was also relatively uniform in April (160 µS/cm), light transmission and dissolved oxygen were both uniform and high (Figure D1d,e,f), and chlorophyll levels were generally low, and uniform (Figure D1g).

By 23-24 May 2017, the top 30 m was slightly stratified with a surface temperature reaching 12 °C (Figure D2b). At this time the conductivity of the top 30 m was just beginning to decline (Figure D2c), and turbid plumes are beginning to be observed (Figure D2d).

By June 2017, thermal stratification was well established with surface temperature reaching 14 °C, and a broad temperature gradient to 60 m depth (Figures D3b and D4b). By this time, the conductivity of the near surface of the reservoir had declined significantly, especially in the upper reaches of the reservoir (Figures D3c and D4c). There were decreases in light transmission (increases in turbidity) consistent with freshet inflow (Figures D3d and D4d). In addition, there were also small peaks in chlorophyll (~ 1 µg/L) just above the depth of the 1% light level, suggesting an increase in biological activity (Figures D3g and D4g).

By July 2017, thermal stratification continued to develop with surface temperature reaching 19 °C (Figure D5b). The conductivity of the top 50 m of the reservoir continued to generally decline due to freshet inflow (Figure D5c). Chlorophyll fluorescence showed peaks of 1 to 1.5 1 µg/L near the depth of the one percent light level (Figure D5g).

***August to October 2017*** By the end of July 2017, the top 50 m of Revelstoke Reservoir was dominated by local inflow, as indicated by the reduced conductivity from the surface to about 50 m depth (Figure D5c). Beginning in mid-June, the outflow from Kinbasket Reservoir increased, and an interflow of (1) cooler, (2) higher conductivity and (3) less turbid water from Kinbasket Reservoir can be observed passing through Revelstoke Reservoir at 20 to 40 m depth. This interflow was first observed at the station closest to Kinbasket Reservoir (e.g. at R3up on 17 July 2017, Figure D5c). By the middle of August, the effect of the interflow was clearly visible at Revelstoke Forebay (Figure D6c).

The effect of the Kinbasket interflow can be also be seen in the temperature data. While there remains a gradient in temperature through the depth of the interflow (from 8-10 °C), this gradient was small compared to the gradients above and below the interflow (Figures D5b to D18b). By 23-24 October 2017, the interflow had reached the surface (Figure D18b).

Comparison of casts in the forebay (e.g. Figure D19) indicate slight changes to the deep water (> 60 m) throughout the summer, with a slight increase in temperature and a decrease in conductivity, likely due to a small degree of exchange with overlying water. The decrease in oxygen over the summer was < 2 mg/L.

***Contour plots*** The contours are shown on the same scale in each (e.g. temperature is show from 2.5 to 20 °C in each figure). However, the intensive surveys are shown with adjusted scales to better highlight features in the figures. For example, in Figures E7 to E10 (29 August to 8 September 2017) temperature is shown from 4 to 19 °C, and in Figures E12 to E17 (29 September to 13 October 2017) temperature is shown from 4 to 14 °C.

## 4. Discussion

### *Trophic Status*

As an indicator of trophic status, Wetzel (2001) gives the following general ranges for chlorophyll concentrations:

- 0.05-0.5 µg/L ultraoliogotrophic;
- 0.3-3 µg/L oligotrophic; and
- 2-15 µg/L mesotrophic.

The low concentrations of chlorophyll in both Kinbasket and Revelstoke Reservoirs (< 2 nominal µg/L) are consistent with oligotrophic conditions.

The reduction in hypolimnetic oxygen over the summer was low in both Kinbasket (< 2 mg/L) and Revelstoke Reservoirs (< 2 mg/L). The use of hypolimnetic oxygen demand as an indicator of trophic status comes with a number of caveats (Wetzel 2001), including the problem of decomposing allochthonous debris. The declines in hypolimnetic oxygen over the summer in Kinbasket and Revelstoke Reservoirs are consistent with oligotrophy, and are comparable to those observed in oligotrophic Harrison Lake (0.3 mg/L, Pieters et al. 2002) and Coquitlam Reservoir (1.5 mg/L, Pieters et al. 2007).

### *Circulation and nutrients*

Both Kinbasket and Revelstoke Reservoirs display unusually broad and deep thermoclines. Typically, thermal structure in summer is dominated by surface heat fluxes and wind. The thermal structure observed in Kinbasket and Revelstoke Reservoirs suggests that high inflow, short residence time (< 1 yr), and deep outlets (in 2017 ranging from 39 to 65 m in Kinbasket and at 29 m in Revelstoke) may also be important.

The variation in the conductivity of the tributary inflows provides a tracer that can be used to identify water masses. Both Kinbasket and Revelstoke Reservoirs had a surface layer of reduced conductivity, which suggests surface waters contain a significant fraction of freshet inflow.

Based on the given data we can tentatively sketch the circulation of Kinbasket and Revelstoke Reservoirs and speculate on the supply of nitrate. As described in Pieters et al. (2018a), late spring and summer can be broken into two periods based on flow: May to June, and July to September. In the first period of May and June, the top 30 m of Kinbasket Reservoir is filled with freshet inflow and there is little outflow from Mica Dam (Figure A2c). The lack of outflow from Mica Dam means that the circulation in Revelstoke Reservoir is dominated by local inflow during this time (Figure A2d). During the second period of July to September, the tail of the freshet is passed through Mica and, in Revelstoke Reservoir, this water forms an interflow directly to the outlet at Revelstoke

Dam (e.g. Figure E7b). This interflow appears to be below the photic zone (Figure E7e). If this occurs, nutrients from Mica will short circuit below the photic zone until fall cooling mixes the interflow into the surface layer later in October. However, profiler data - for example, from mid-September to mid-October 2012 (Pieters and Lawrence 2014b) - suggests that internal wave motions can bring the interflow into the photic zone for significant periods of time. Internal motions can also be seen on, for example, 5 September 2017 when the internal deflections were large, and part of the interflow (Figure E9b) was in the photic zone (Figure E9e).

**Acknowledgements**

Profiles were collected by B. Manson, P. Bourget and K. Bray. We gratefully acknowledge funding provided by B.C. Hydro. We thank A. Baysheva, J. Bowman, A. Sharp, K. Lywe, T. Rodgers, C. Huang, A. Law, A. Quainoo, and P. Buskas for assistance with data processing, and the UBC Work-Learn program for salary subsidy. We thank R. Pawlowicz for helpful discussions of instruments and data.

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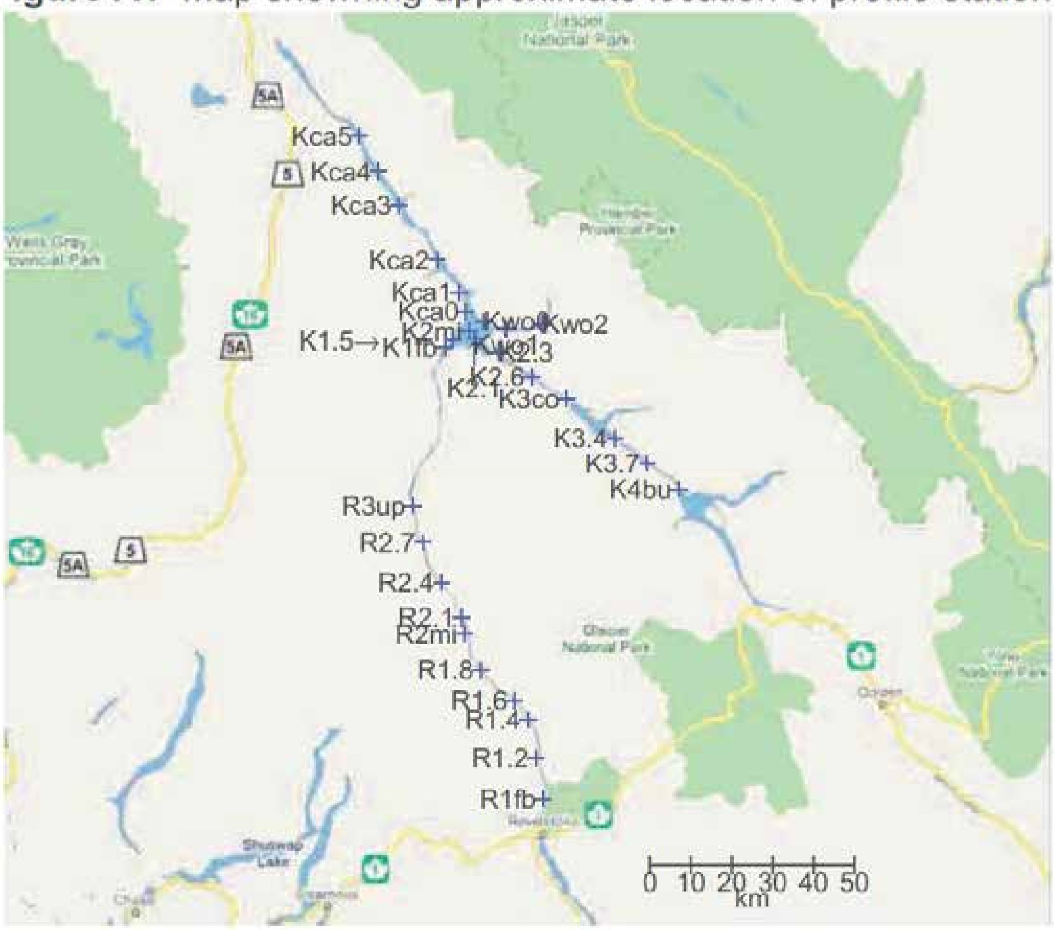
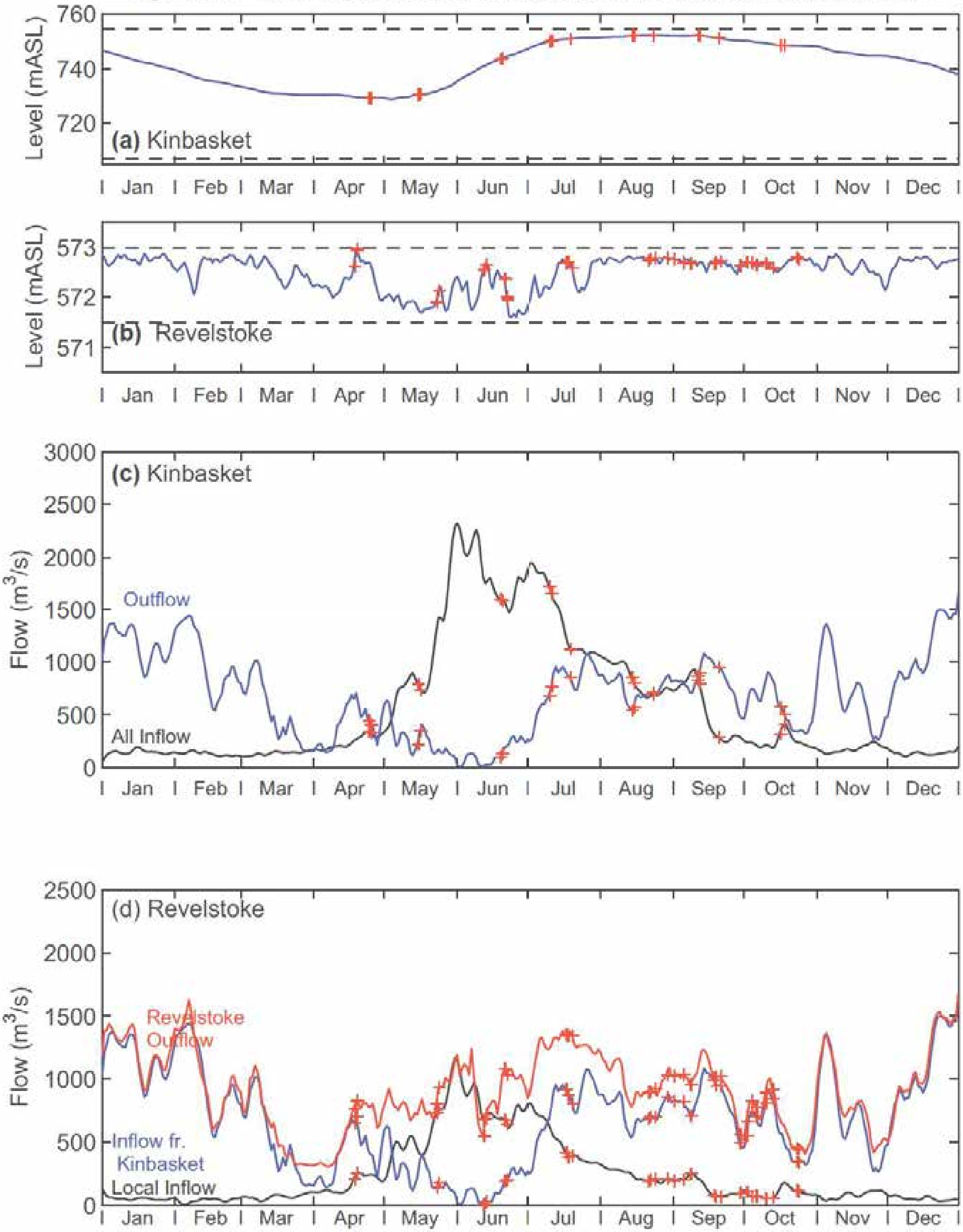
**Figure A1** Map showning approximate location of profile stations



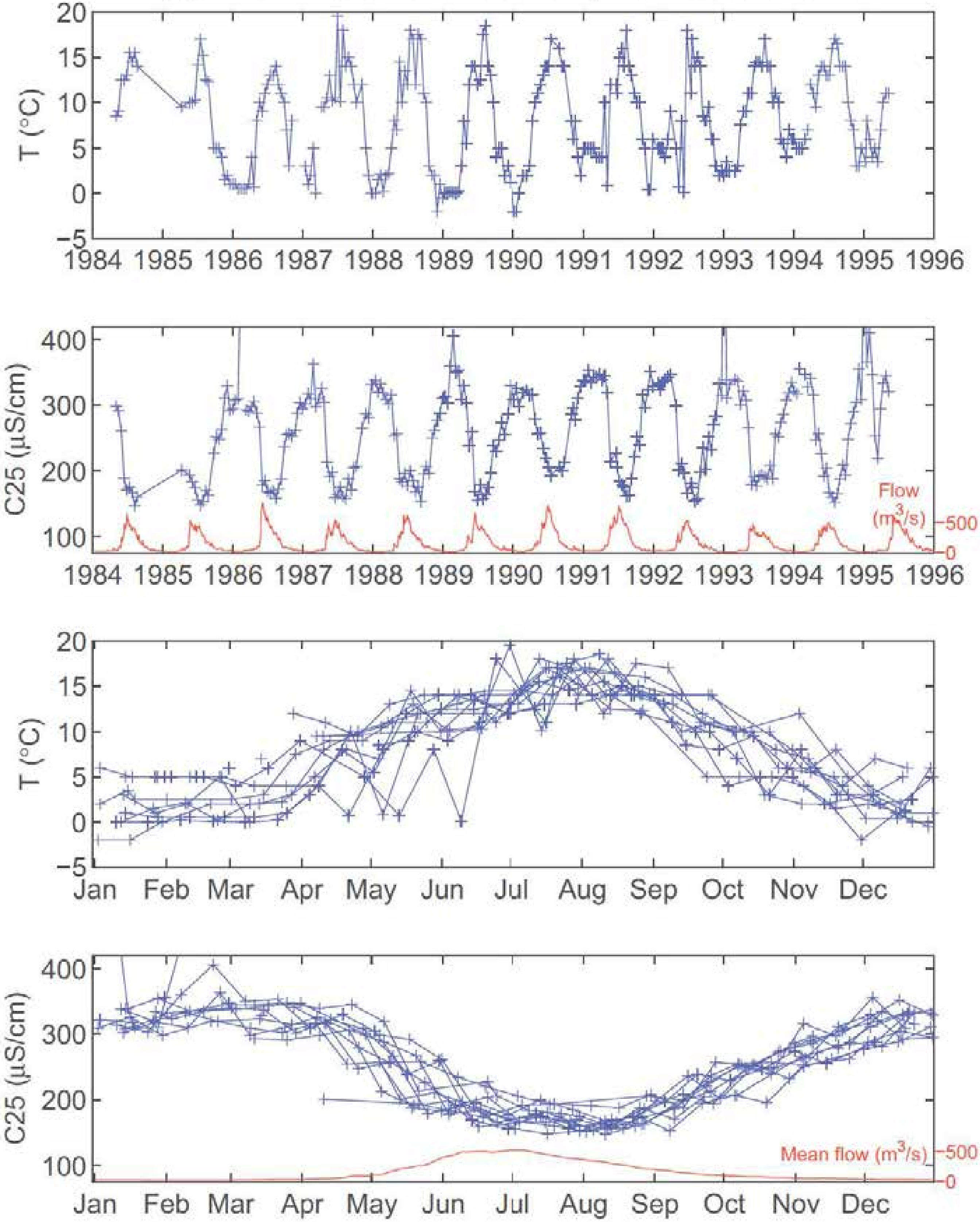

/ocean/rpieters/kr/bathy/map/map1REP09.m fig= 1 2011−Jan−26

Figure A2 Water level and flow, Kinbasket and Revelstoke Reservoirs, 2017



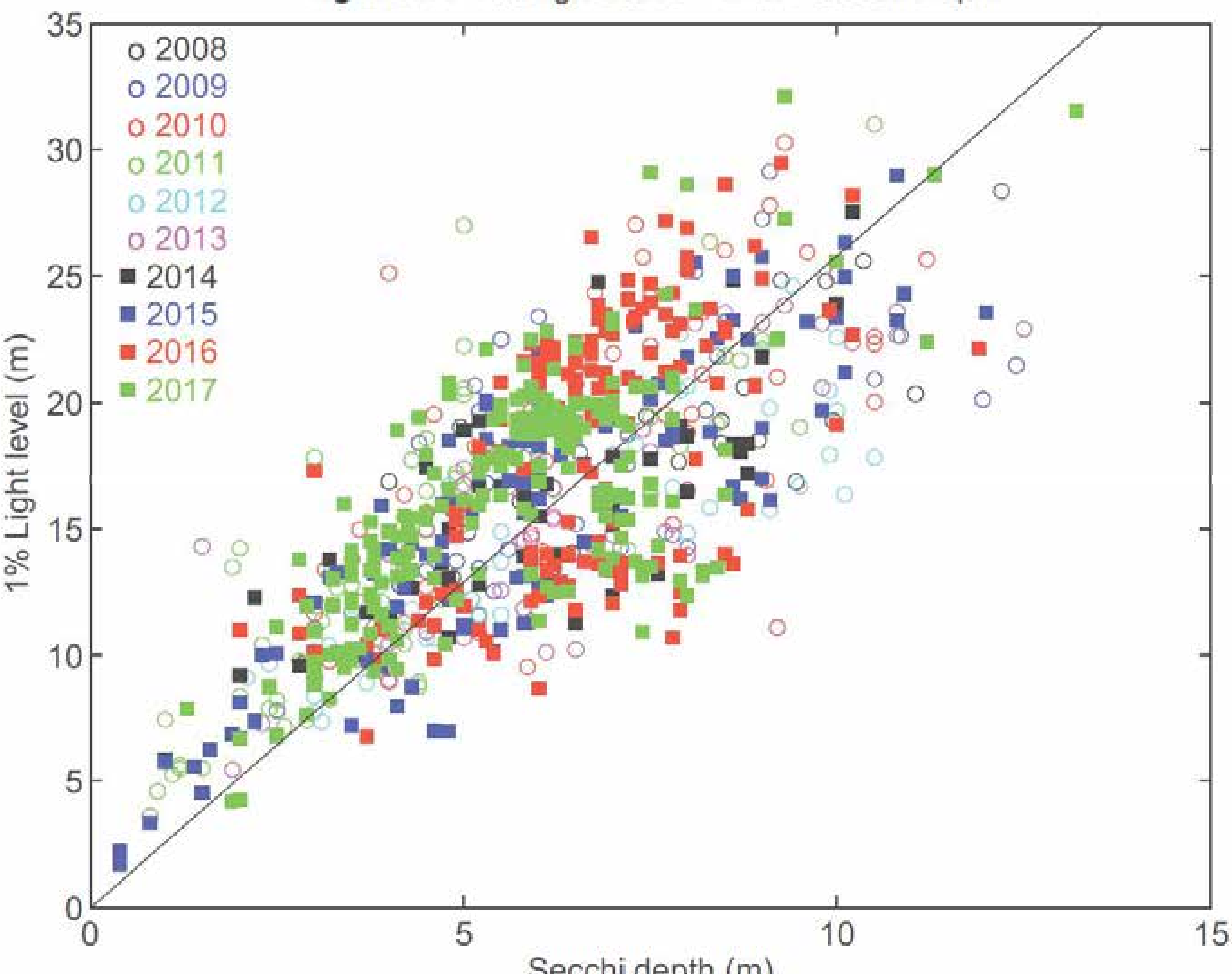

/ocean/rpieters/kr/flow/plot/localflow2017.m fig= 1 2019-Mar-08

**Figure A3** Columbia River at Donald, T and C25, 1984−1995




/ocean/rpieters/kr/flow/ecan/plot/plotcoldo.m fig= 1 2009−Jun−01

**Figure A4** 1% Light Level = 2.5 X Secchi Depth




/ocean/rpieters/kr/sbe/info17/plotsecchi08to17.m fig= 1 2018−Mar−13

**Figure B1** Kinbasket Reservoir, 24–25 Apr 2017

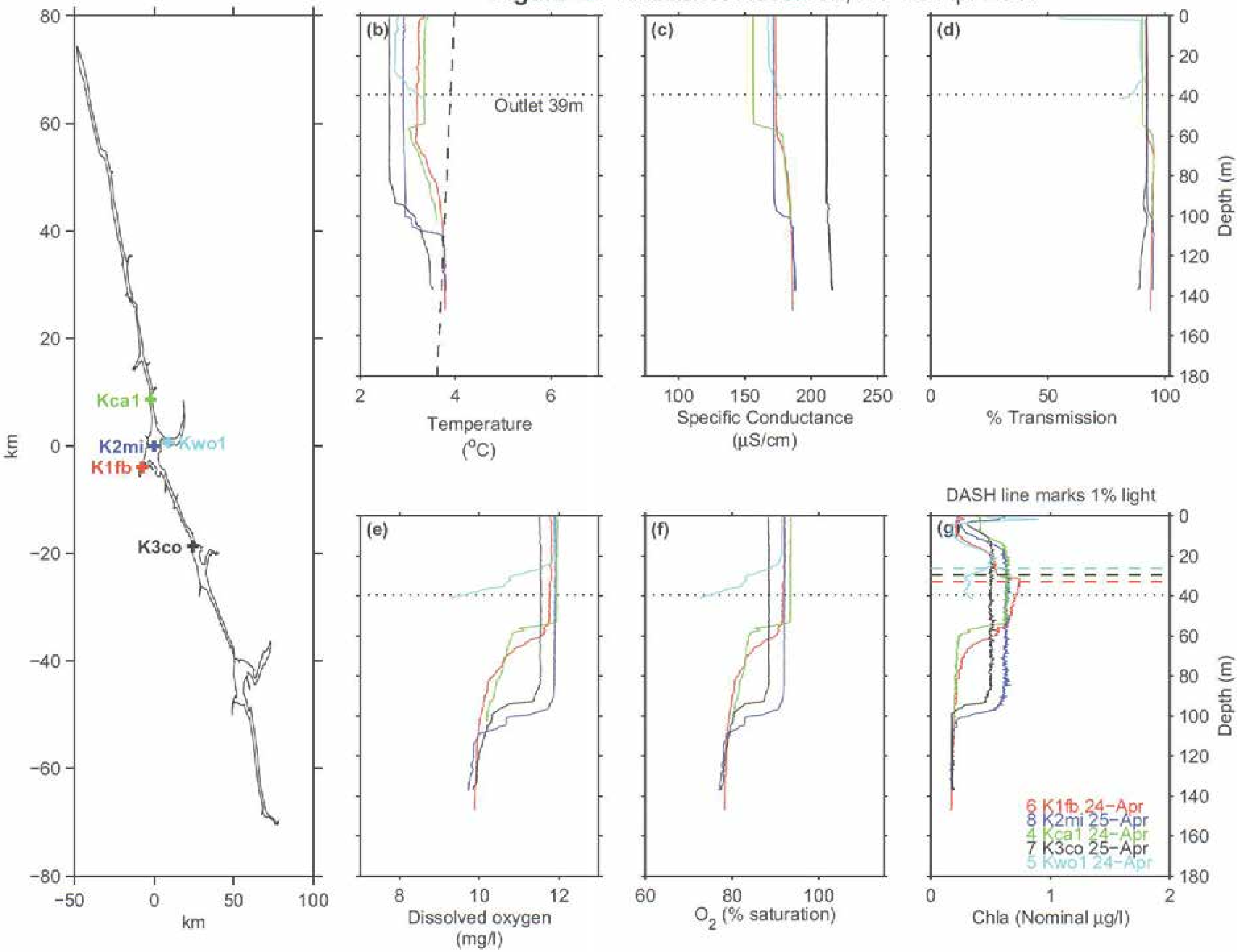


**Figure B2** Kinbasket Reservoir, 15−16 May 2017

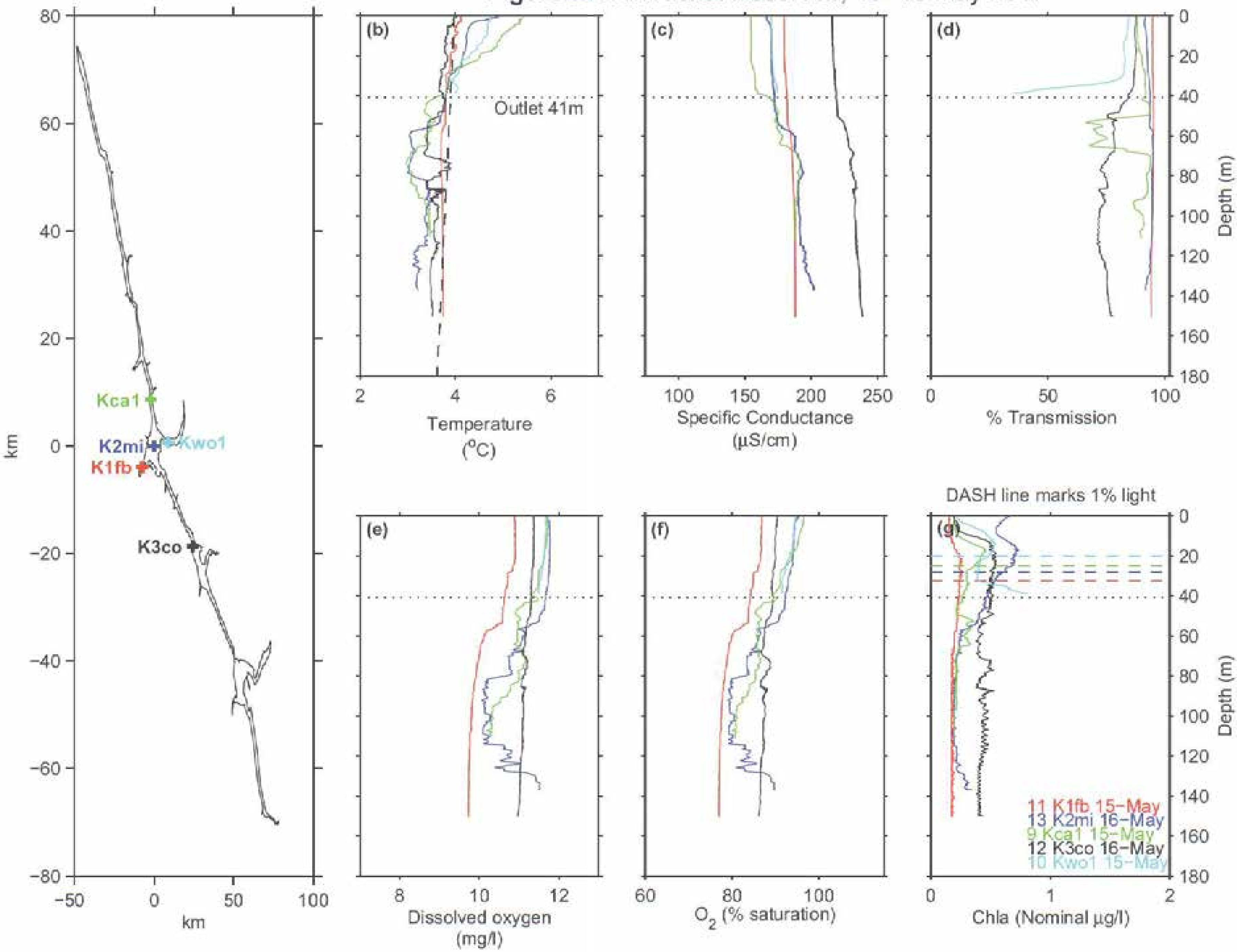


**Figure B3** Kinbasket Reservoir, 19–20 Jun 2017

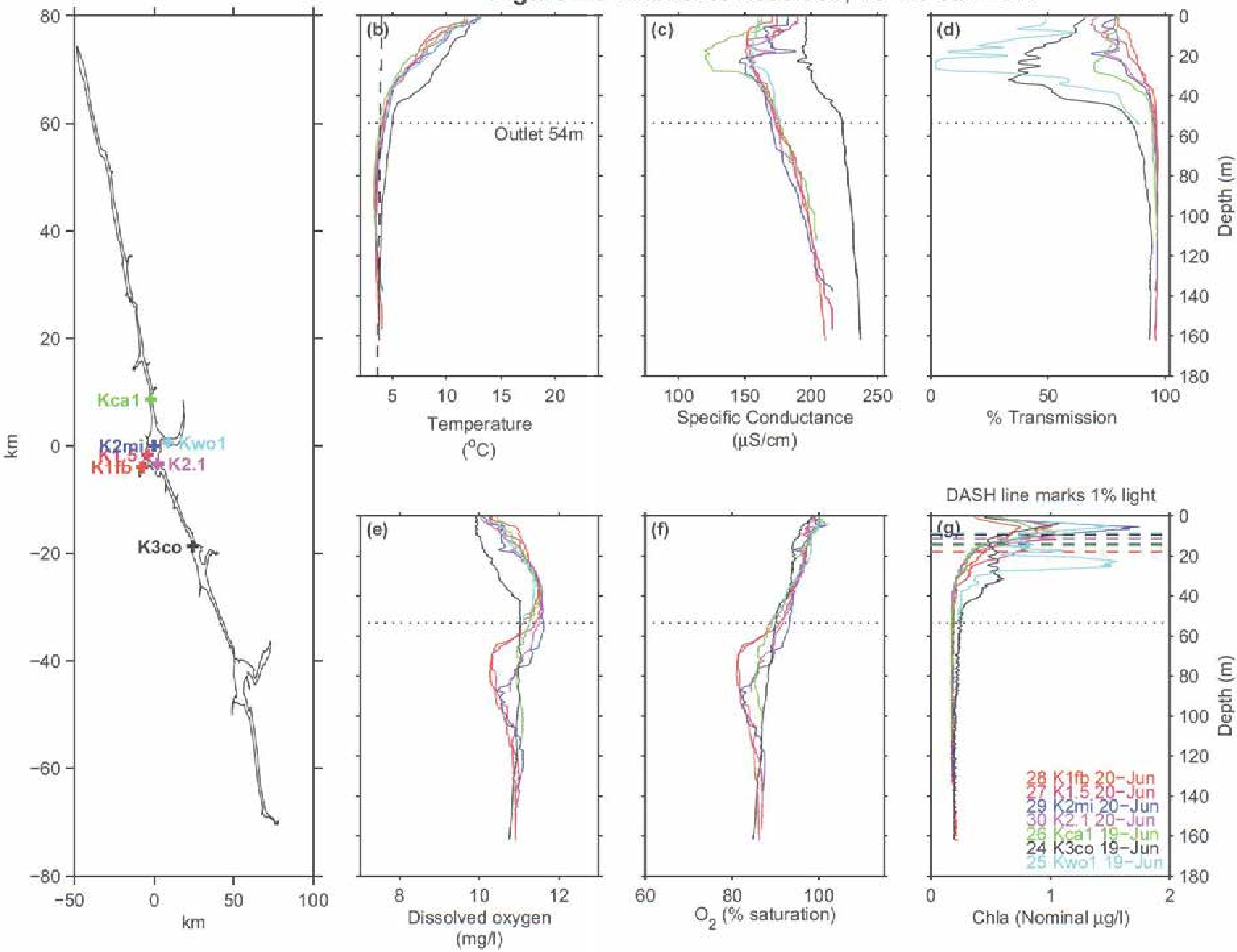


**Figure B4** Kinbasket Reservoir, 10−11 Jul 2017

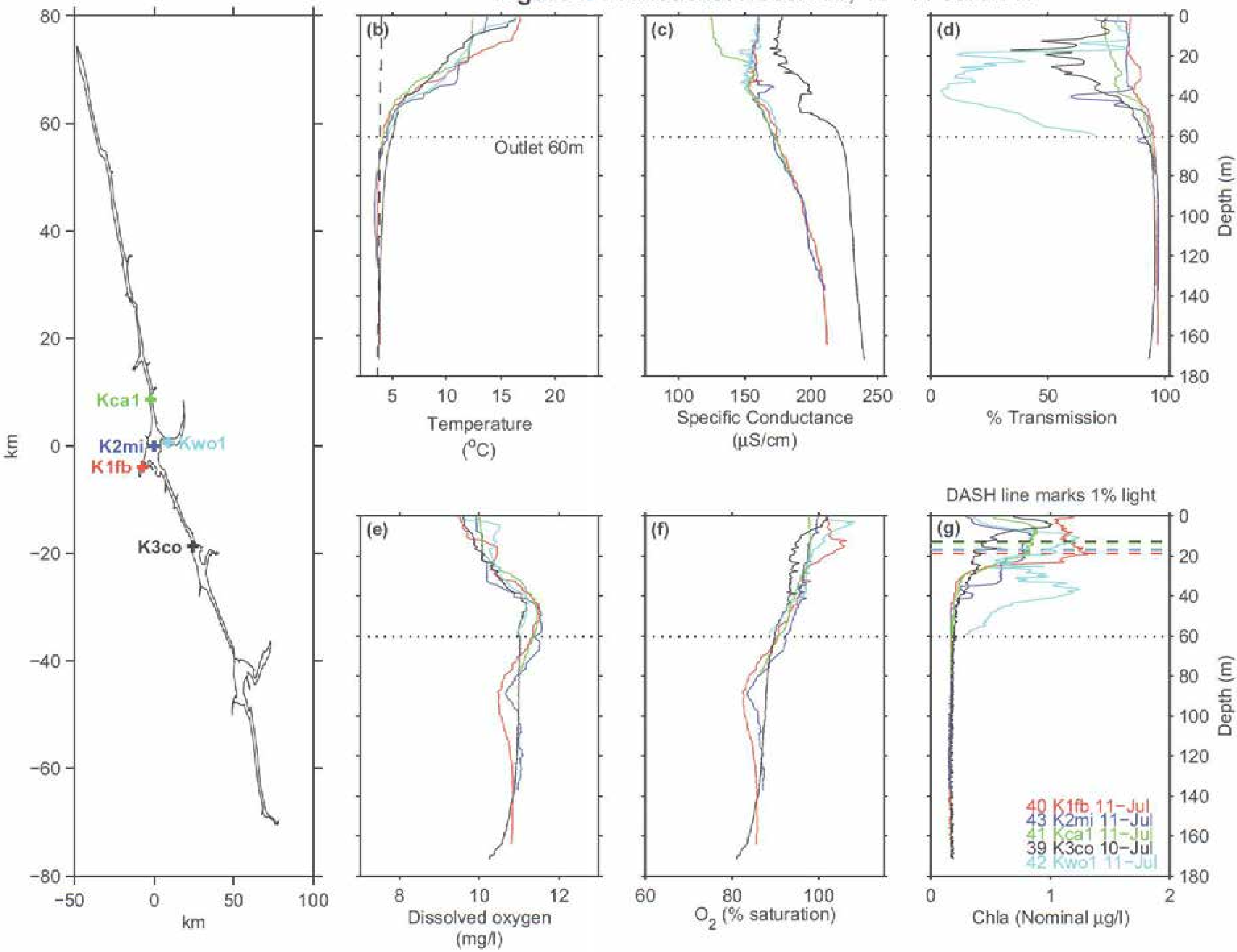


**Figure B5** Kinbasket Reservoir, 19 Jul 2017

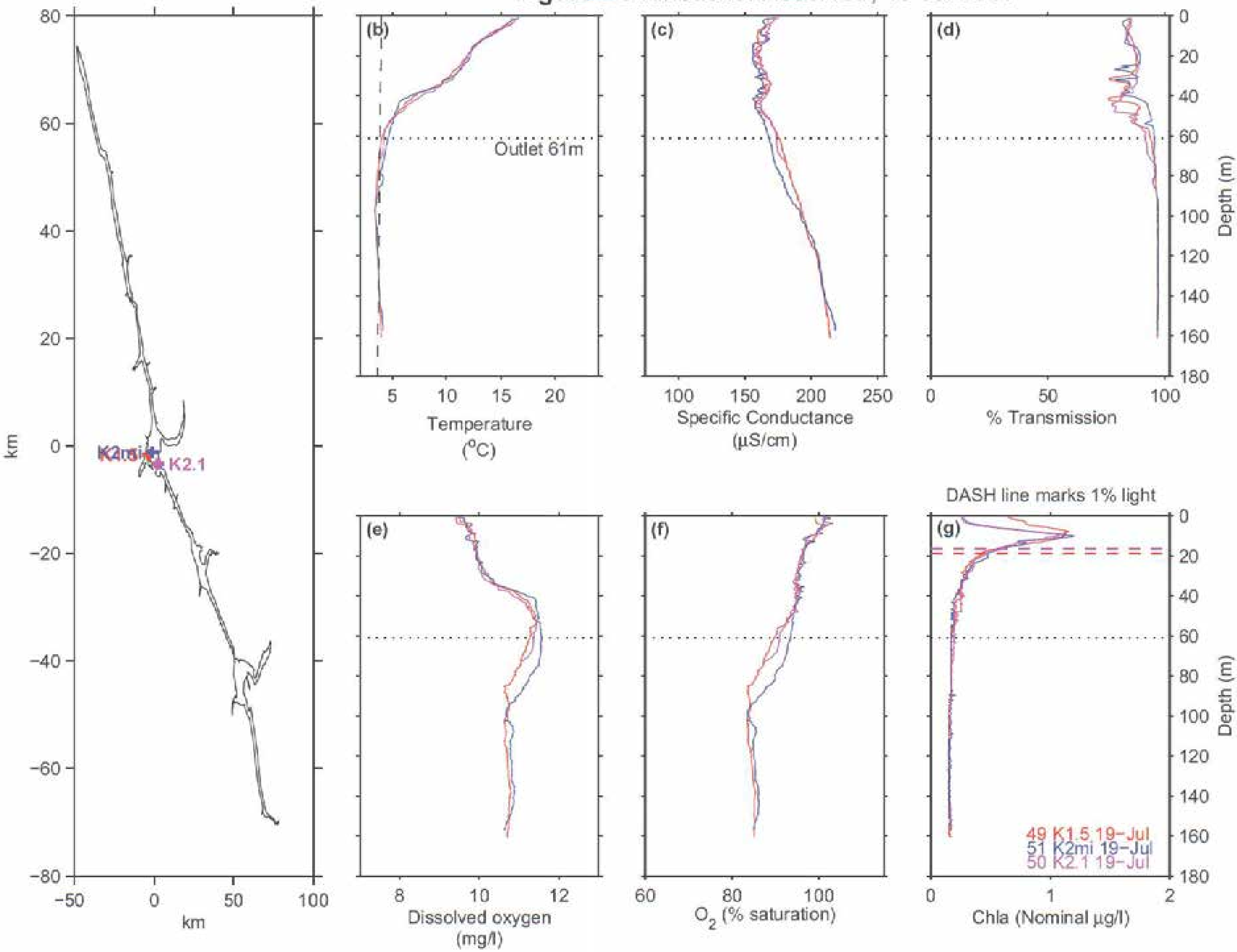


**Figure B6** Kinbasket Reservoir, 14−15 Aug 2017

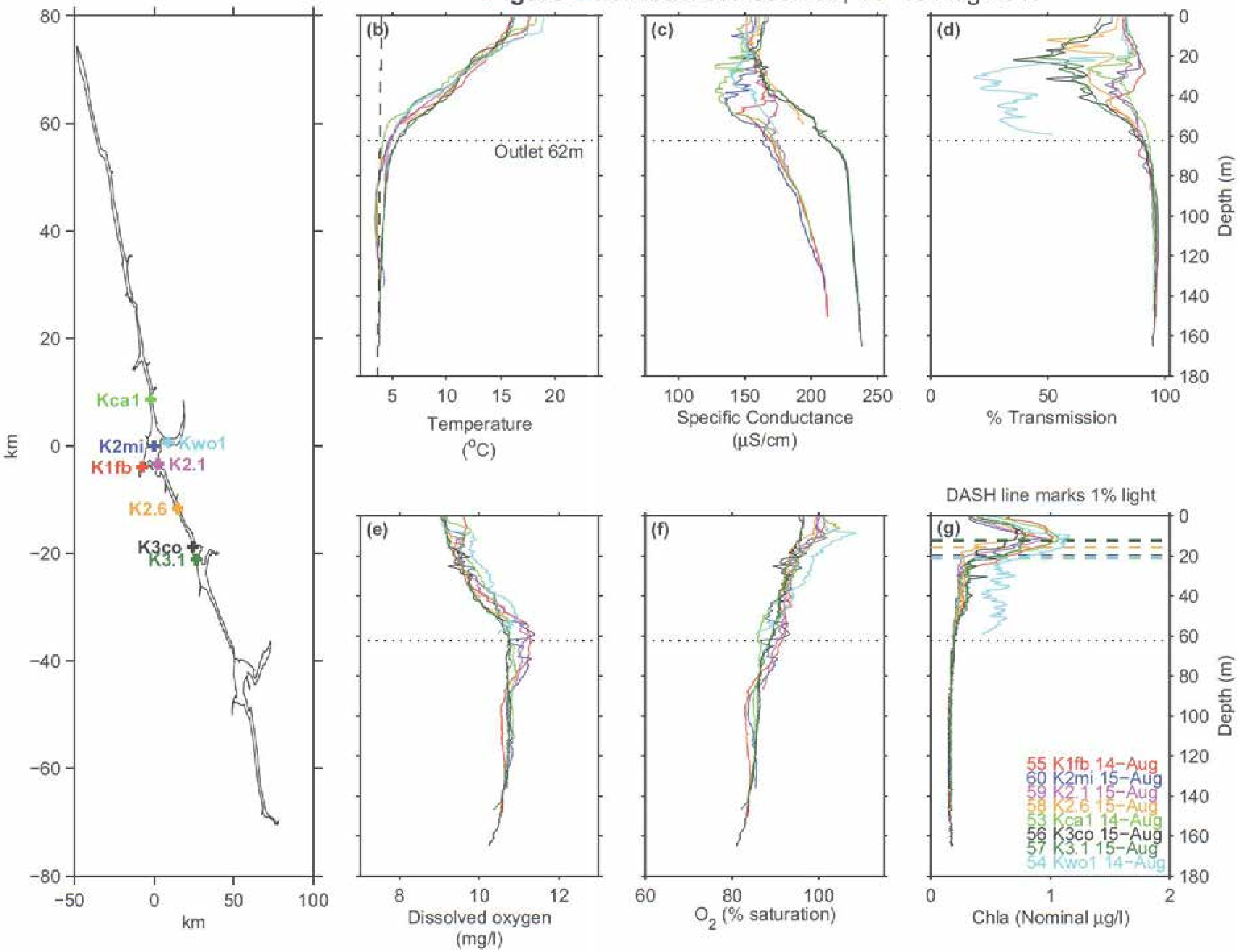


**Figure B7** Kinbasket Reservoir, 11−12 Sep 2017

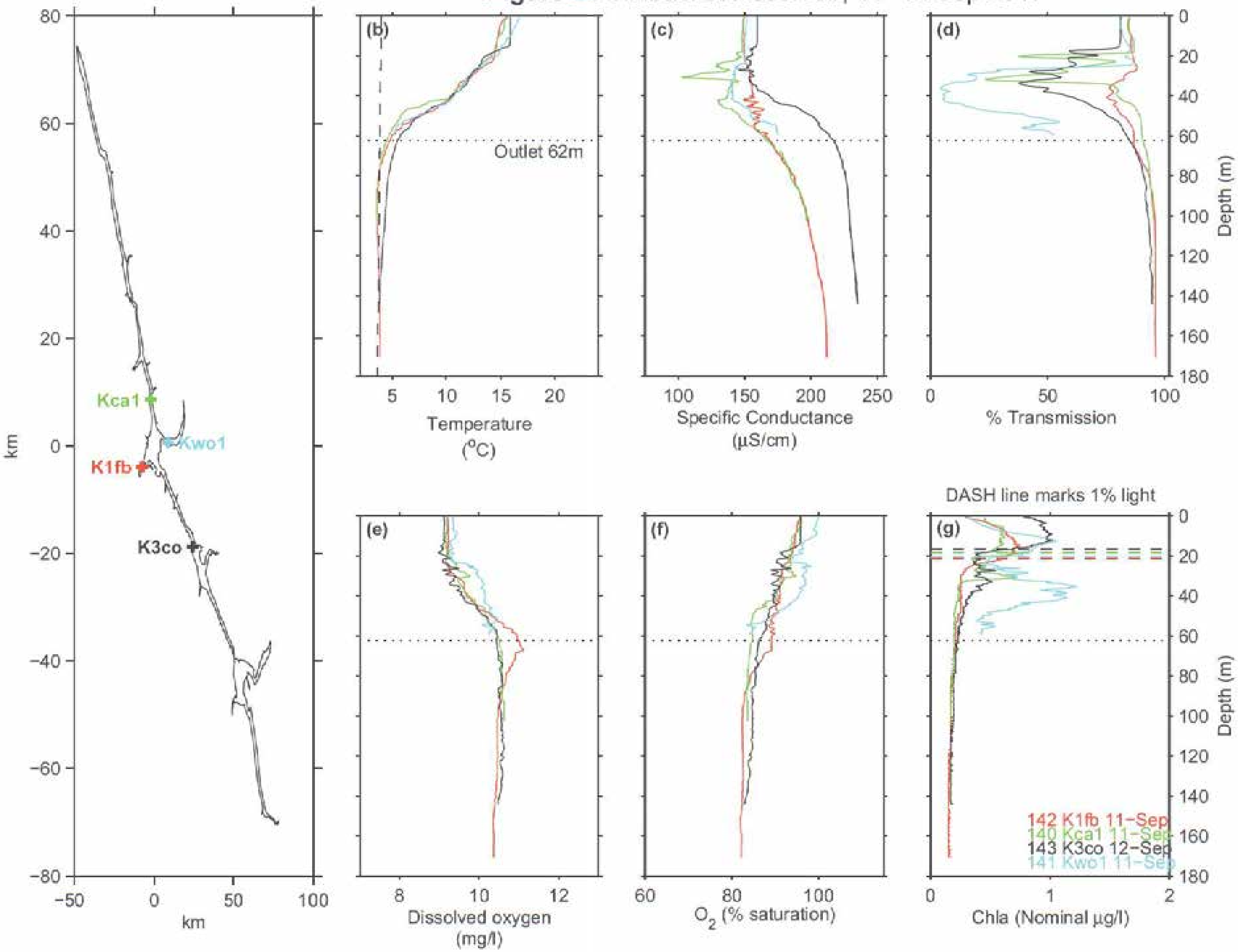


**Figure B8** Kinbasket Reservoir, 16−18 Oct 2017

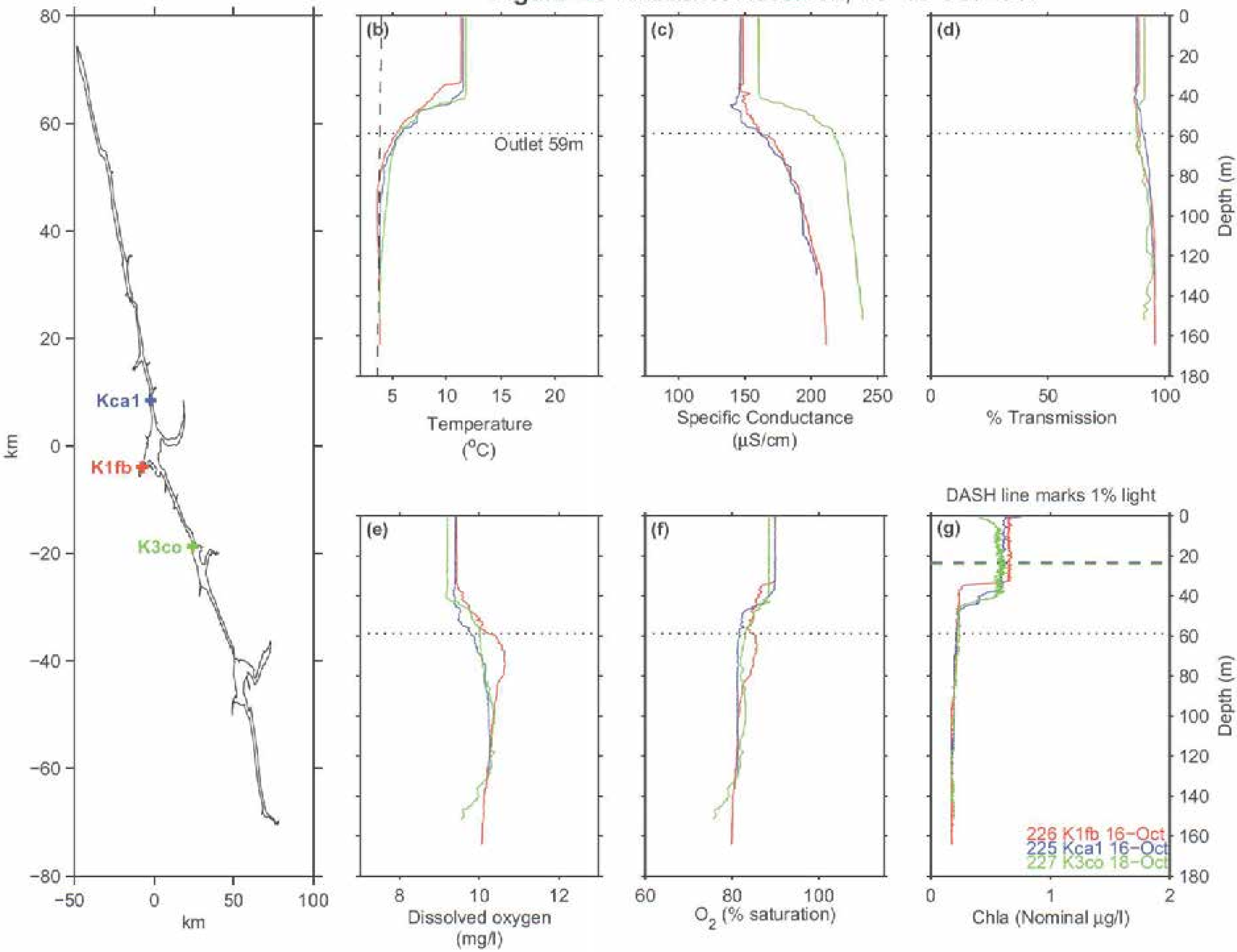


**Figure B9** Kinbasket Reservoir, Forebay, K1fb, 2017

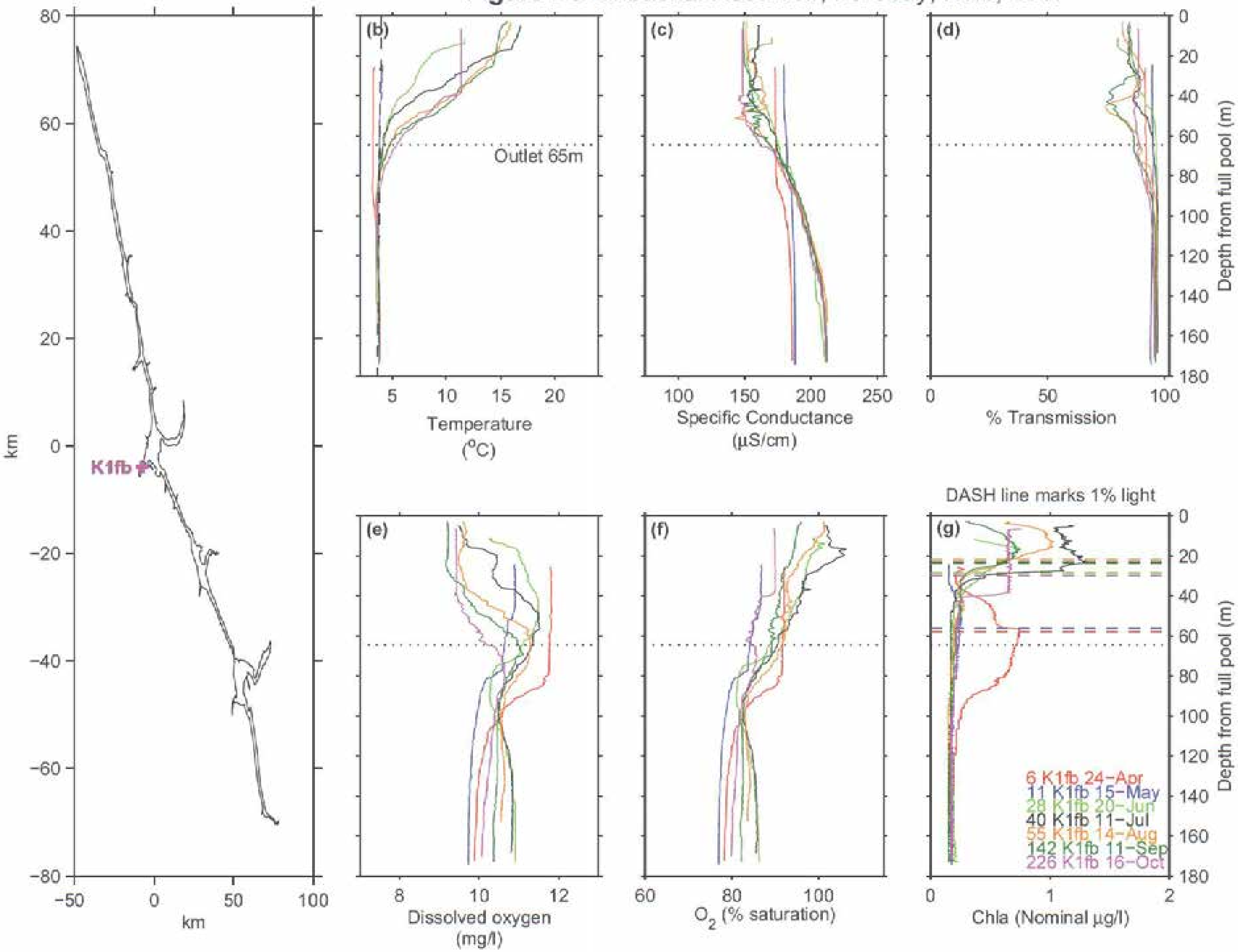


**Figure B10** Kinbasket Reservoir, Middle, K2mi, 2017

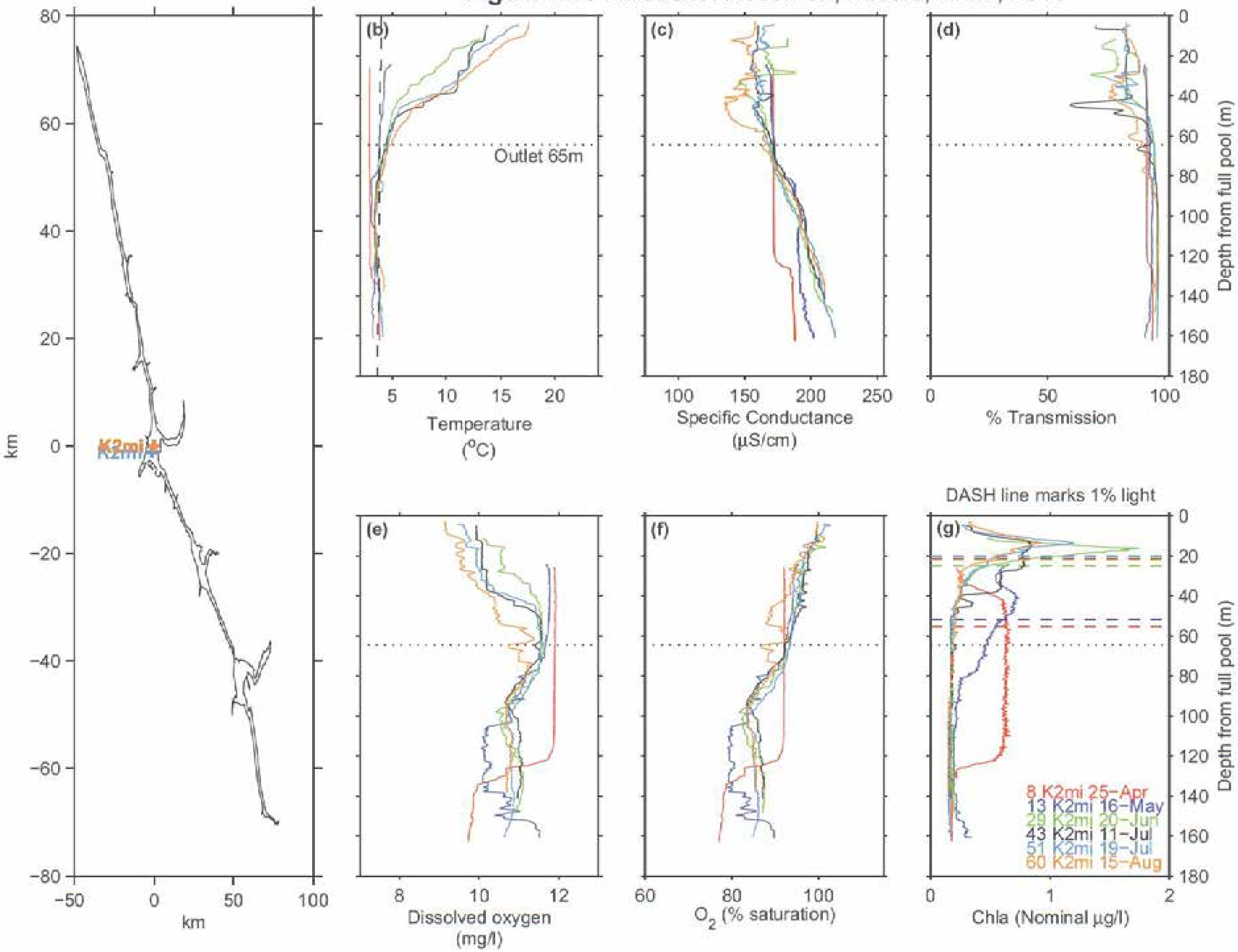


**Figure B11** Kinbasket Reservoir, Columbia, K3co, 2017

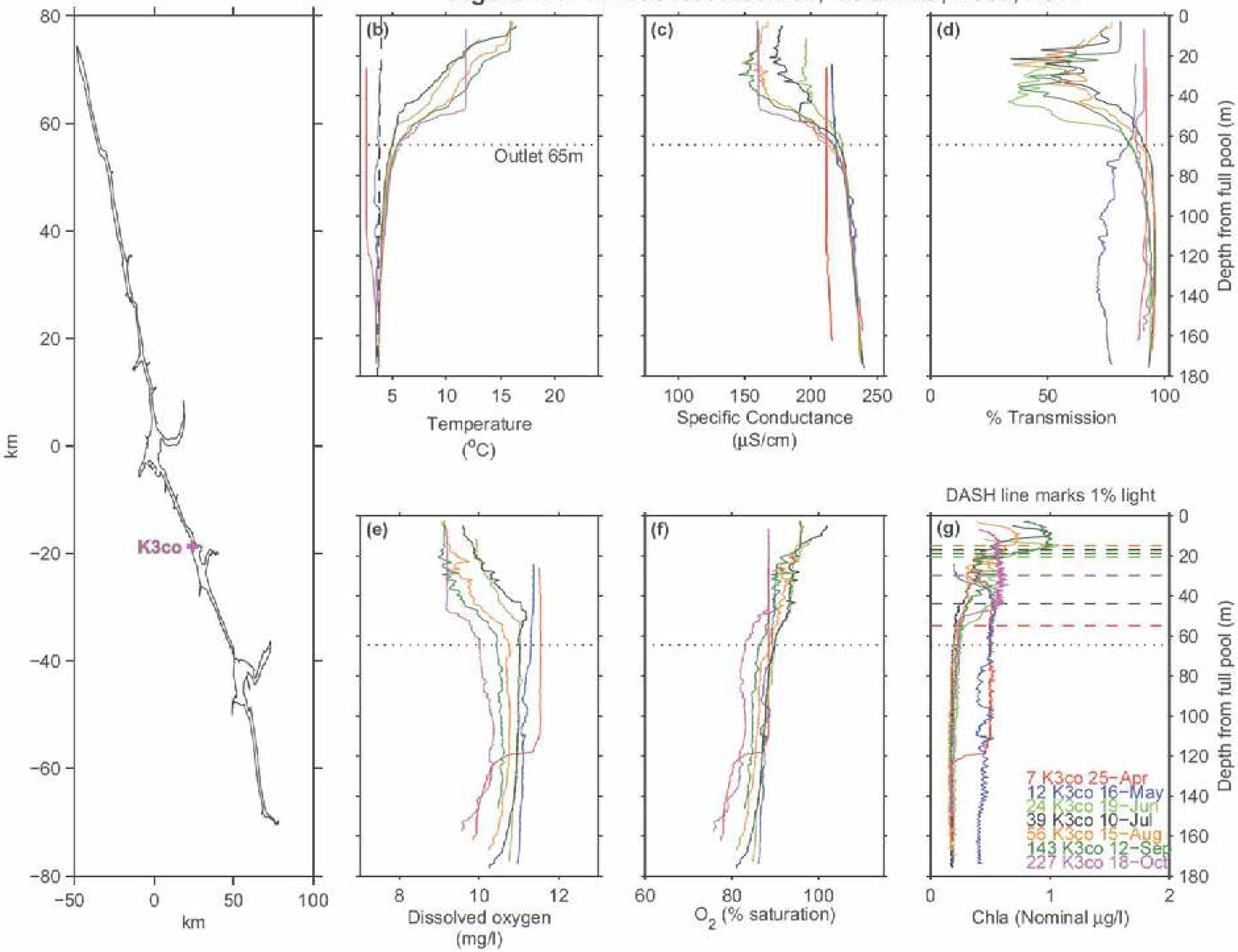


**Figure B12** Kinbasket Reservoir, Canoe, Kca1, 2017

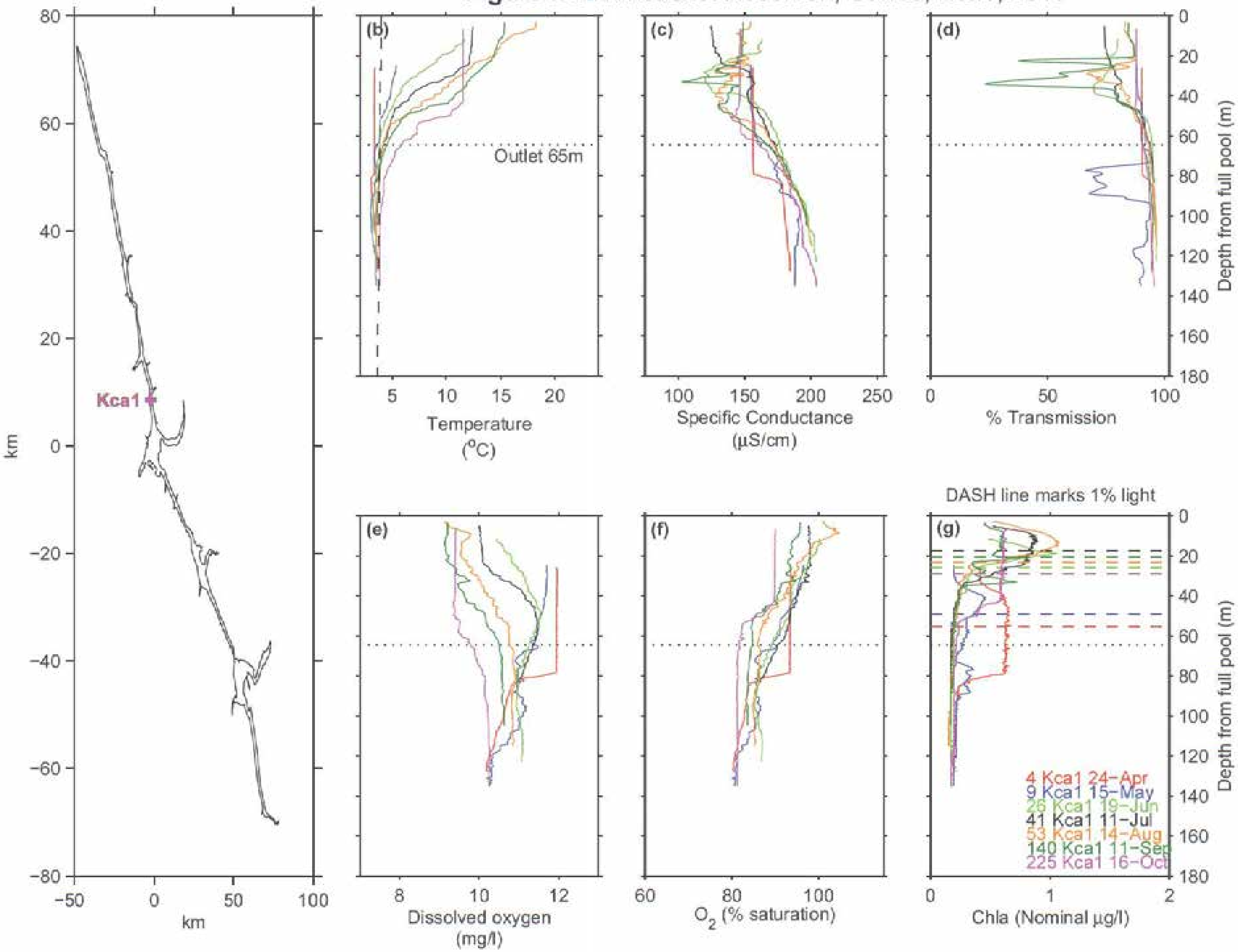
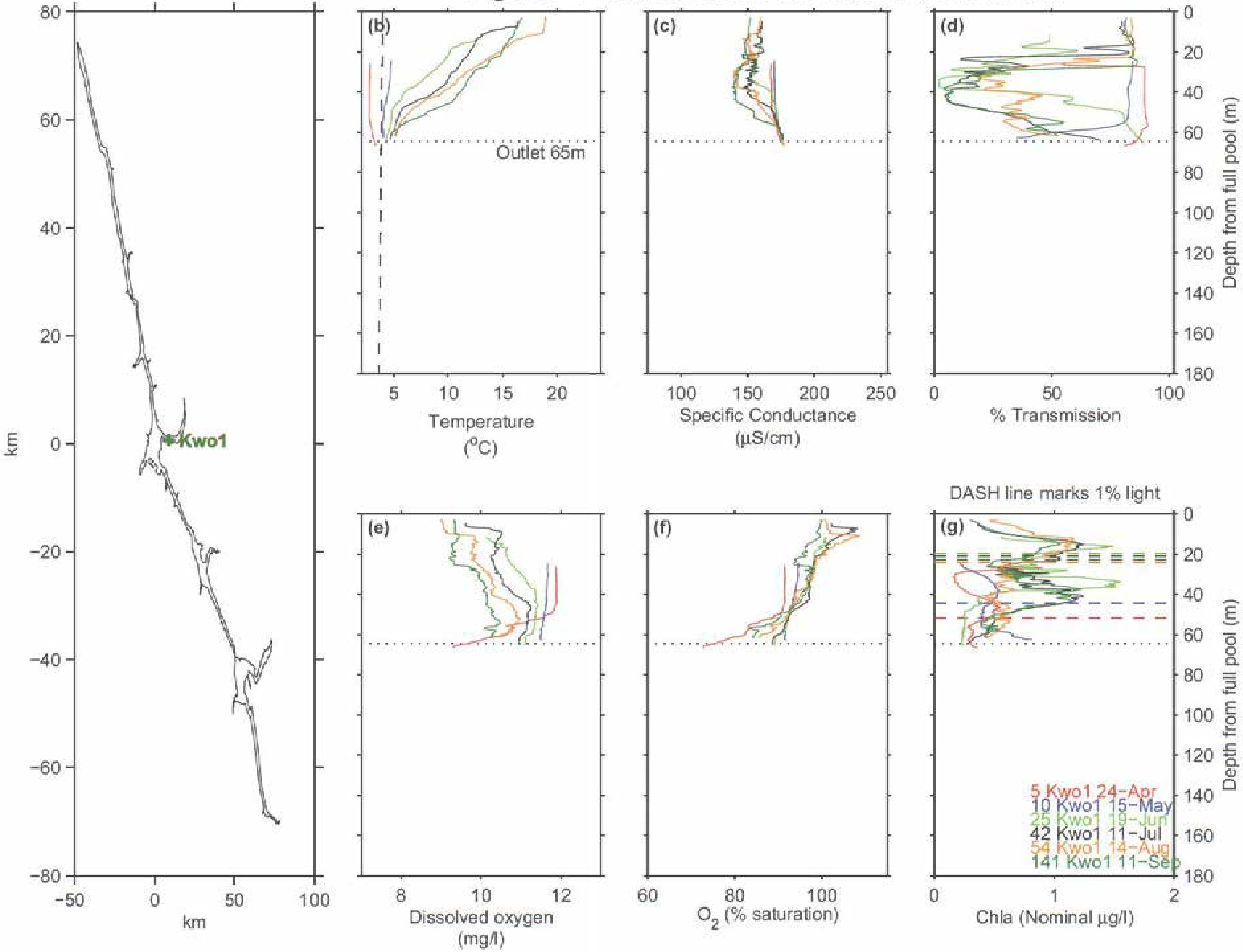


**Figure B13** Kinbasket Reservoir, Wood, Kwo1, 2017



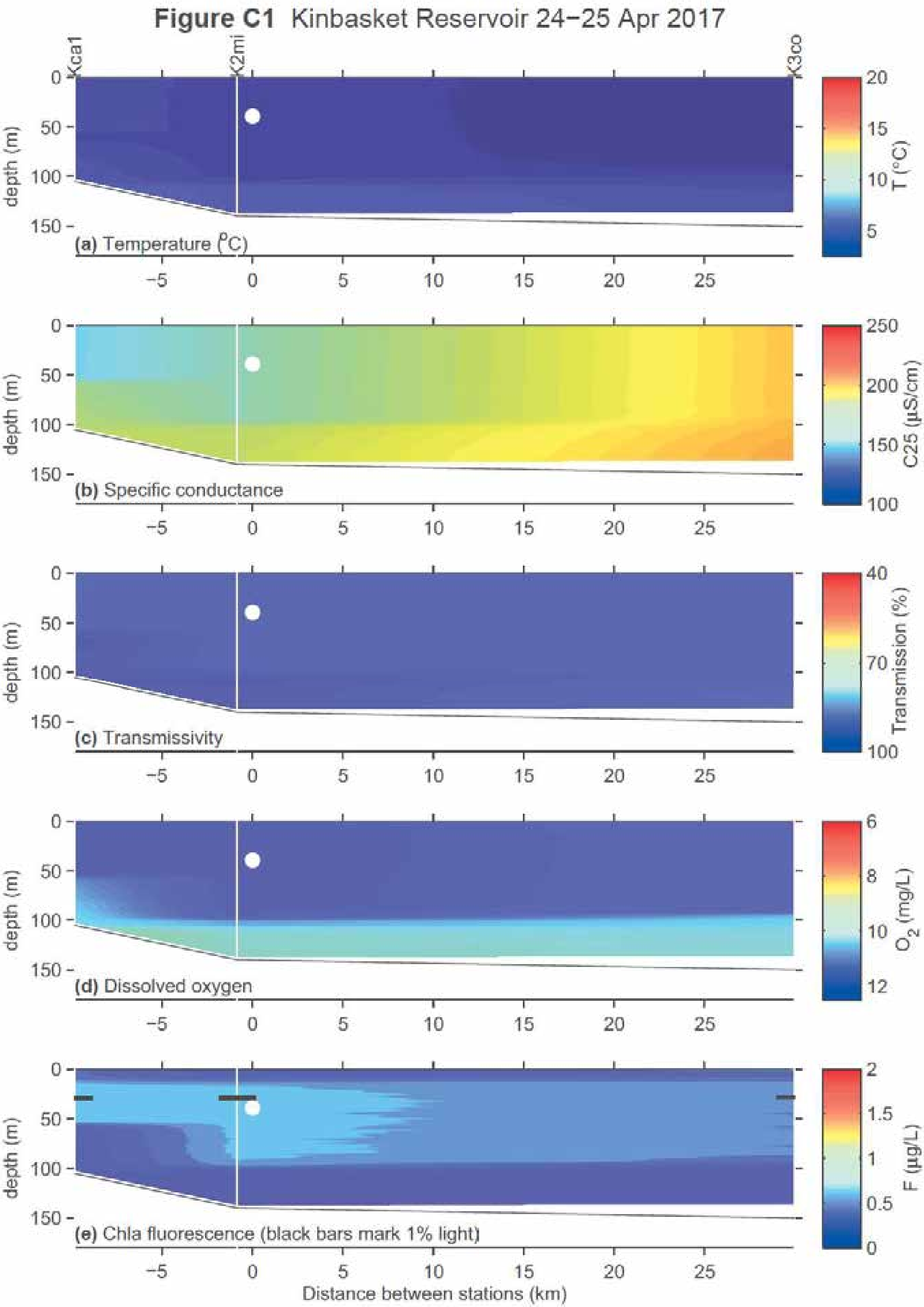


Figure C1 Kinbasket Reservoir 24−25 Apr 2017
Kca1
K2mi
K3co
depth (m)
(a) Temperature (°C)
T (°C)
(b) Specific conductance
C25 (µS/cm)
(c) Transmissivity
Transmission (%)
(d) Dissolved oxygen
O2 (mg/L)
(e) Chla fluorescence (black bars mark 1% light)
F (µg/L)
Distance between stations (km)

**Figure C2** Kinbasket Reservoir 15−16 May 2017

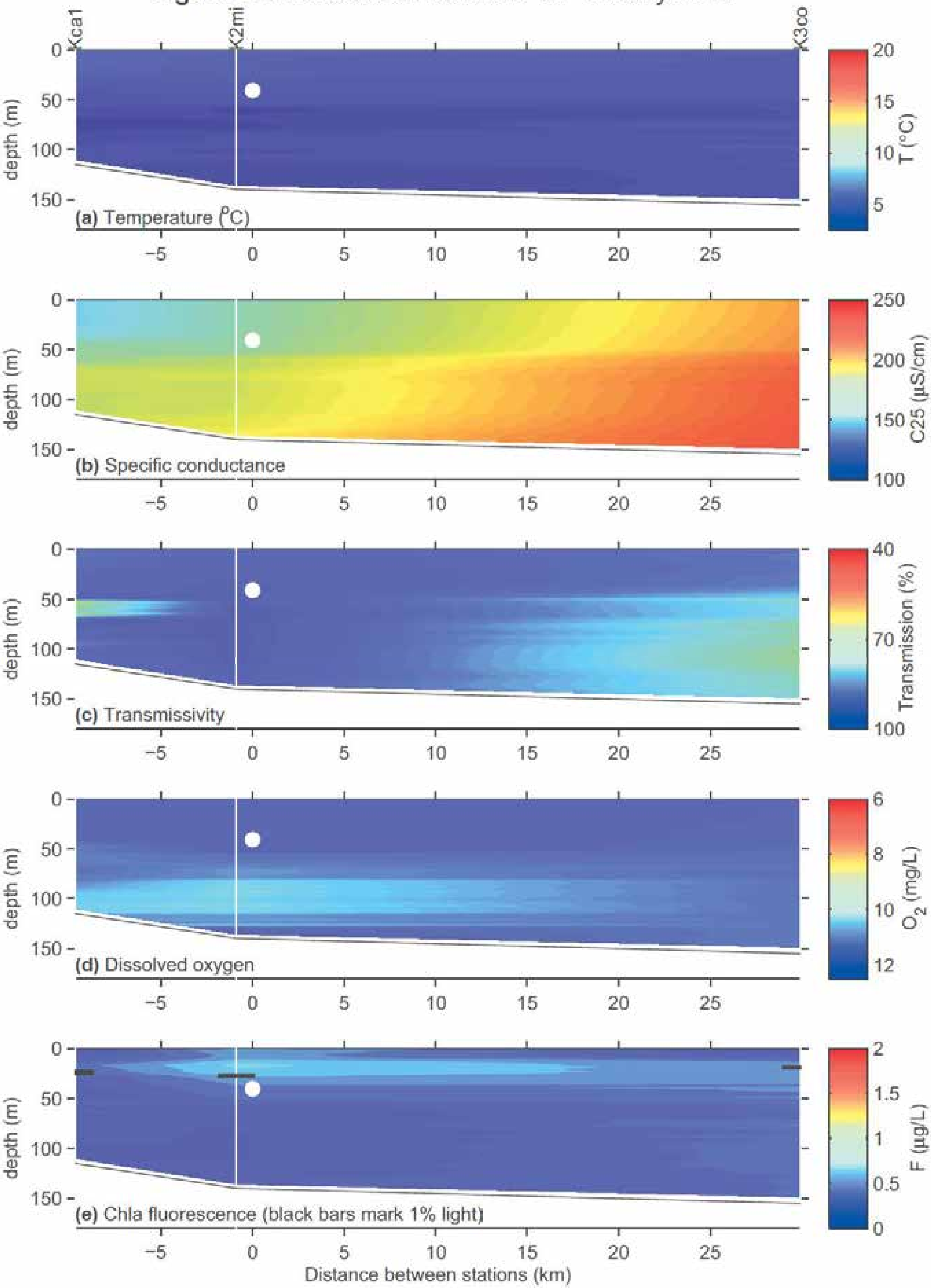


**Figure C3** Kinbasket Reservoir 19−20 Jun 2017

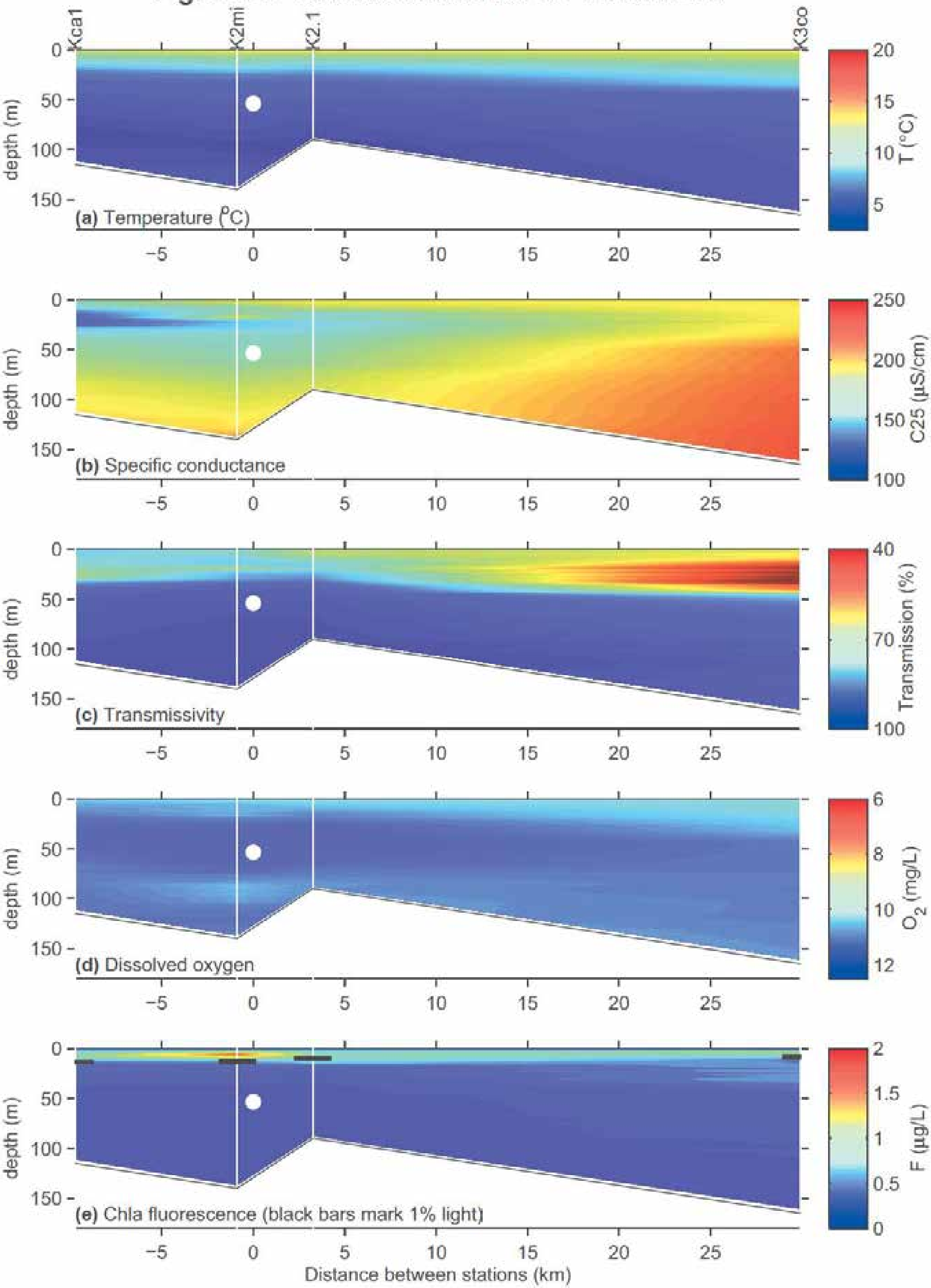
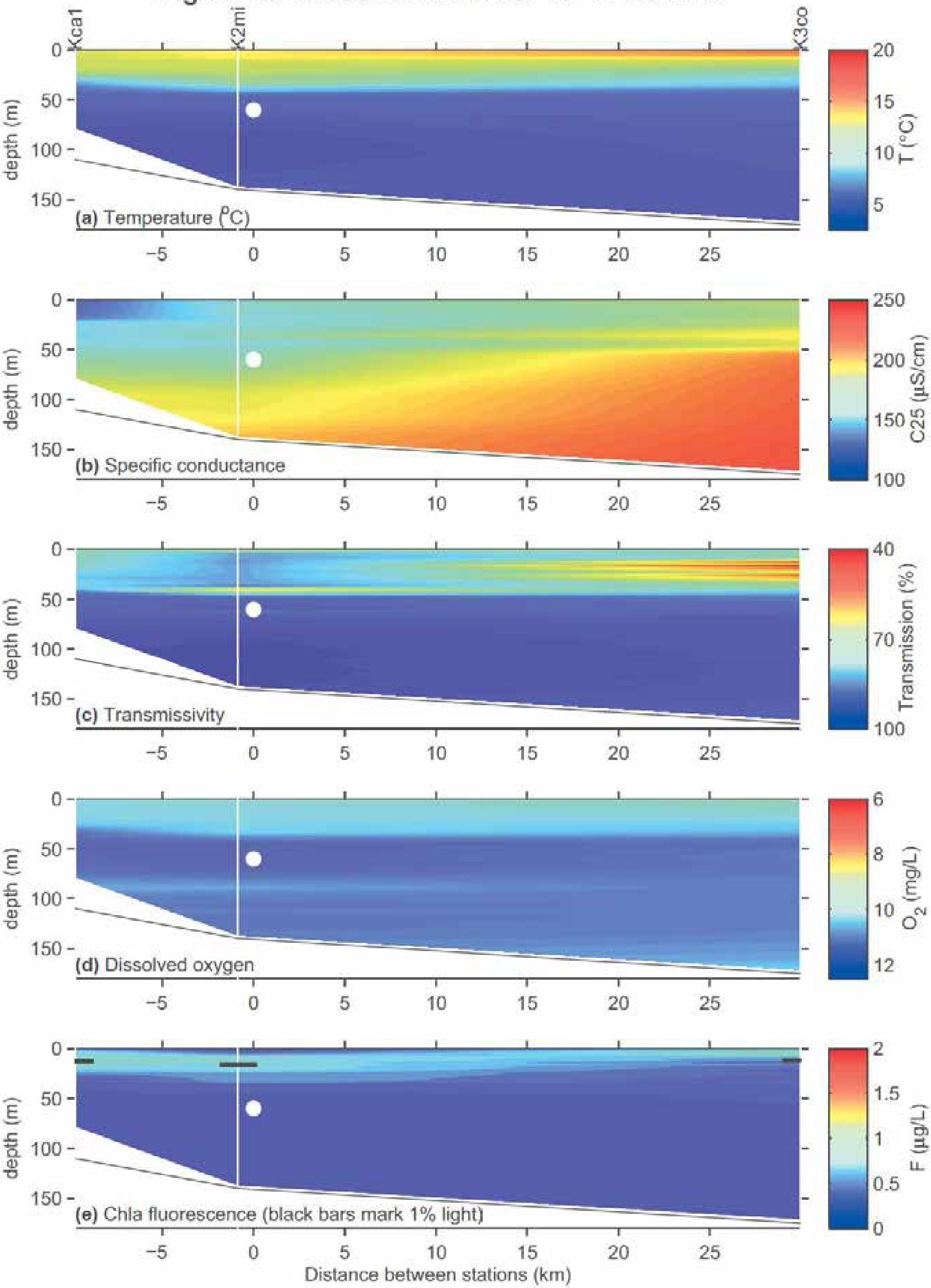


**Figure C4** Kinbasket Reservoir 10−11 Jul 2017



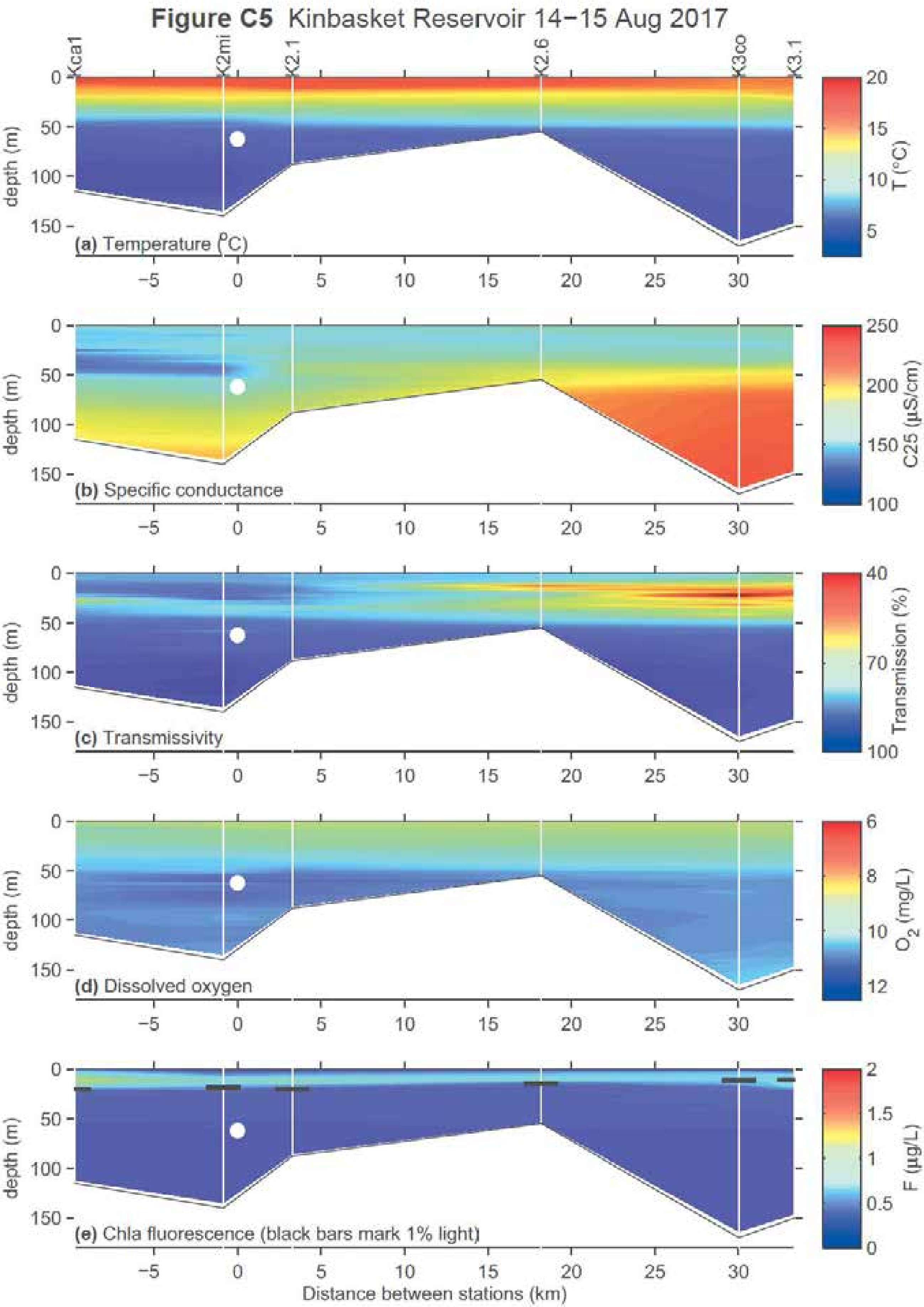


Figure C5 Kinbasket Reservoir 14−15 Aug 2017
Kca1
K2mi
K2.1
K2.6
K3co
K3.1
depth (m)
(a) Temperature (°C)
T (°C)
(b) Specific conductance
C25 (µS/cm)
(c) Transmissivity
Transmission (%)
(d) Dissolved oxygen
O2 (mg/L)
(e) Chla fluorescence (black bars mark 1% light)
F (µg/L)
Distance between stations (km)

**Figure C6** Kinbasket Reservoir 11−12 Sep 2017

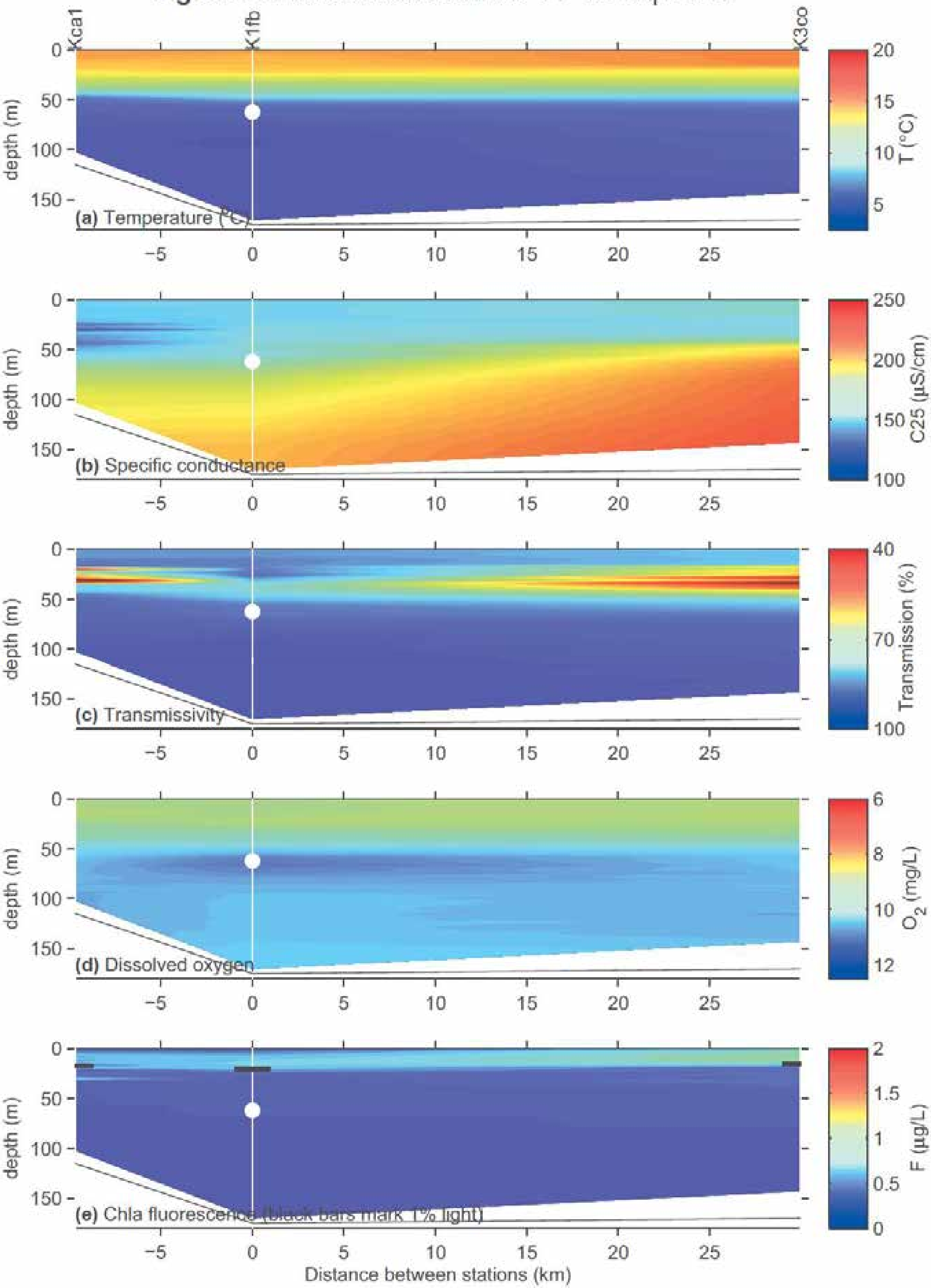


**Figure C7** Kinbasket Reservoir 16−18 Oct 2017

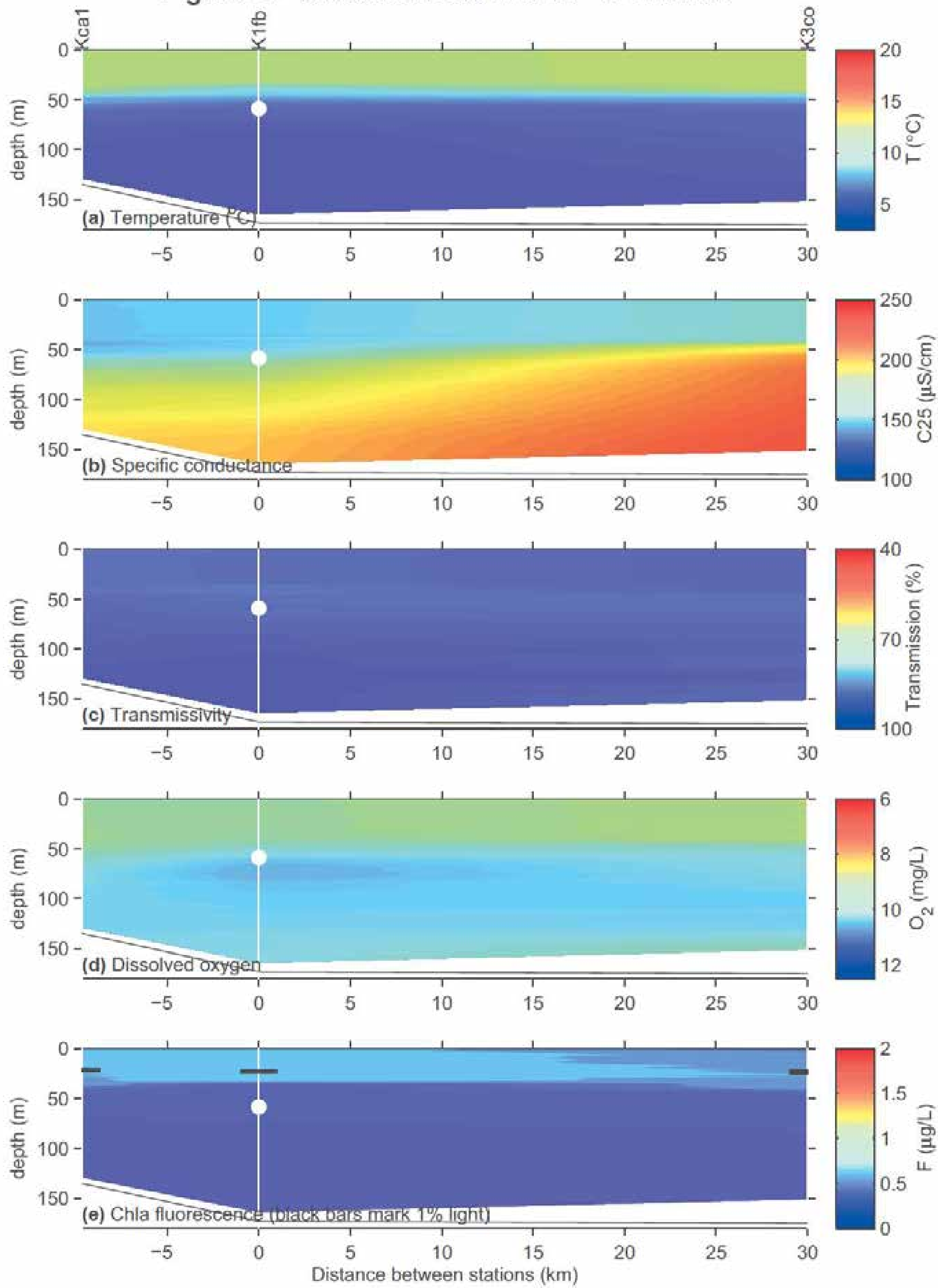


**Figure D1** Revelstoke Reservoir, 18−19 Apr 2017

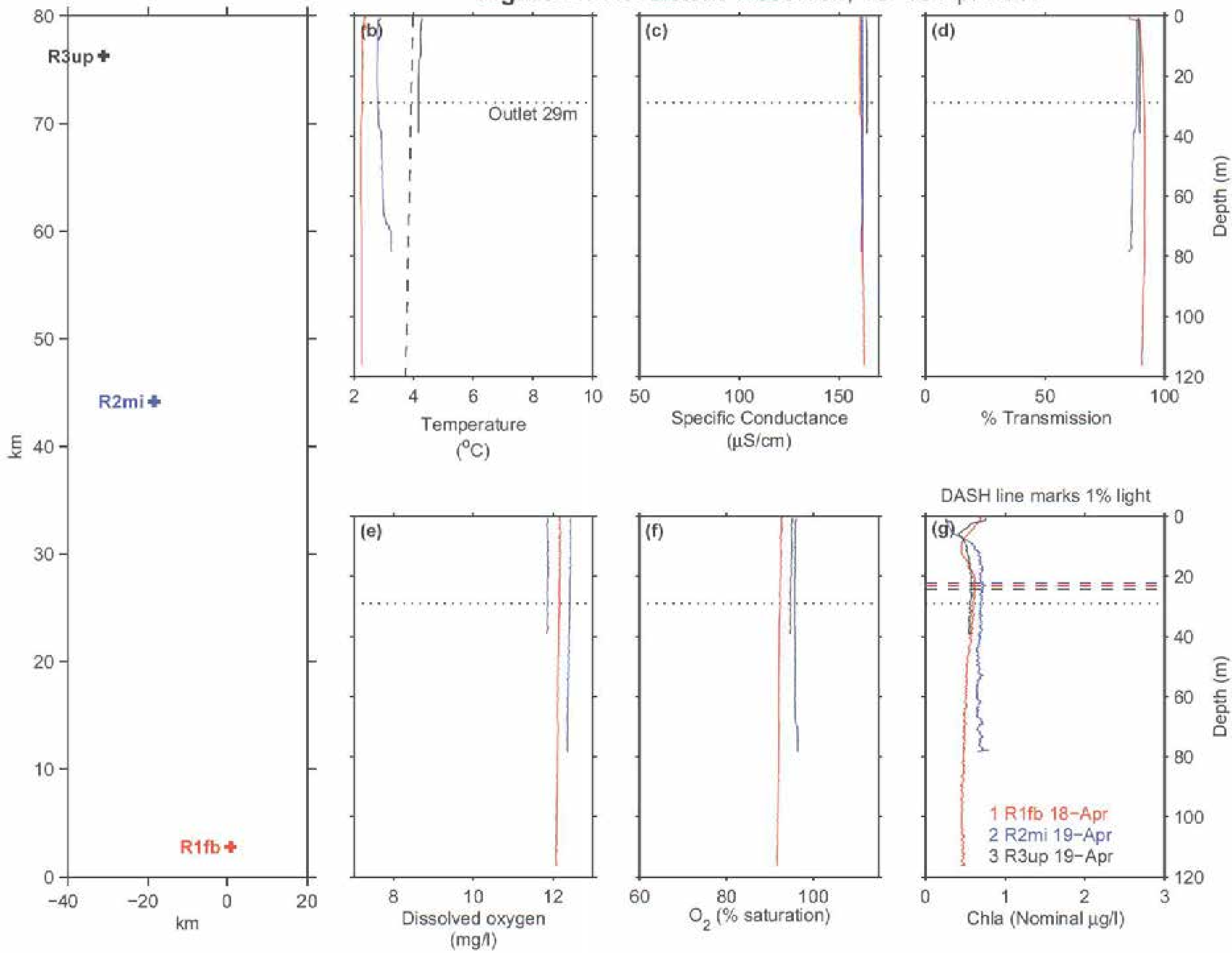


**Figure D2** Revelstoke Reservoir, 23−24 May 2017

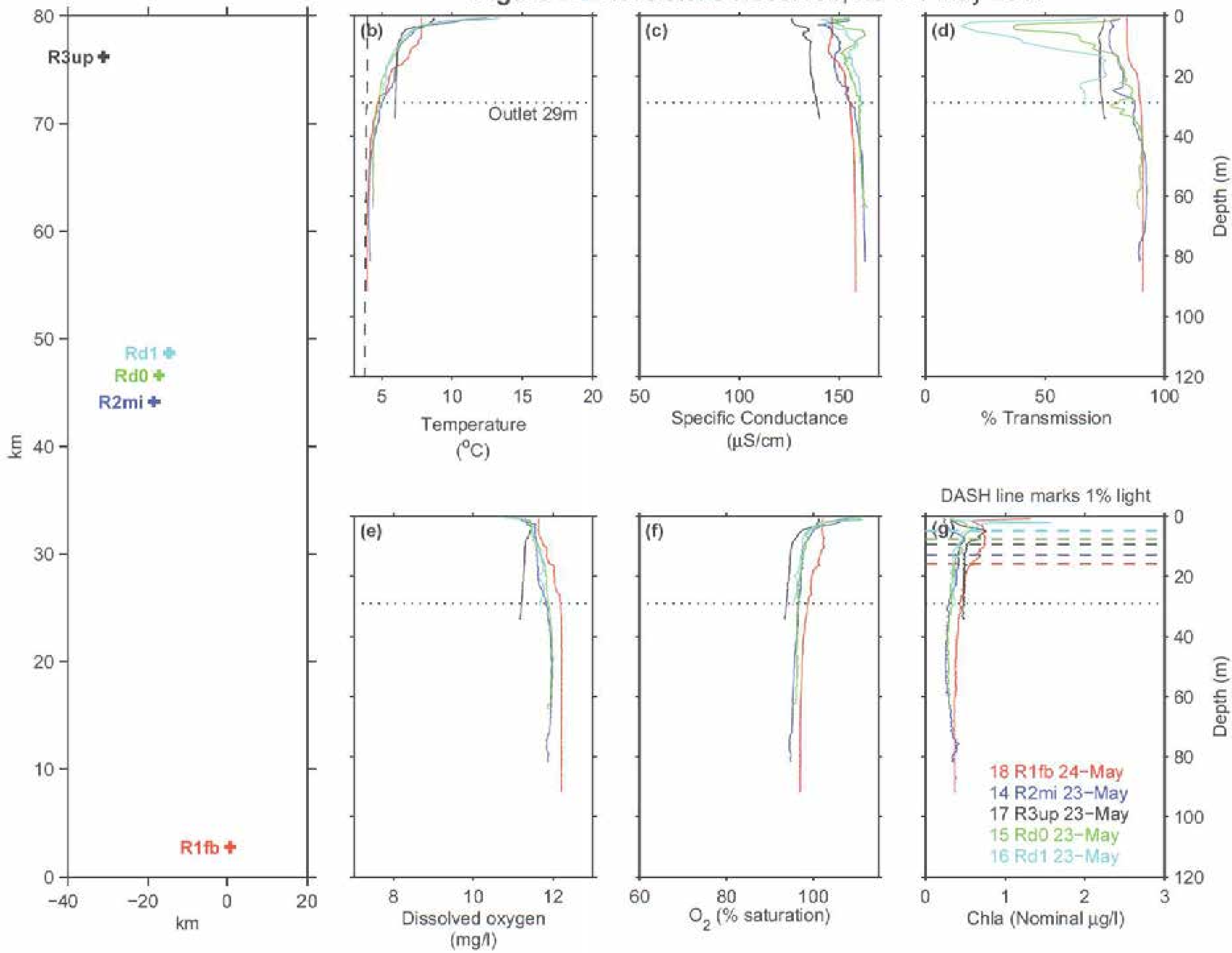


**Figure D3** Revelstoke Reservoir, 12−13 Jun 2017

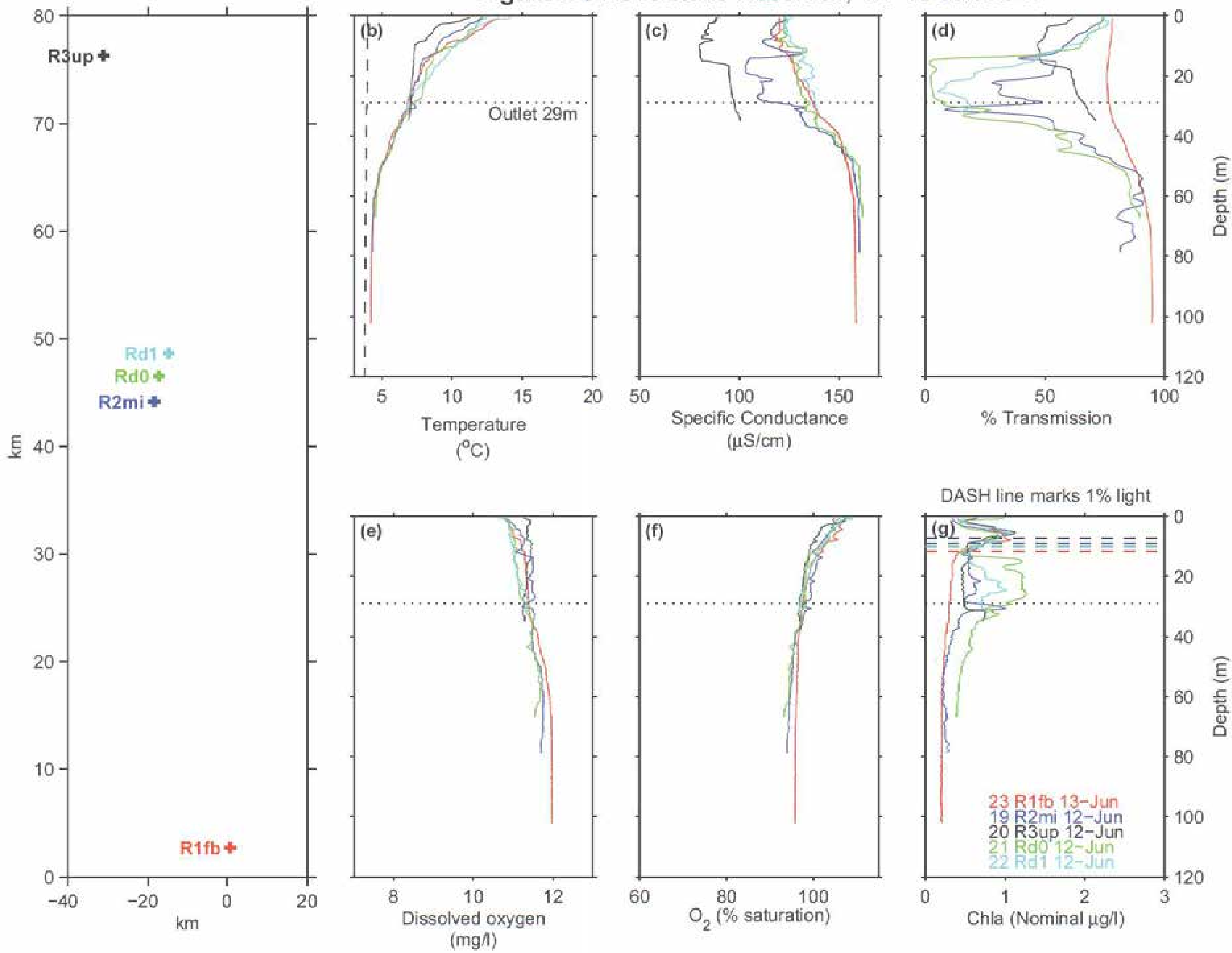


**Figure D4** Revelstoke Reservoir, 21–22 Jun 2017

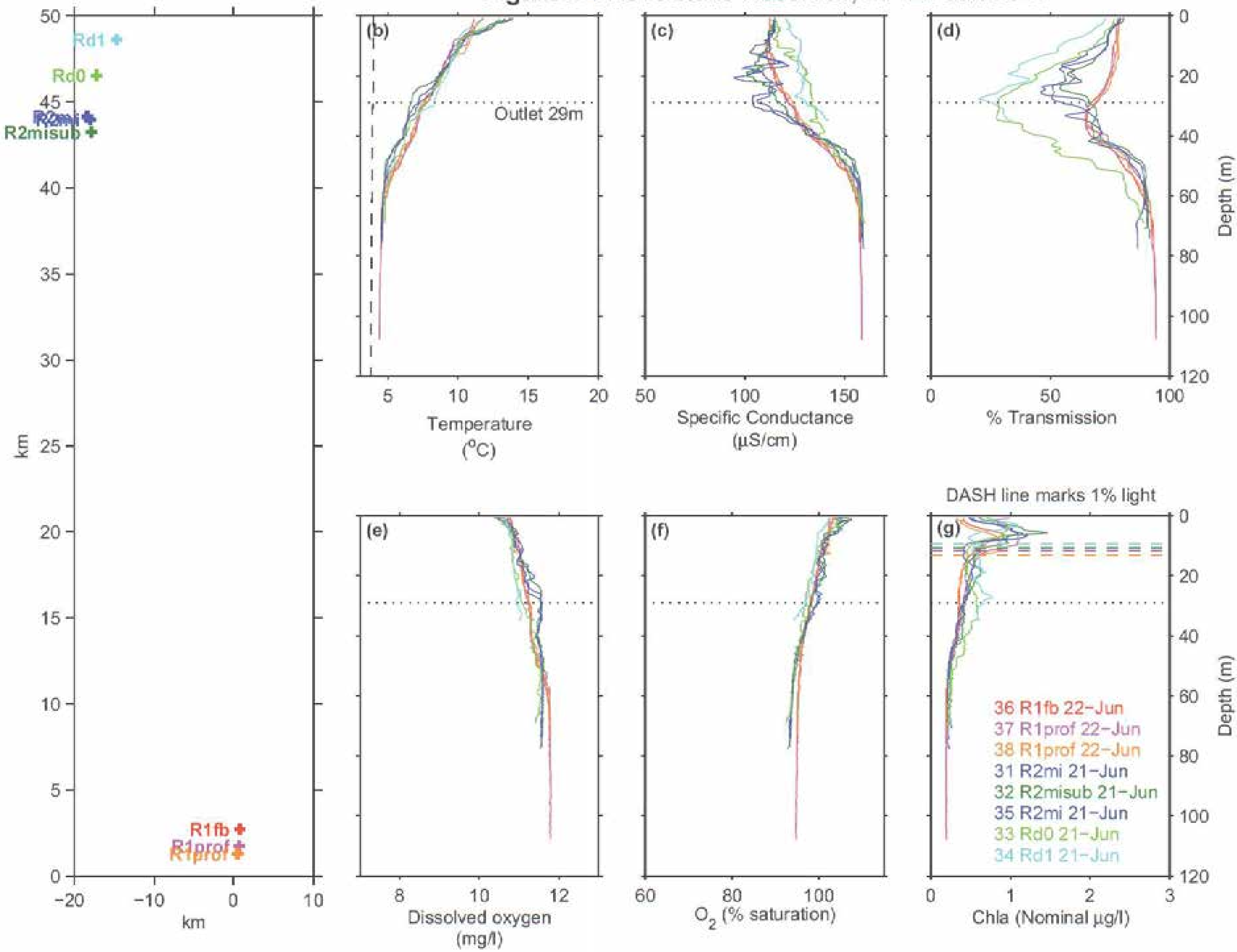


**Figure D5** Revelstoke Reservoir, 17−18 Jul 2017

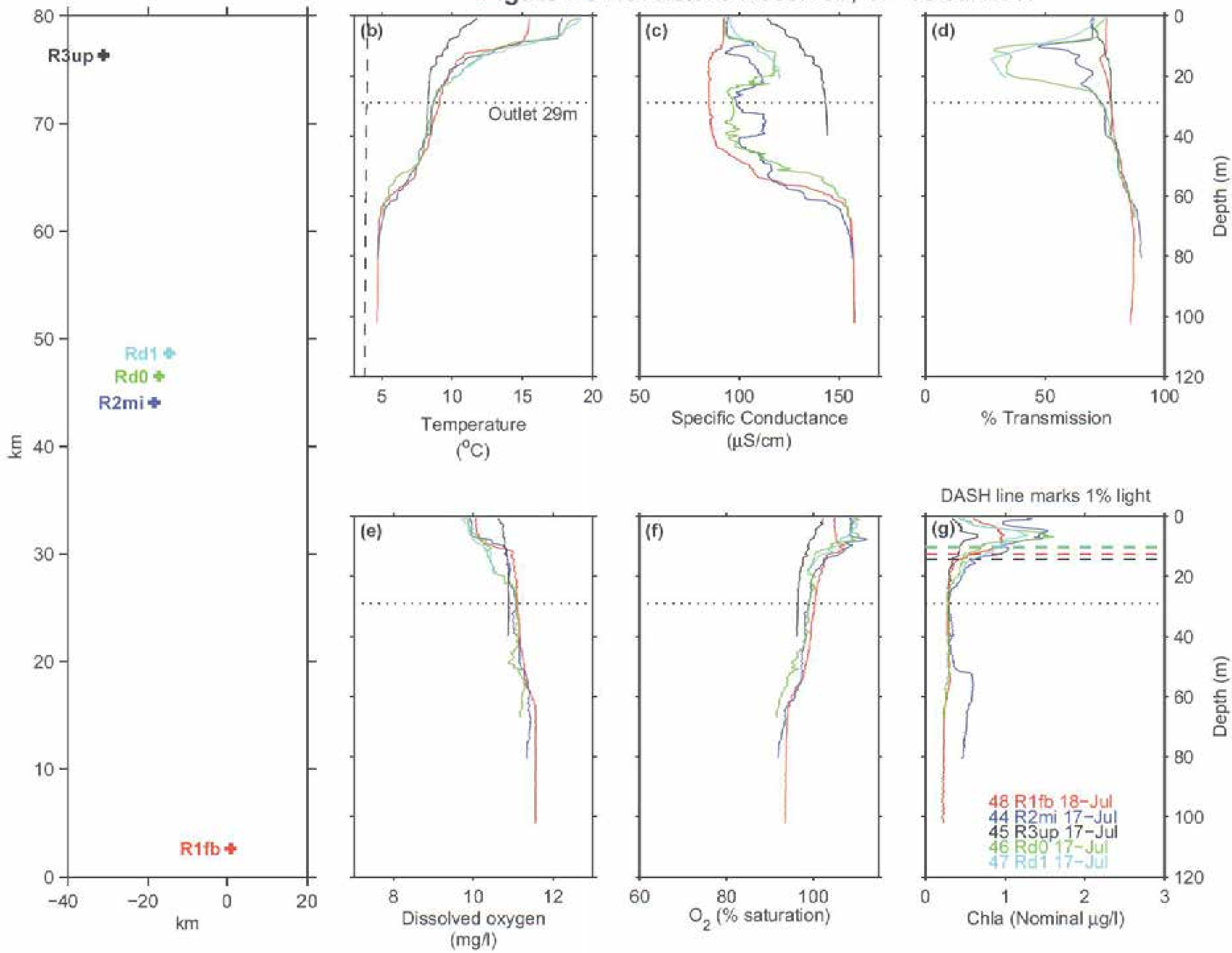


**Figure D6** Revelstoke Reservoir, 21−22 Aug 2017

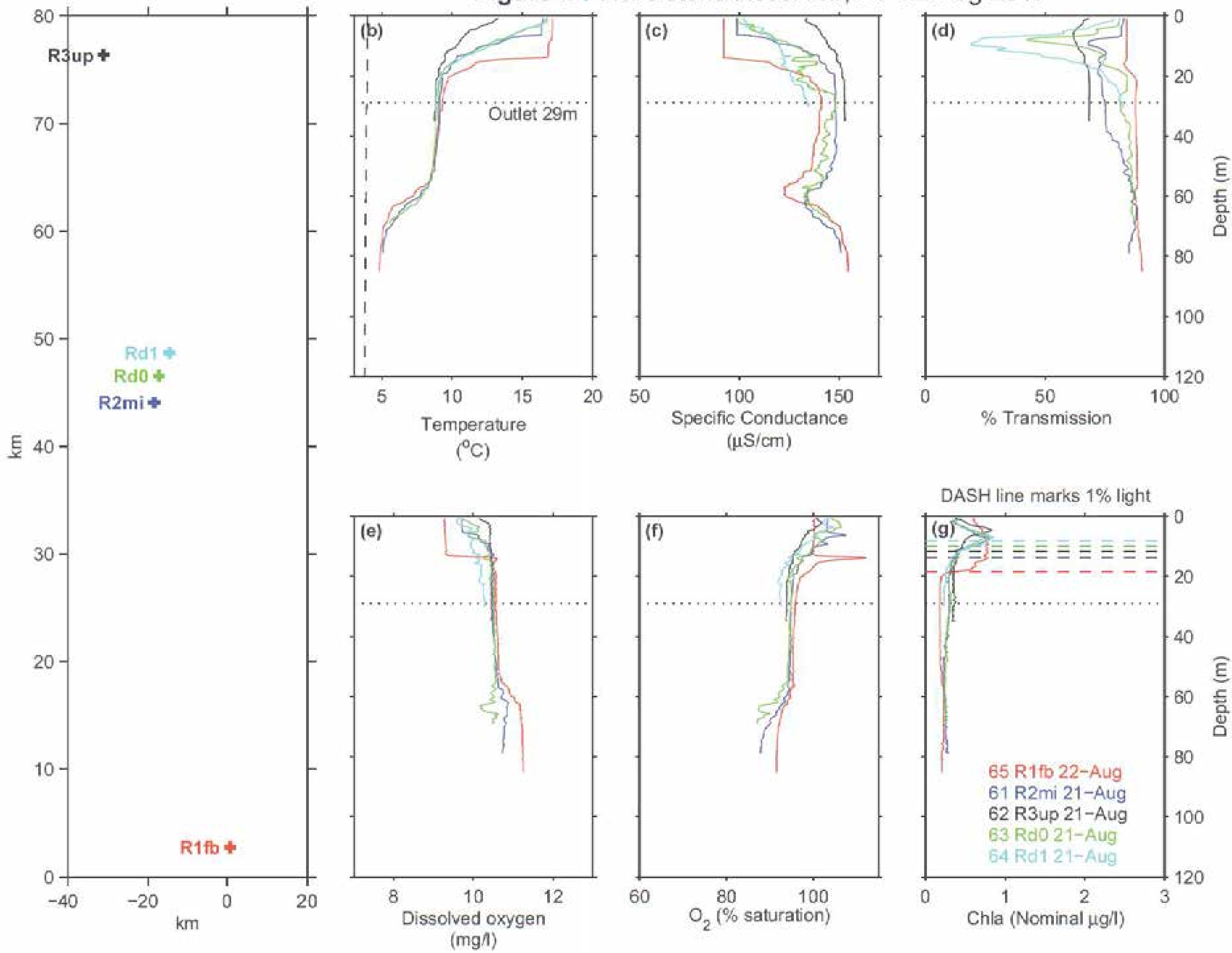


**Figure D7** Revelstoke Reservoir, 29 Aug 2017

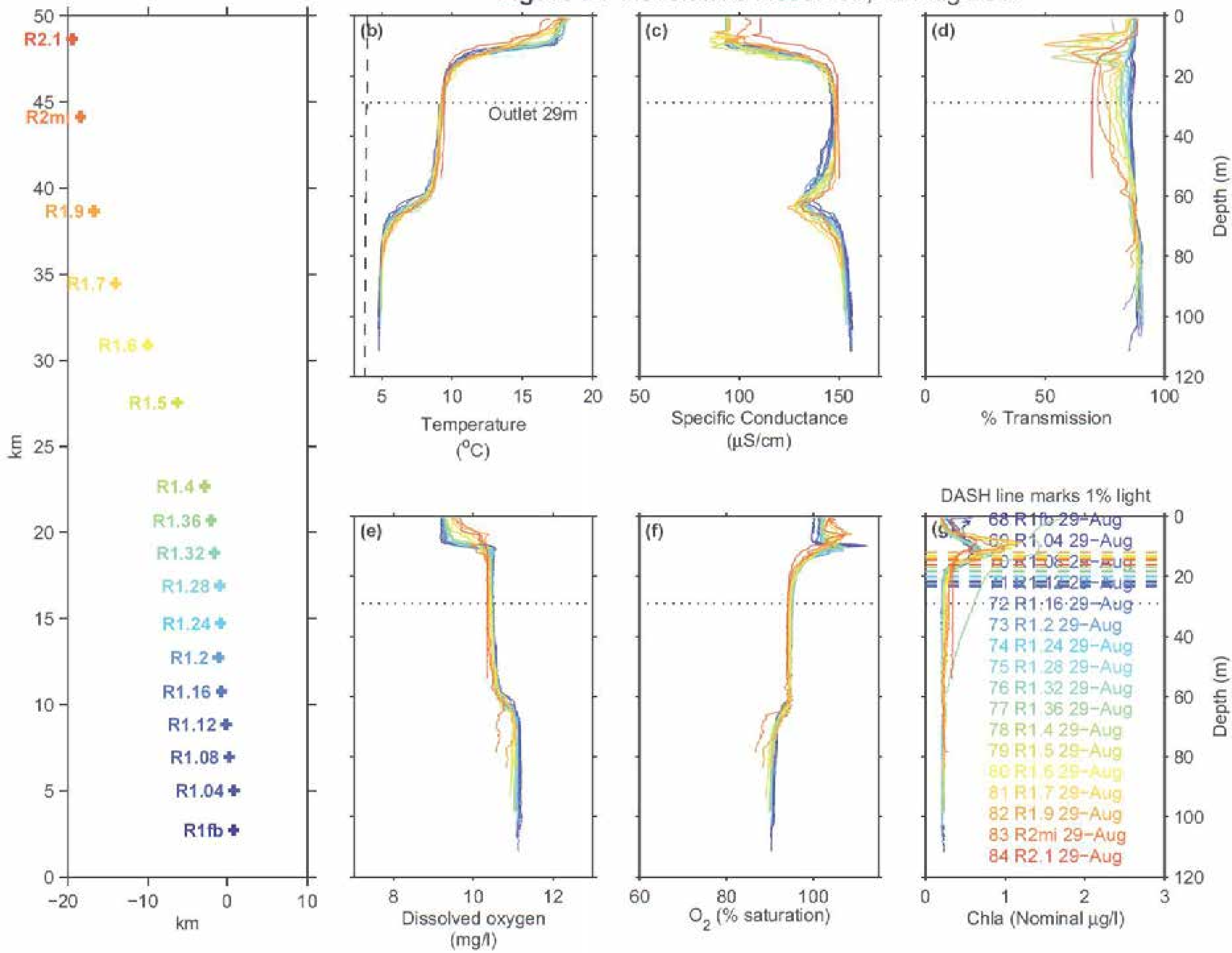


**Figure D8** Revelstoke Reservoir, 1 Sep 2017

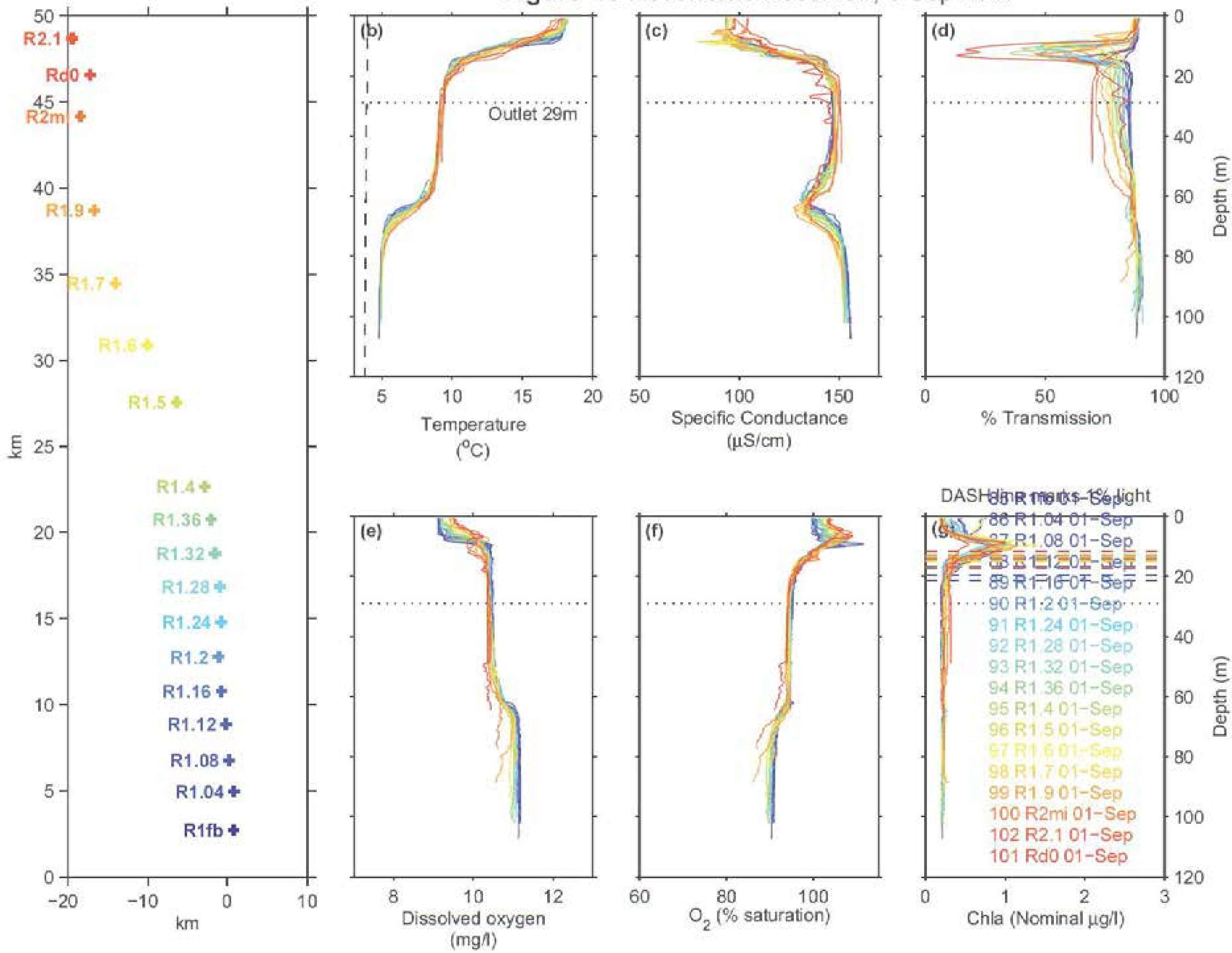


**Figure D9** Revelstoke Reservoir, 5 Sep 2017

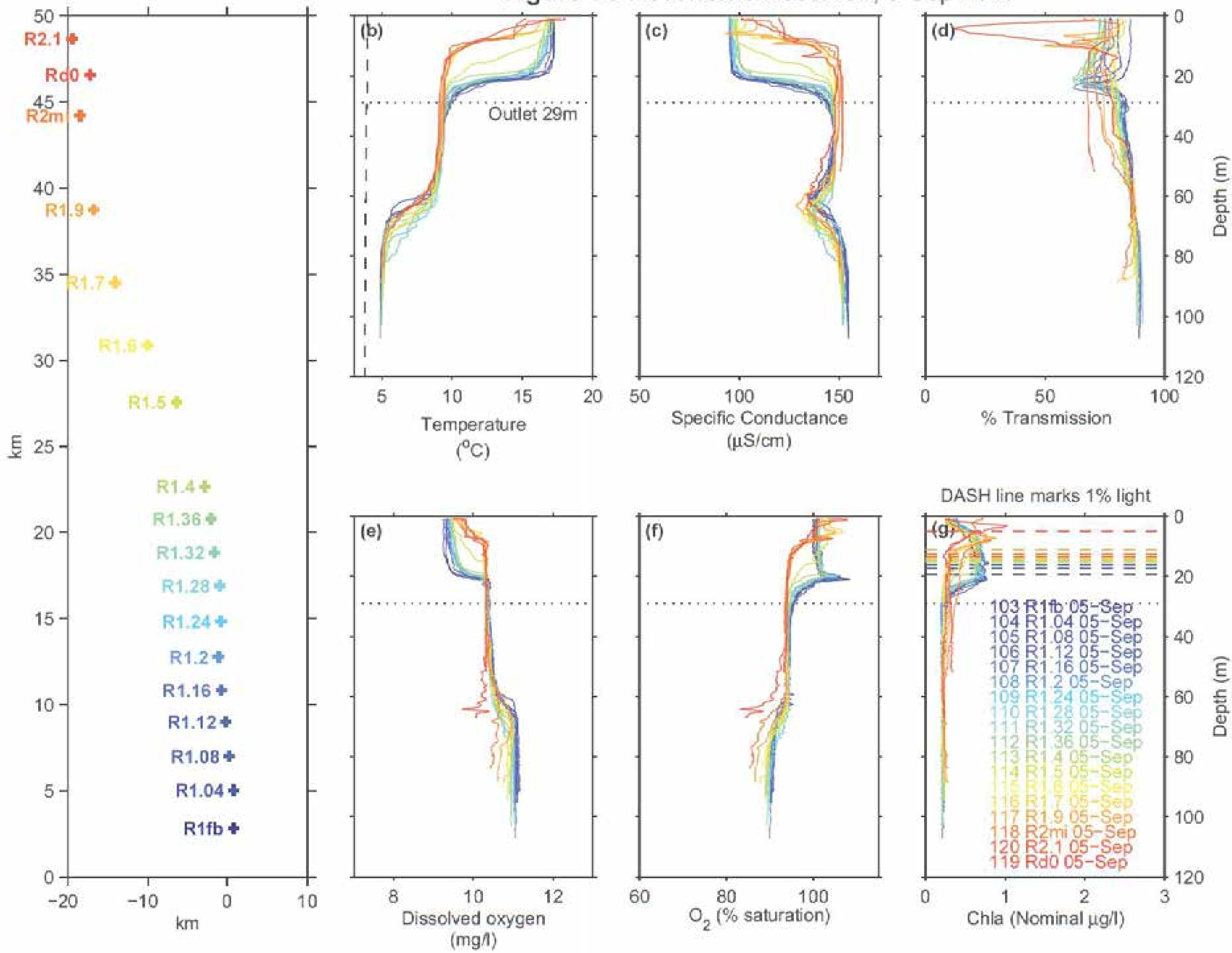
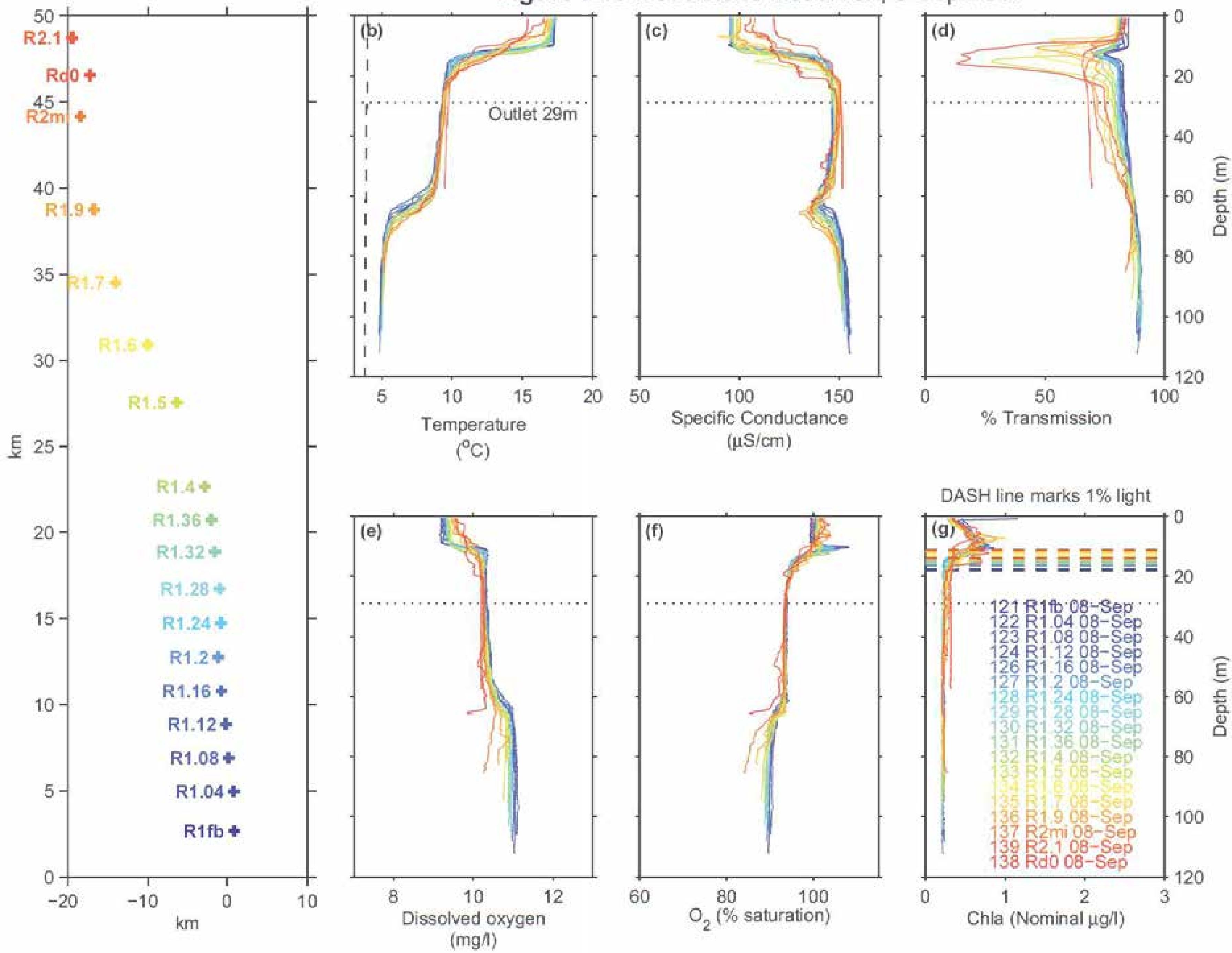


**Figure D10** Revelstoke Reservoir, 8 Sep 2017



## **Figure D11** Revelstoke Reservoir, 18−19 Sep 2017

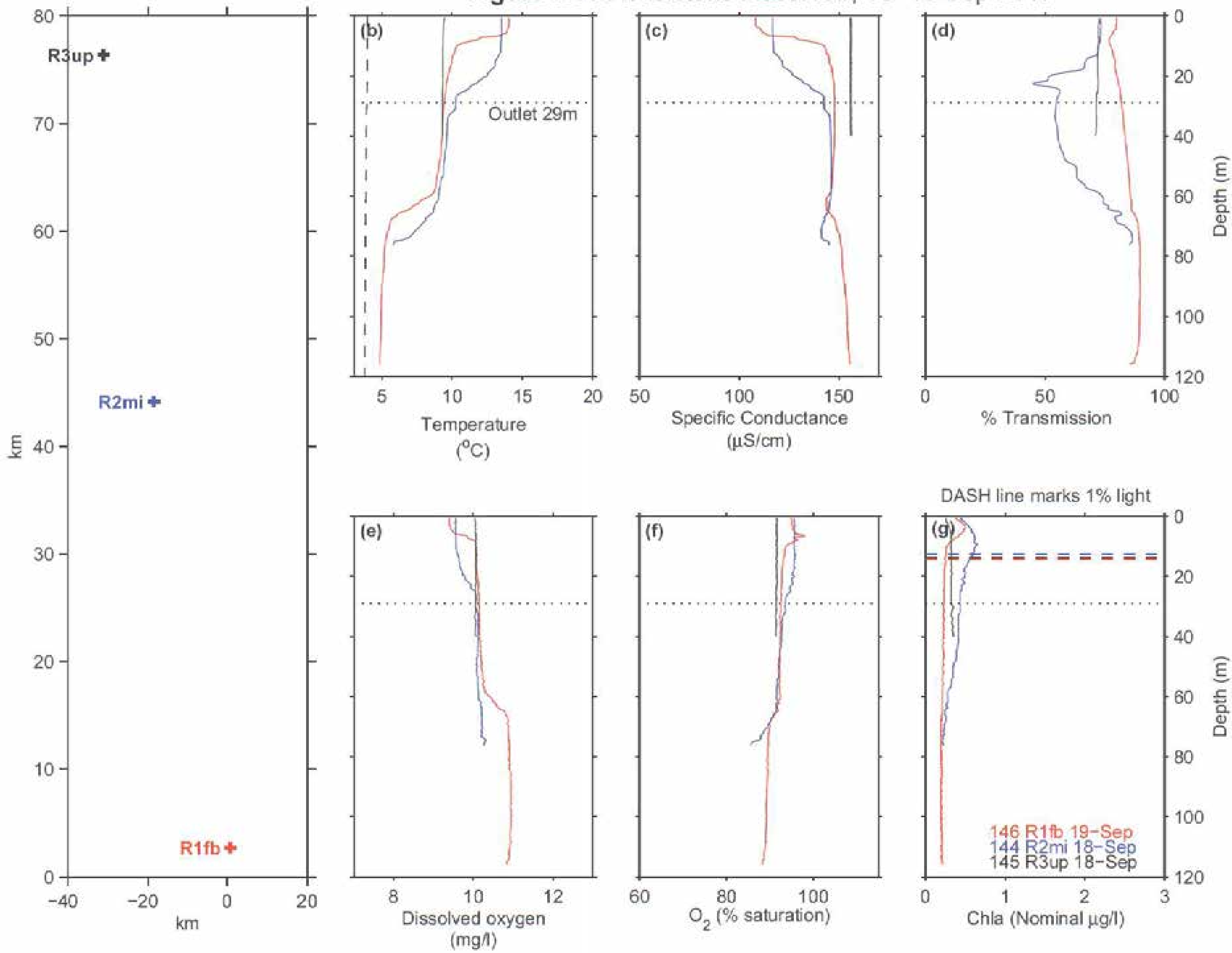


**Figure D12** Revelstoke Reservoir, 29 Sep 2017

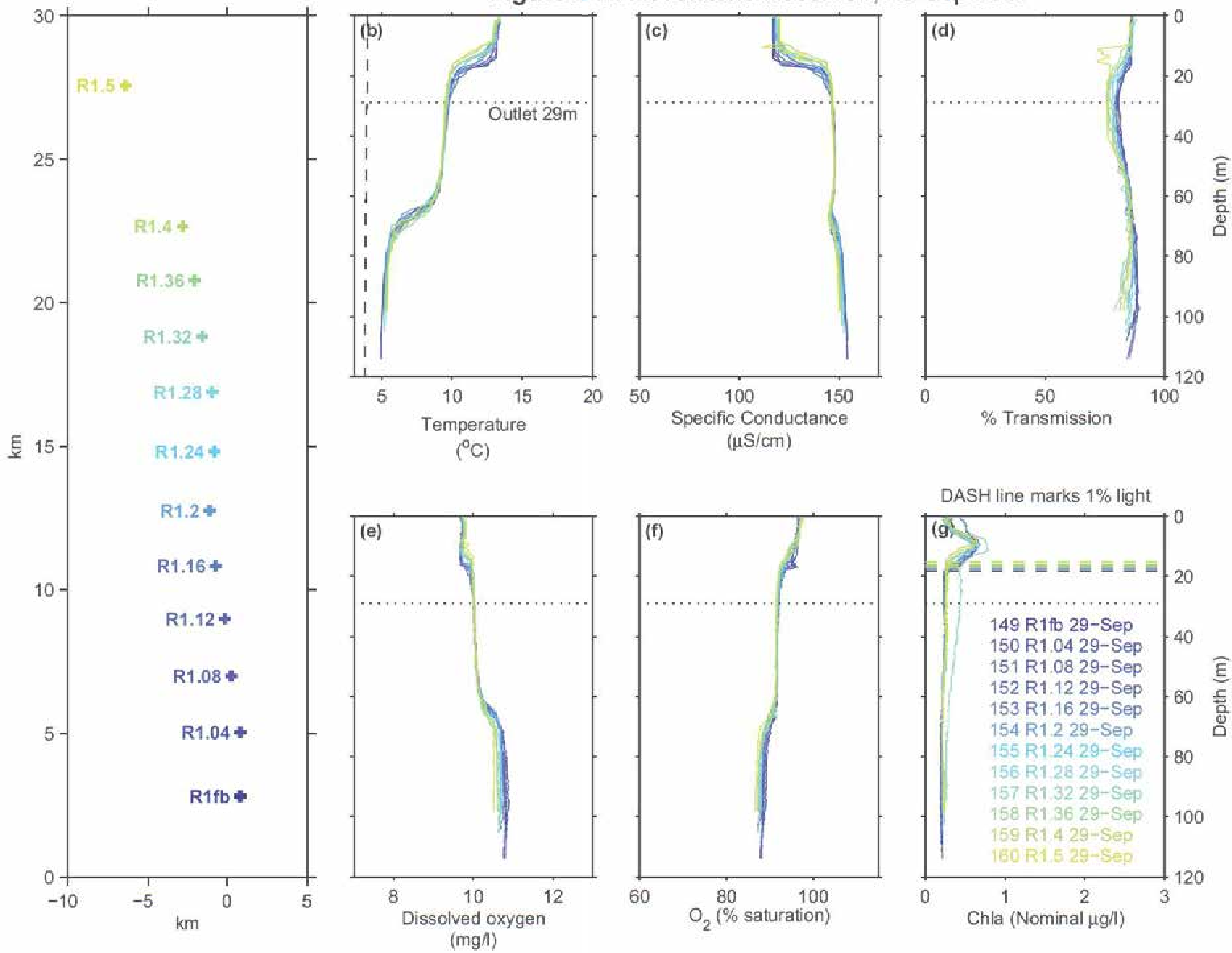


**Figure D13** Revelstoke Reservoir, 2 Oct 2017

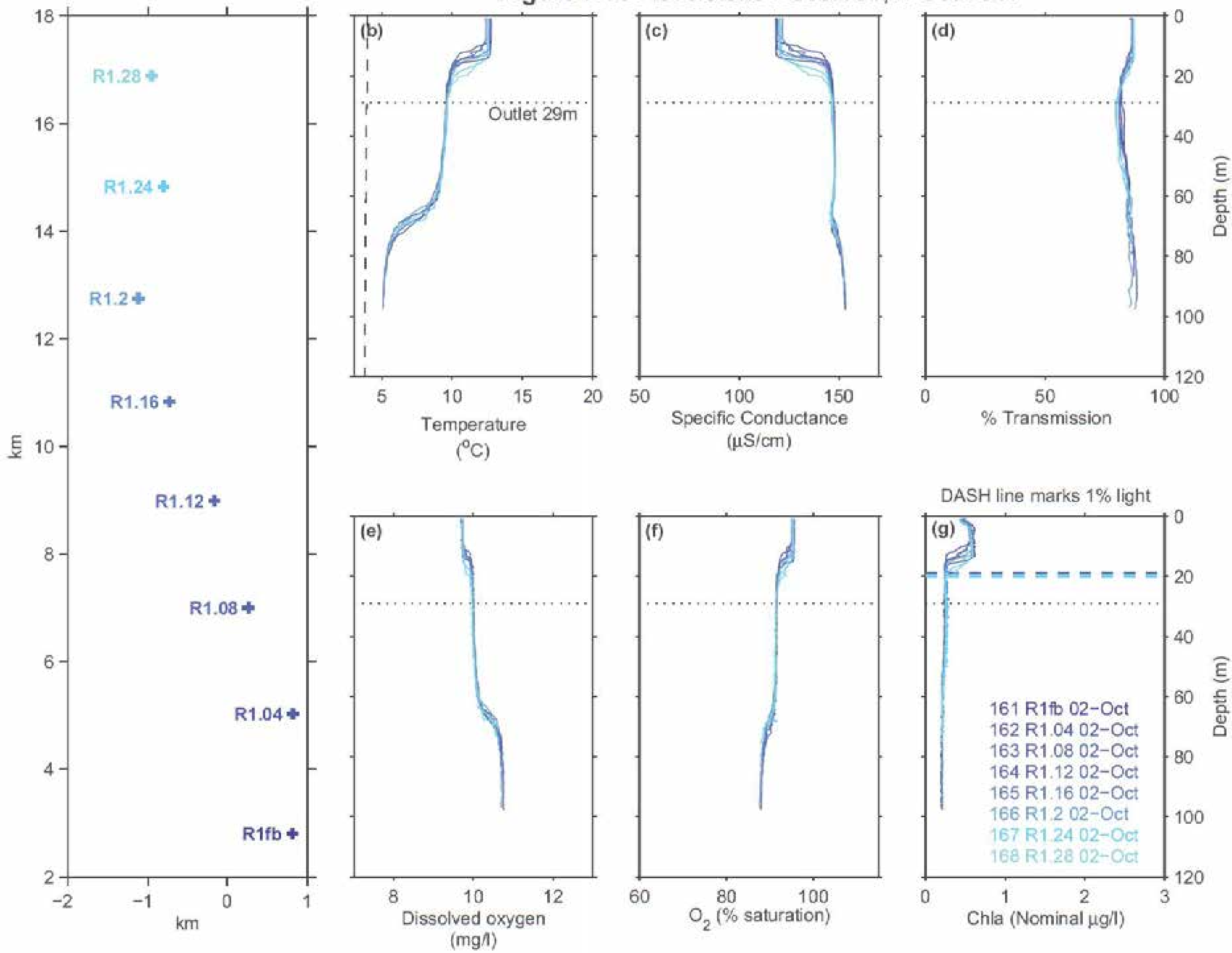


**Figure D14** Revelstoke Reservoir, 4 Oct 2017

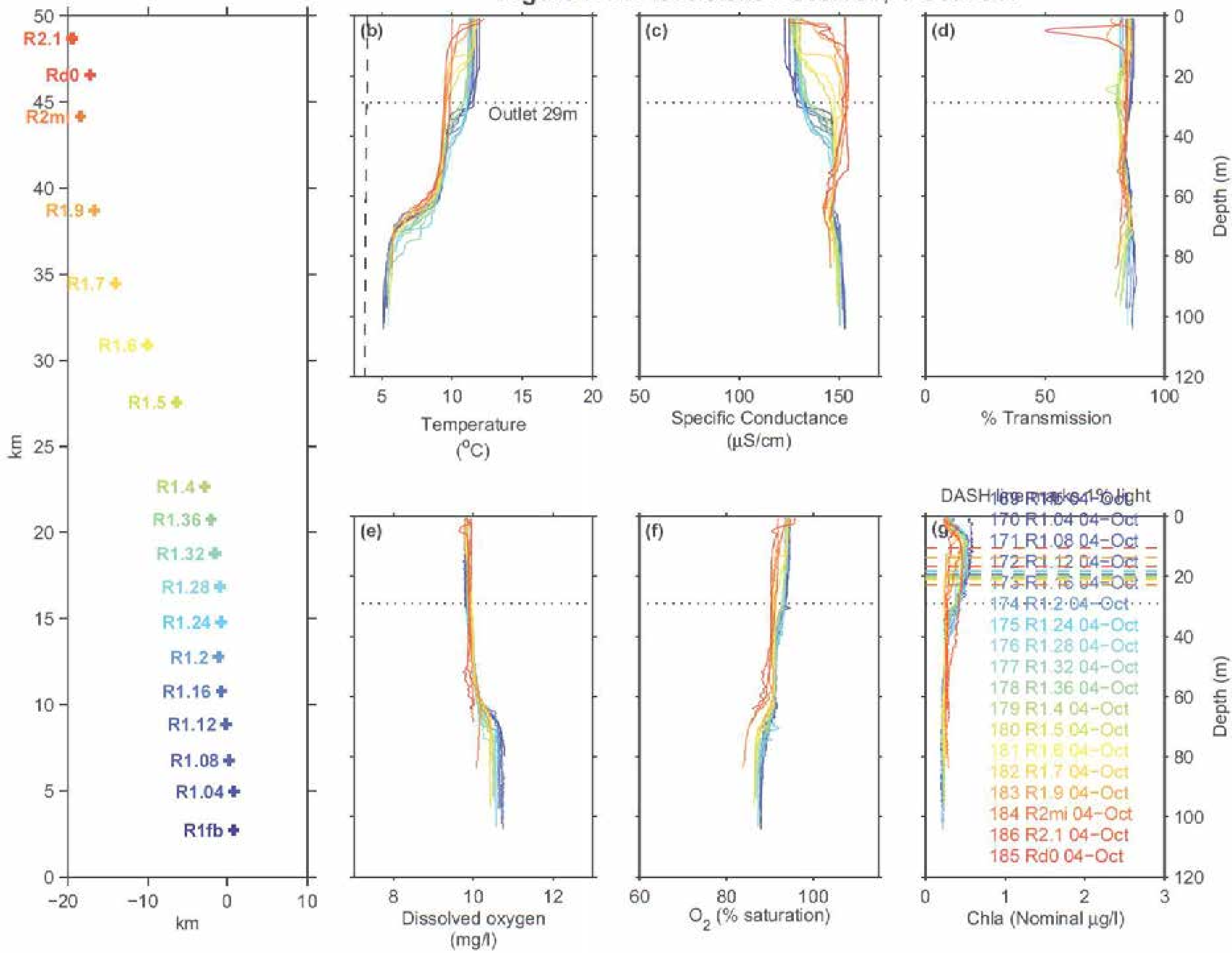


**Figure D15** Revelstoke Reservoir, 6 Oct 2017

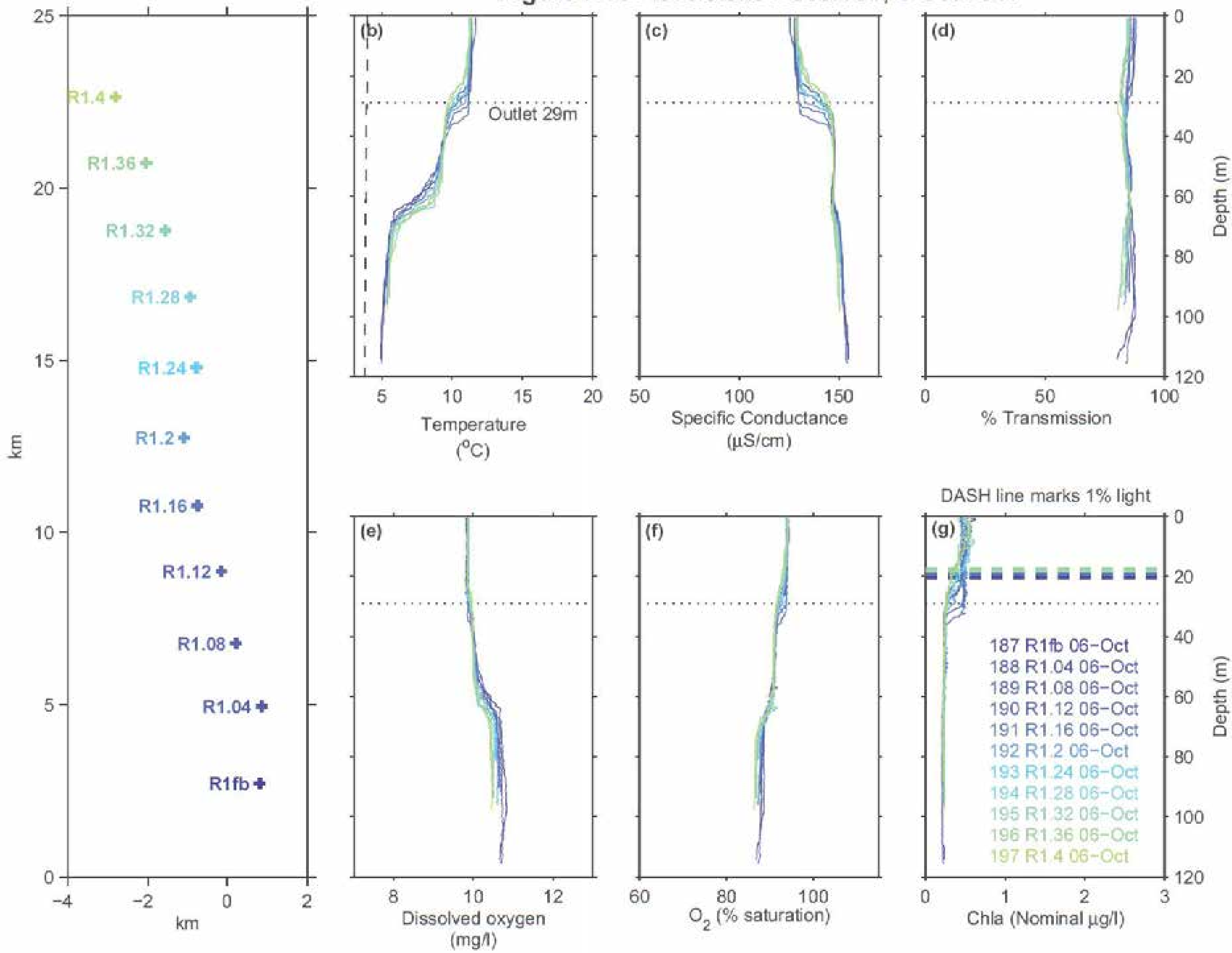


**Figure D16** Revelstoke Reservoir, 10 Oct 2017

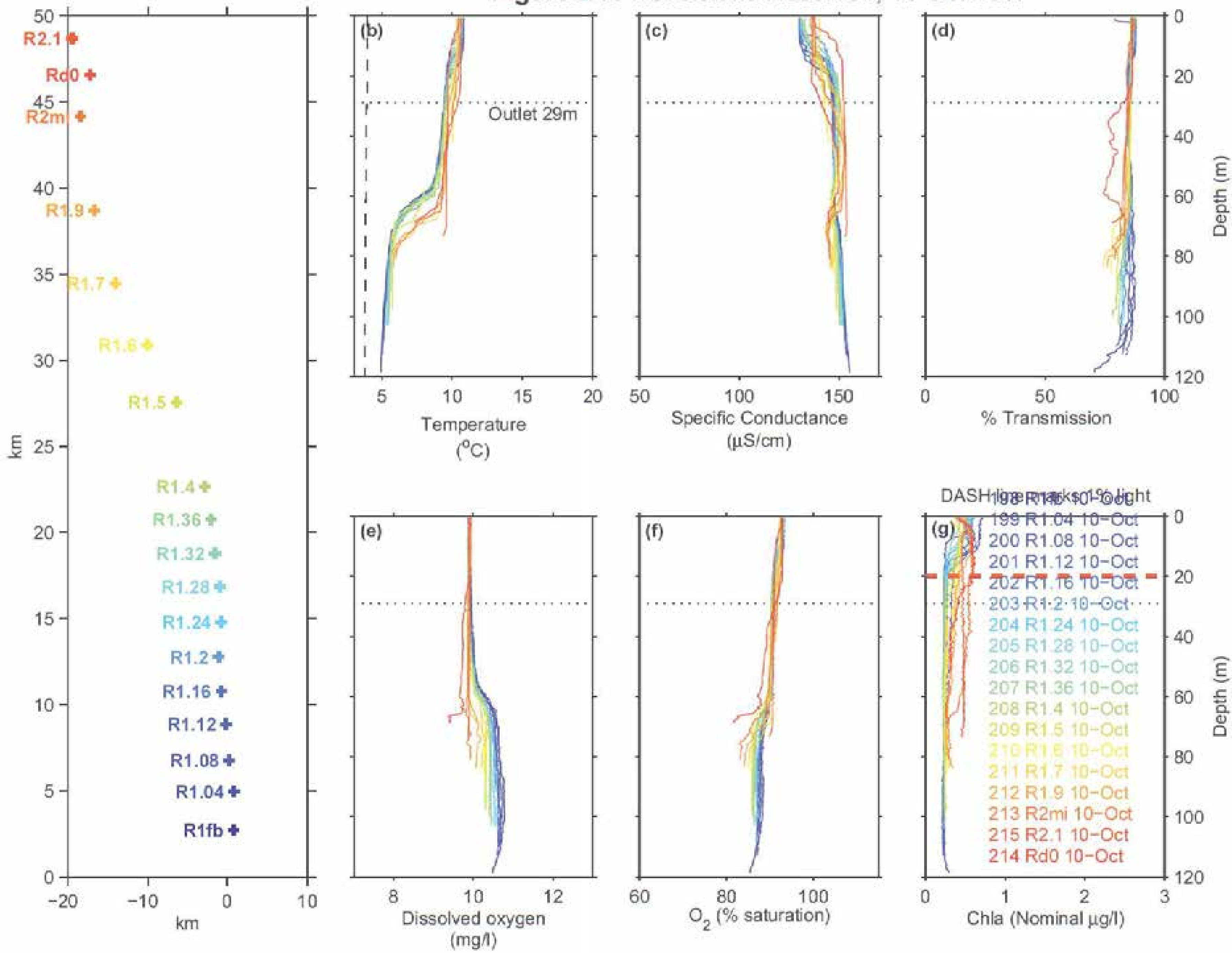


**Figure D17** Revelstoke Reservoir, 13 Oct 2017

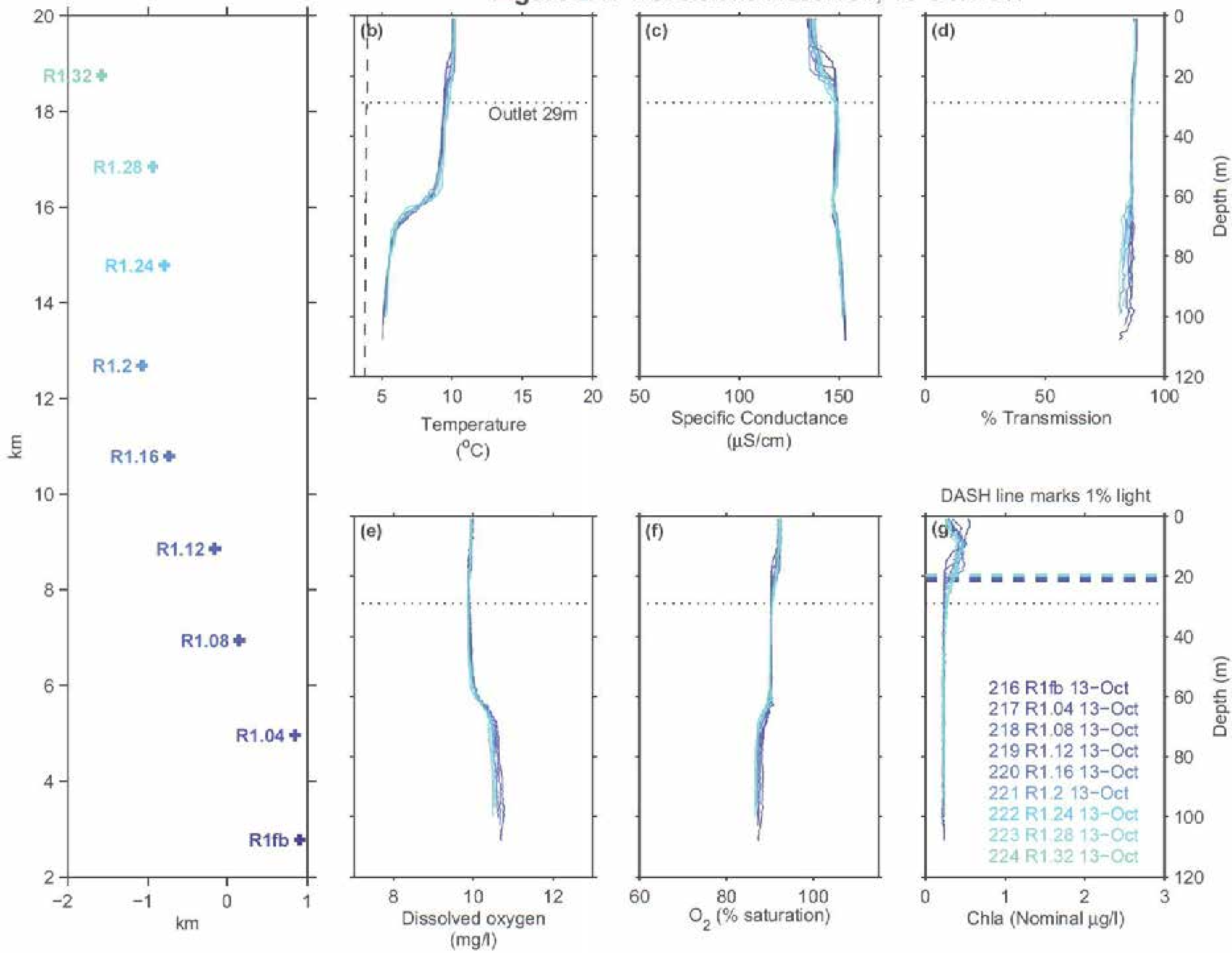


**Figure D18** Revelstoke Reservoir, 23−24 Oct 2017

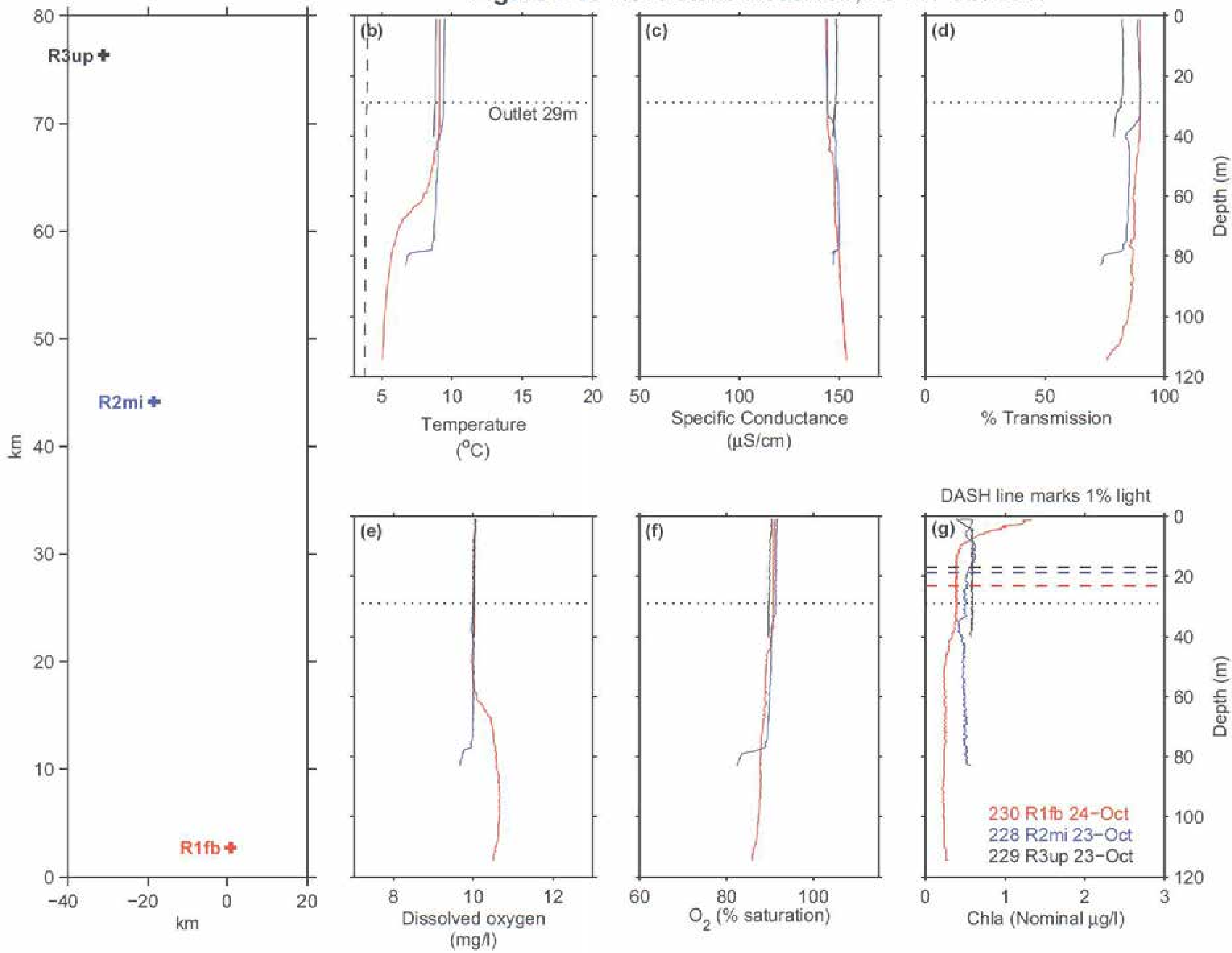


**Figure D19** Revelstoke Reservoir, Forebay 2017

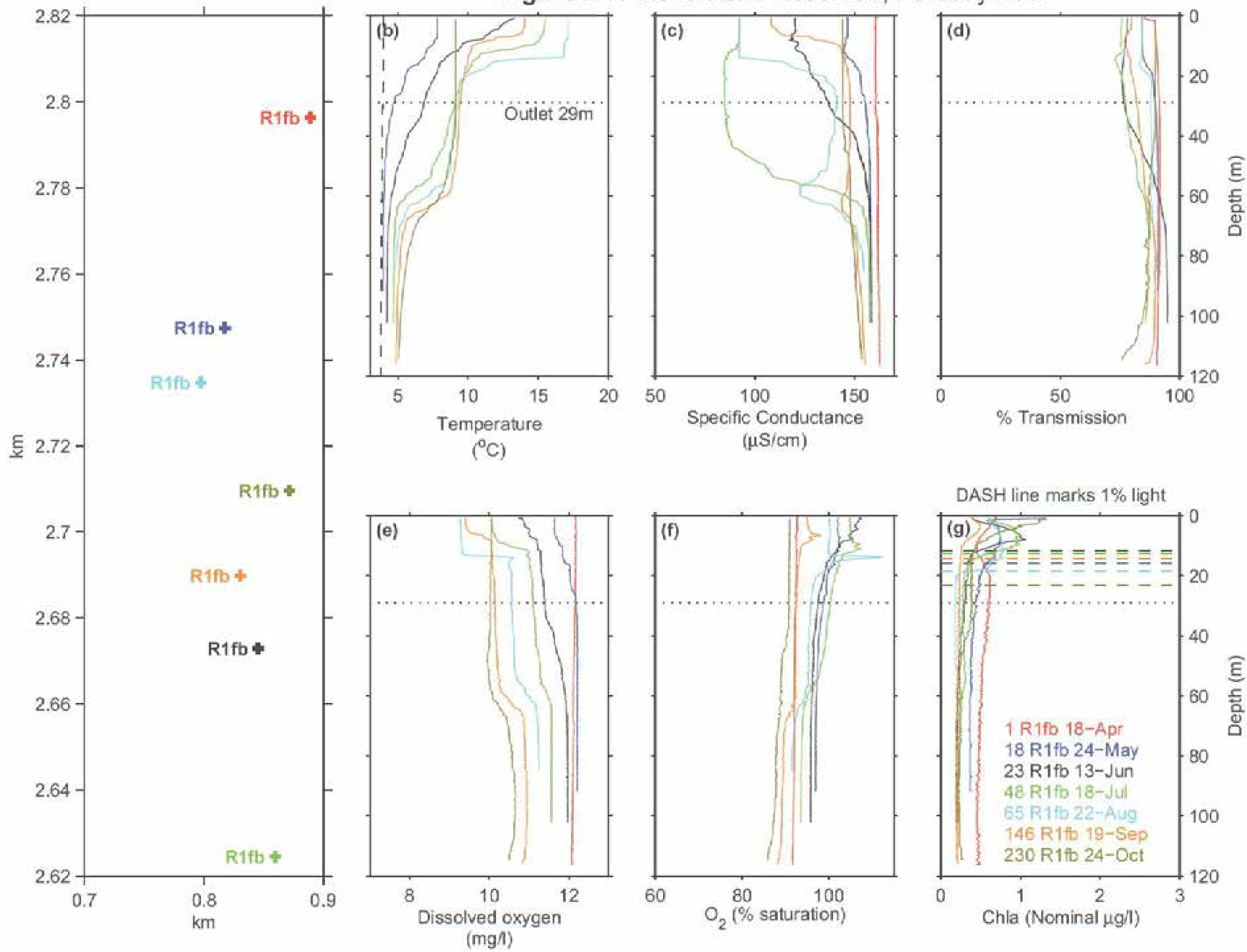


**Figure D20** Revelstoke Reservoir, Middle 2017

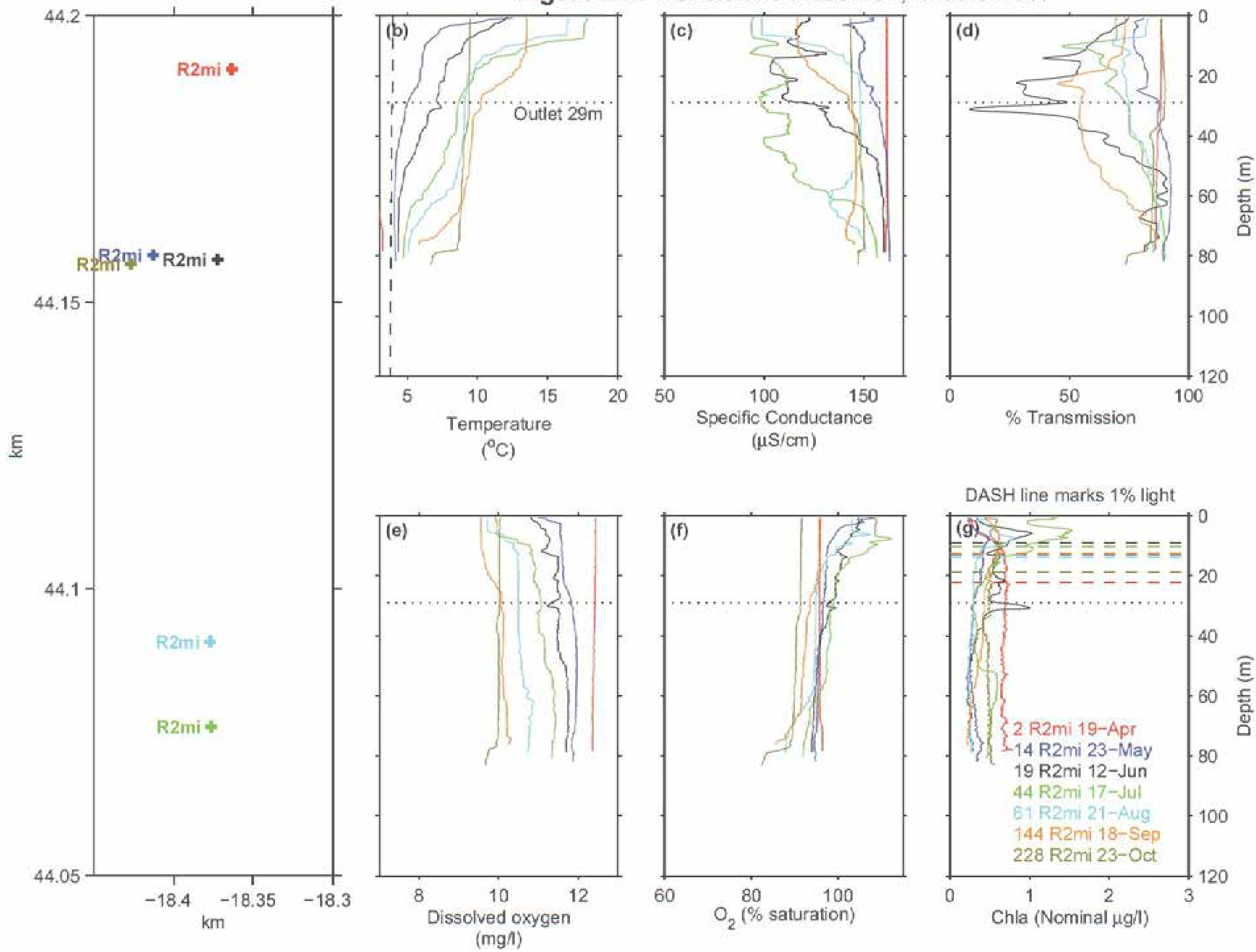


**Figure D21** Revelstoke Reservoir, Upper 2017

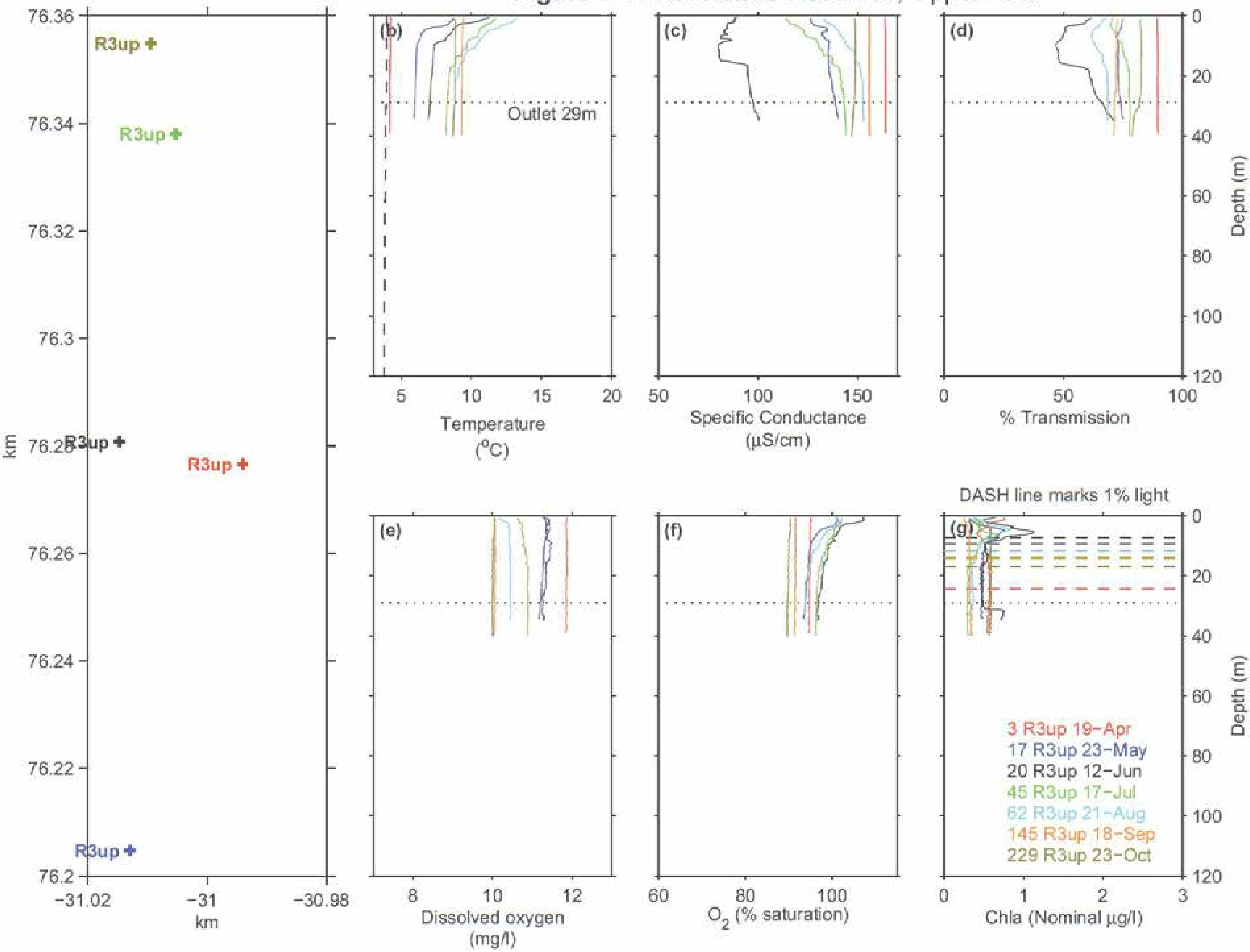


**Figure D22** Revelstoke Reservoir, Downie Arm 2016, D0

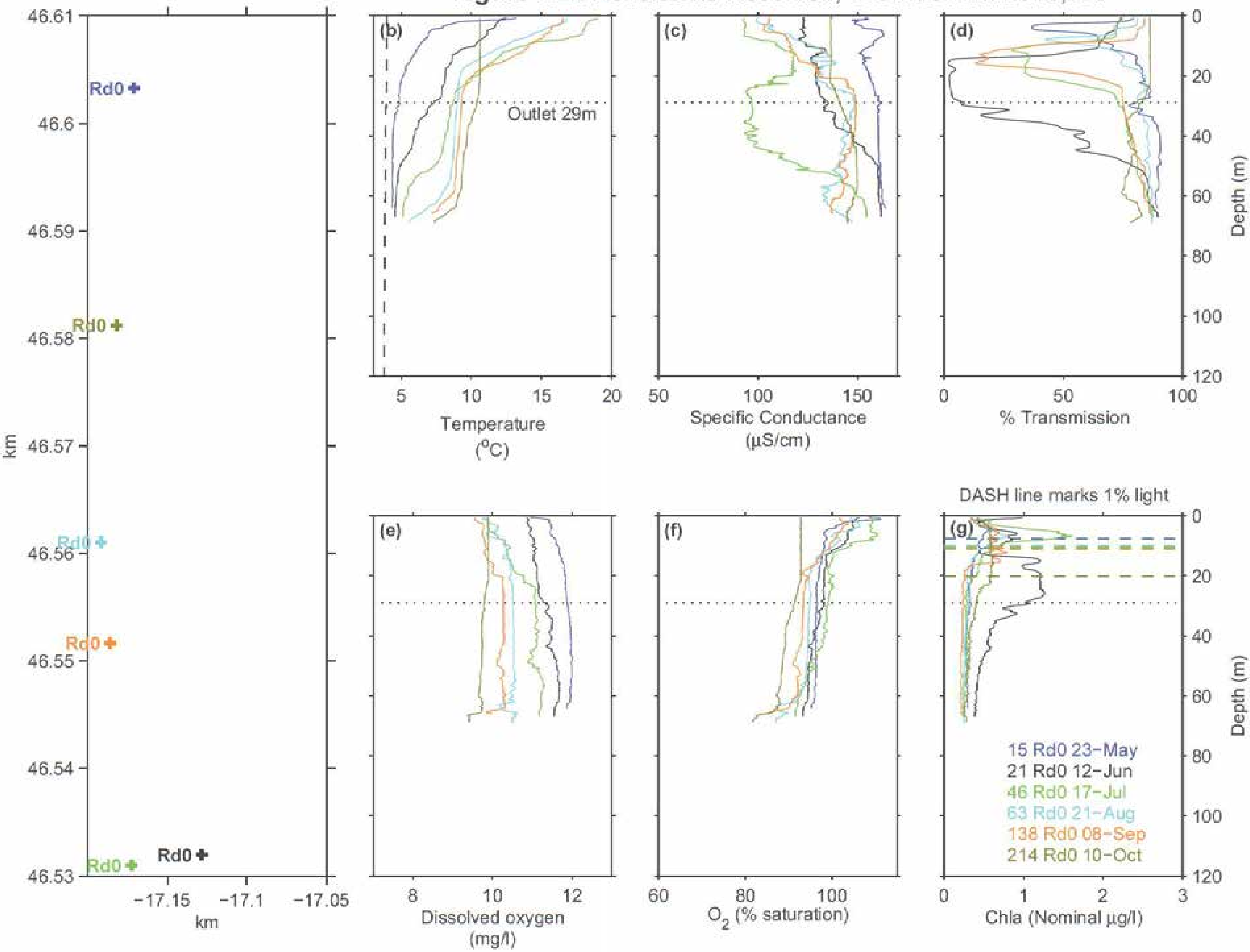


**Figure D23** Revelstoke Reservoir,  Downie Arm 2016, D1

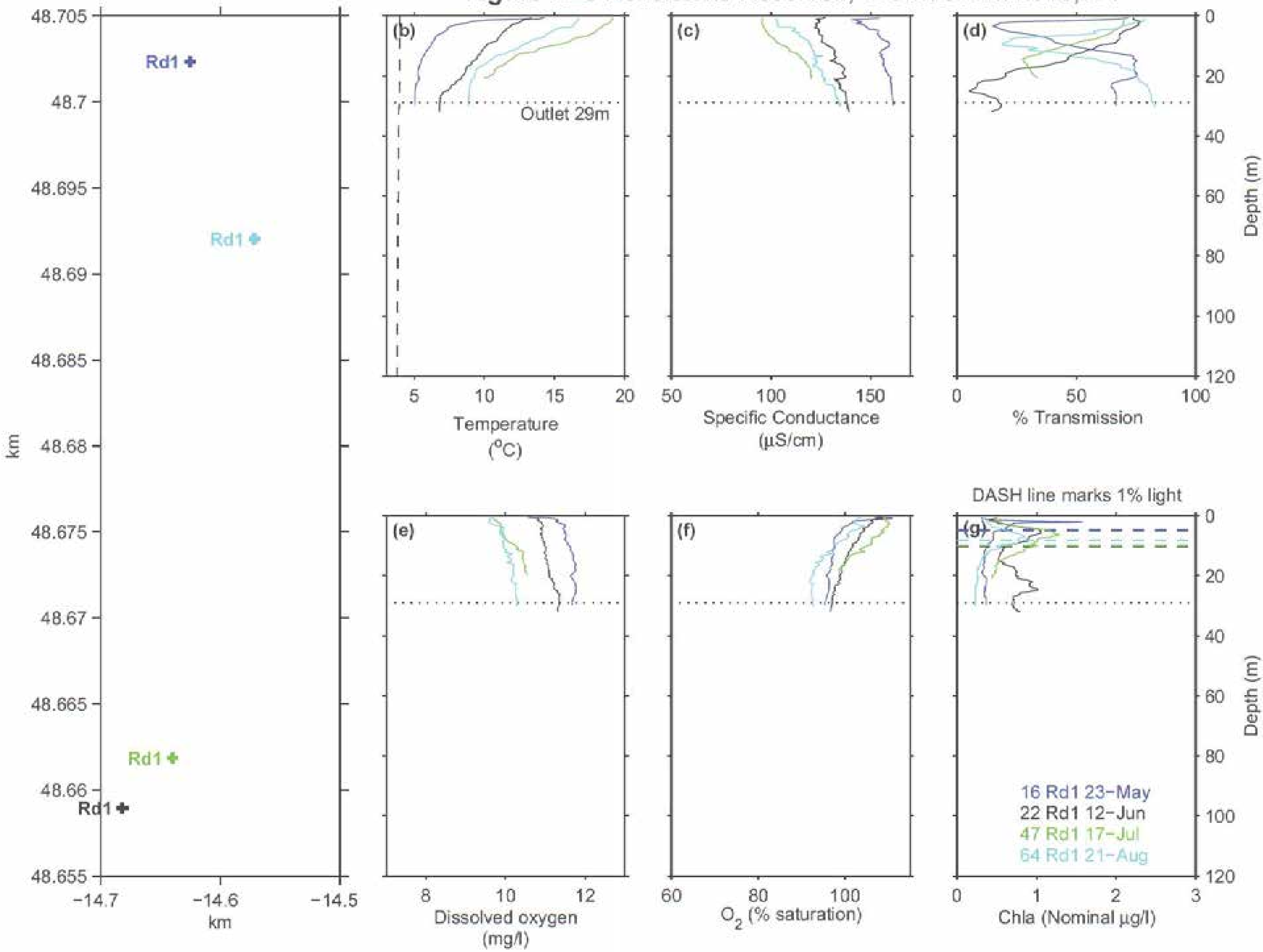
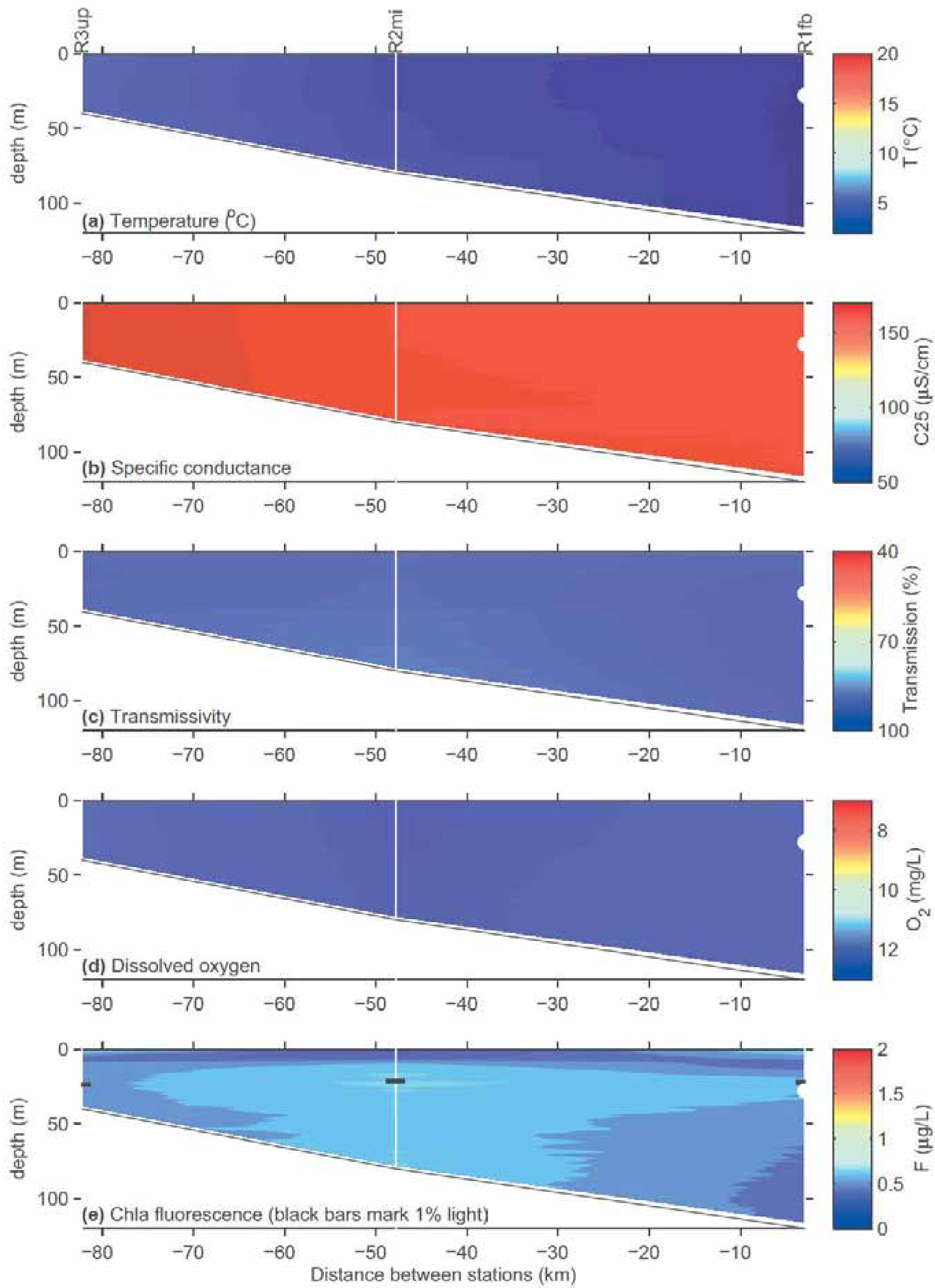
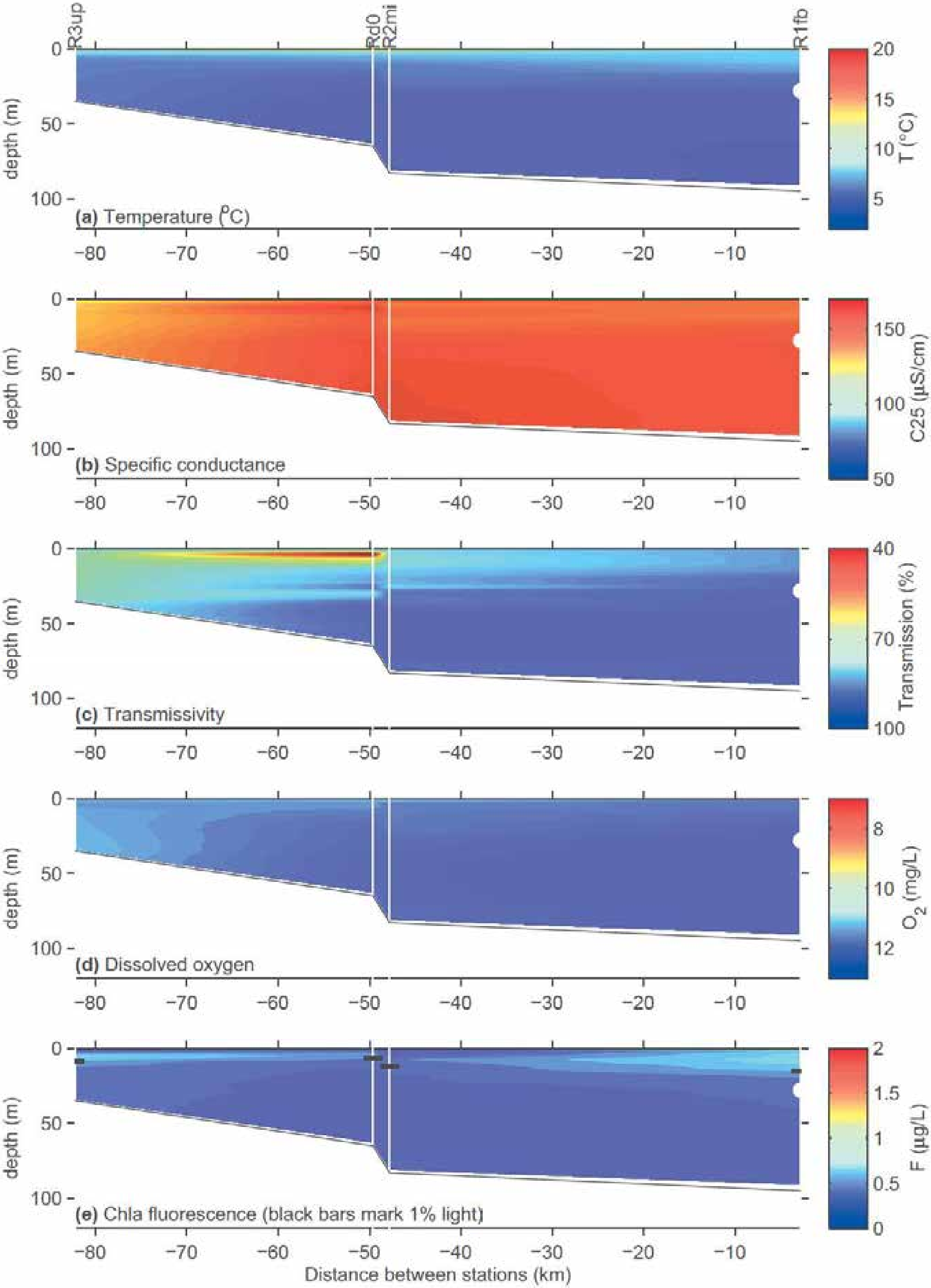


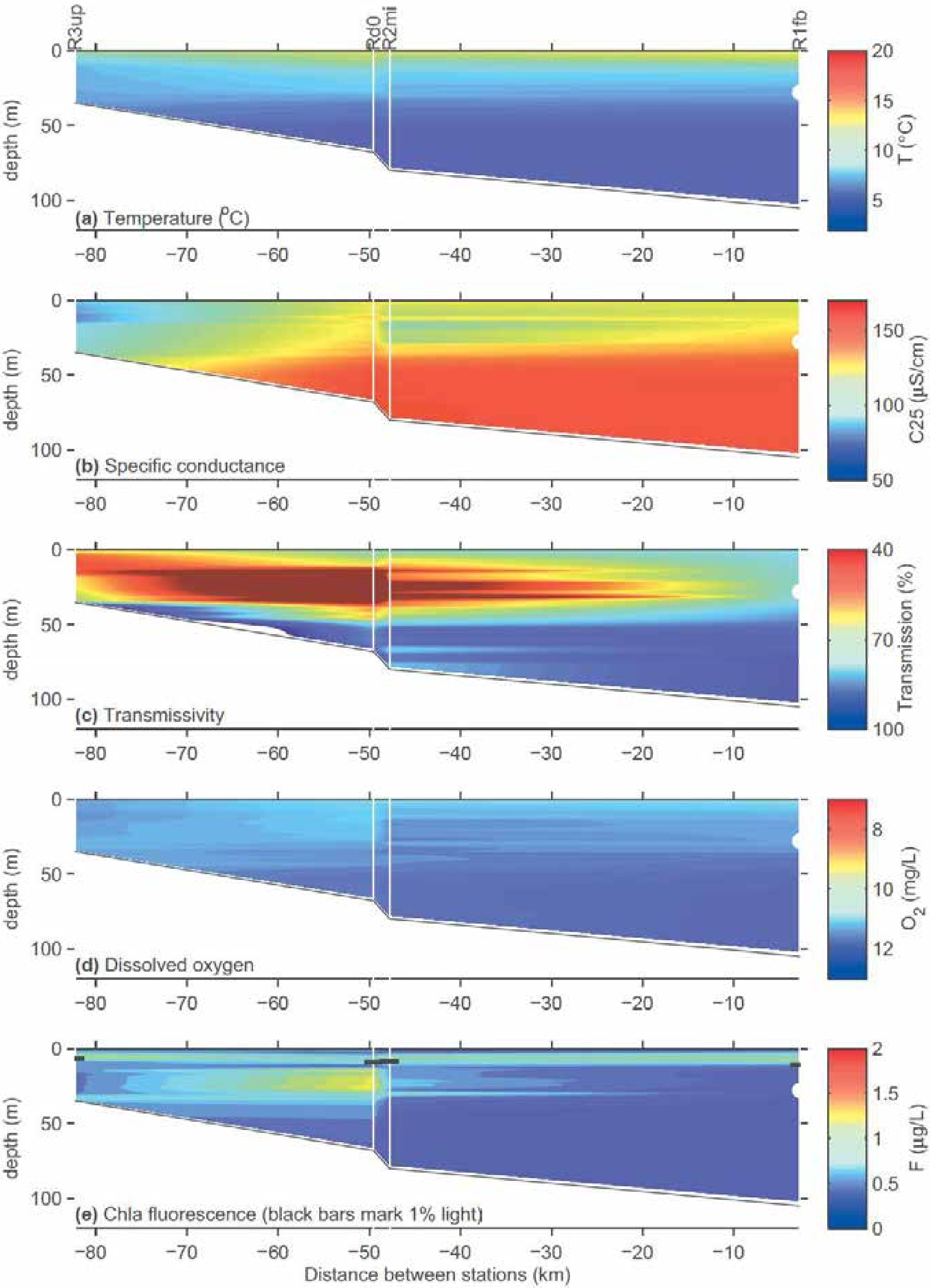
**Figure E1** Revelstoke Reservoir 18−19 Apr 2017



## Figure E2 Revelstoke Reservoir 23−24 May 2017



## Figure E3 Revelstoke Reservoir 12−13 Jun 2017



## Figure E4 Revelstoke Reservoir 21−22 Jun 2017

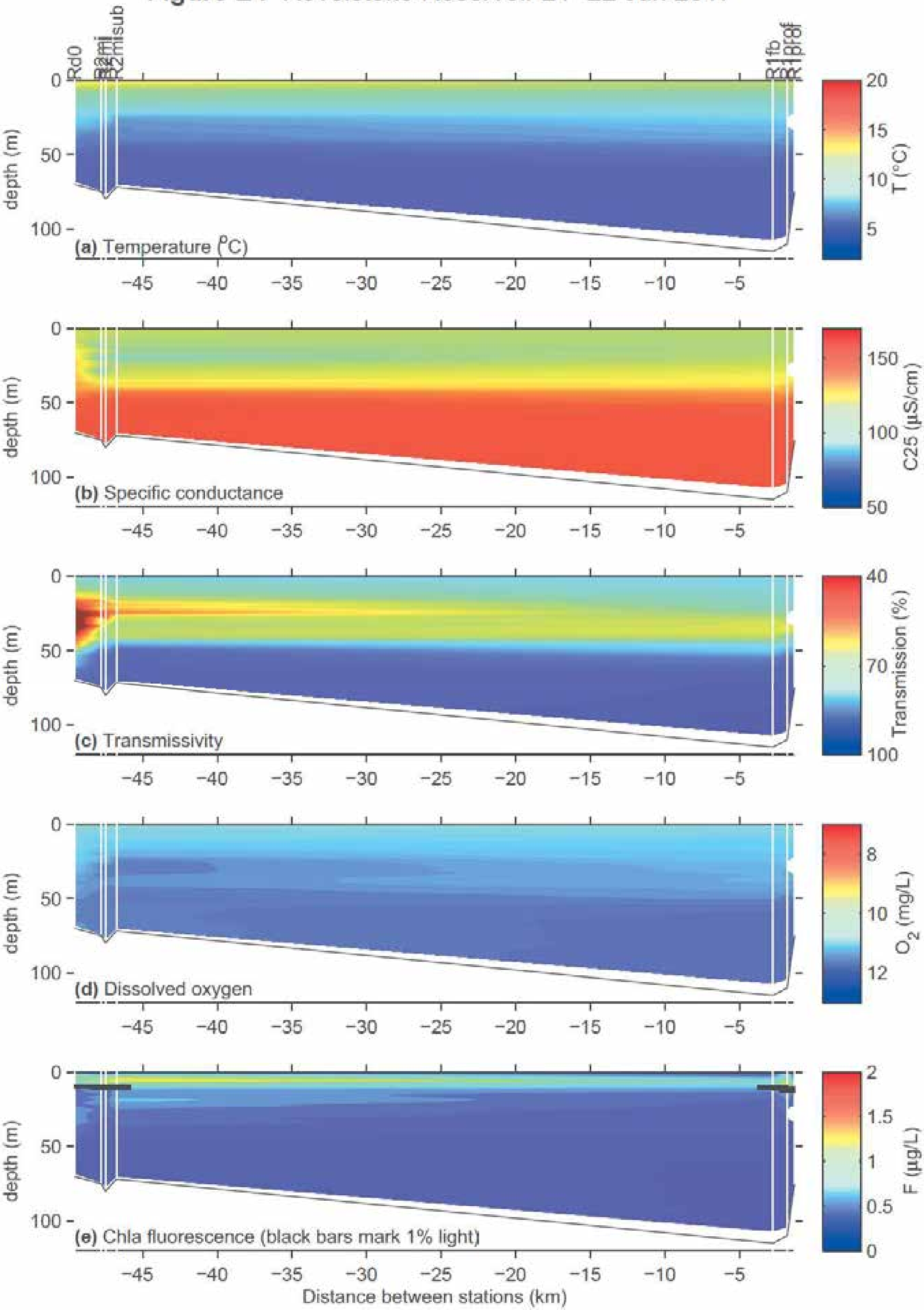


**Figure E5** Revelstoke Reservoir 17−18 Jul 2017

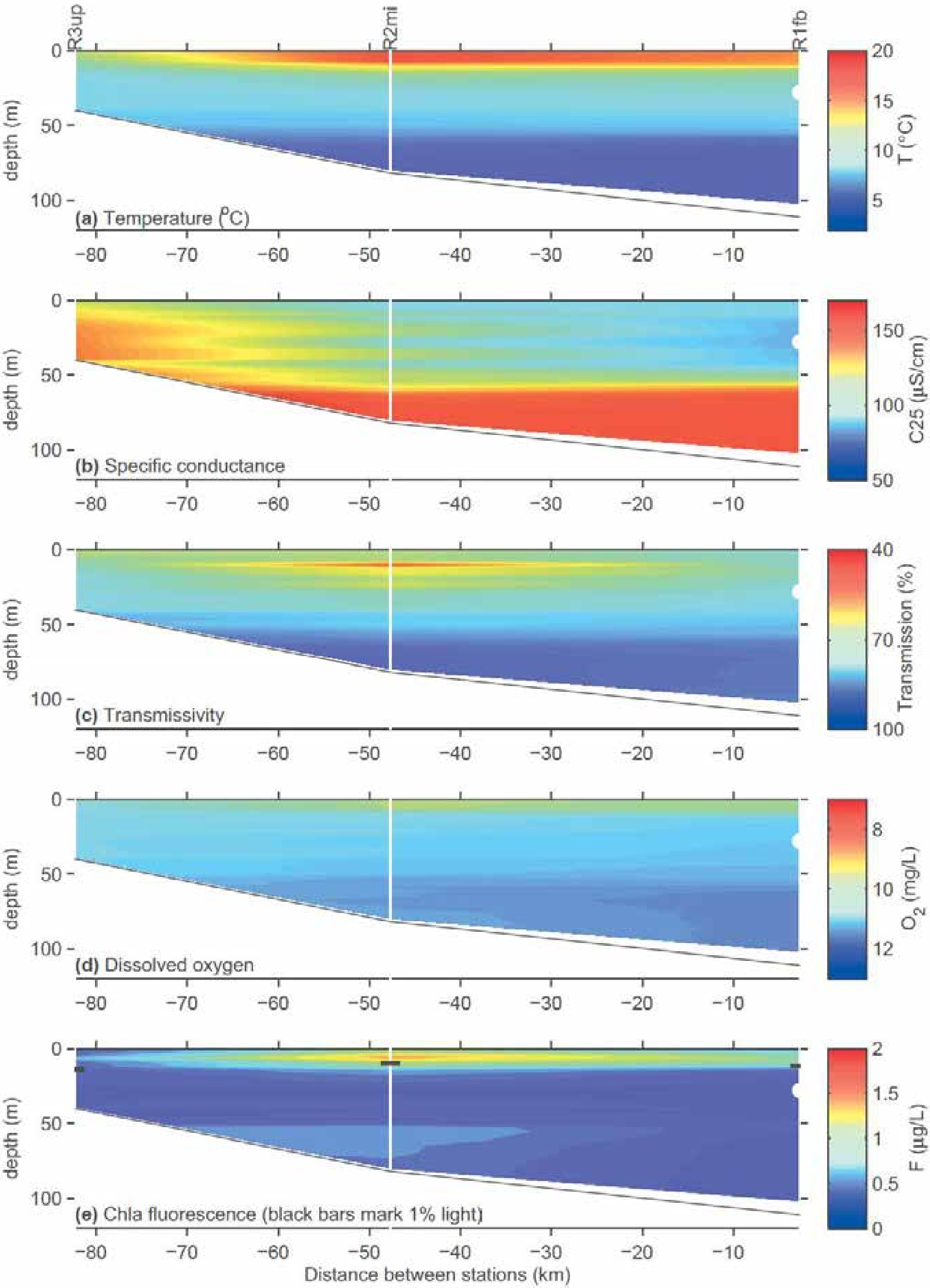


**Figure E6** Revelstoke Reservoir 21−22 Aug 2017

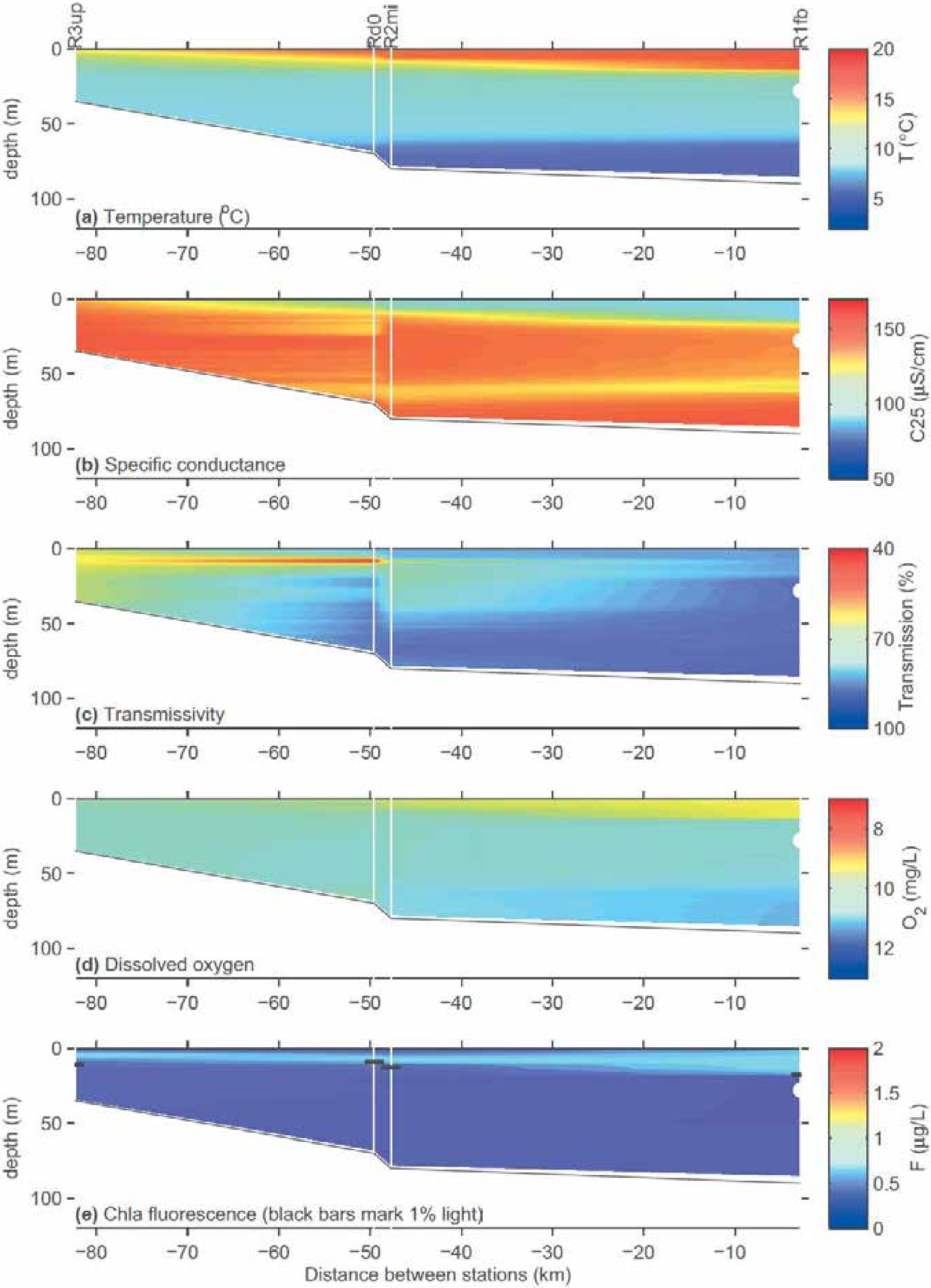
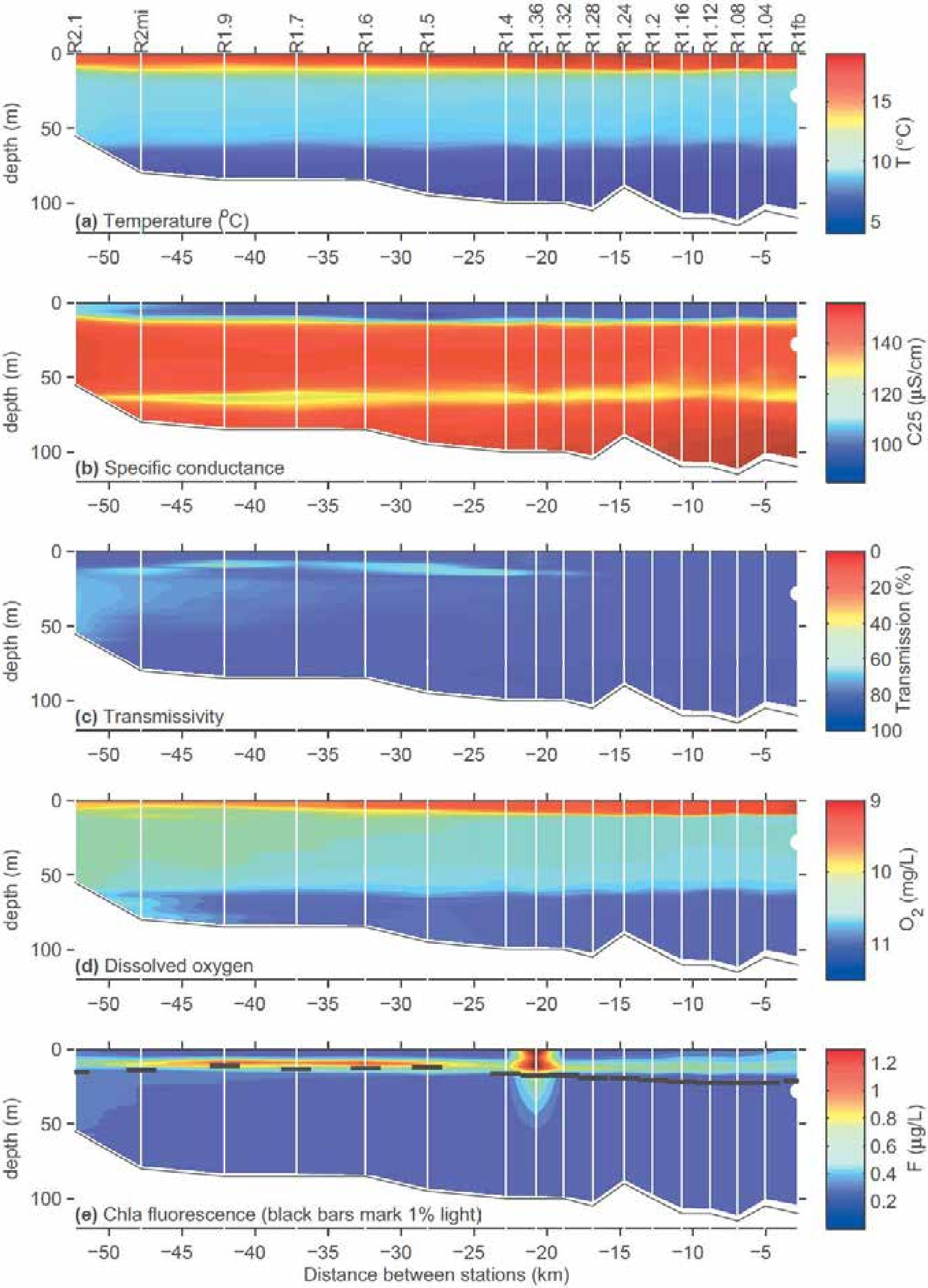


**Figure E7** Revelstoke Reservoir 29 Aug 2017



# Figure E8 Revelstoke Reservoir 1 Sep 2017

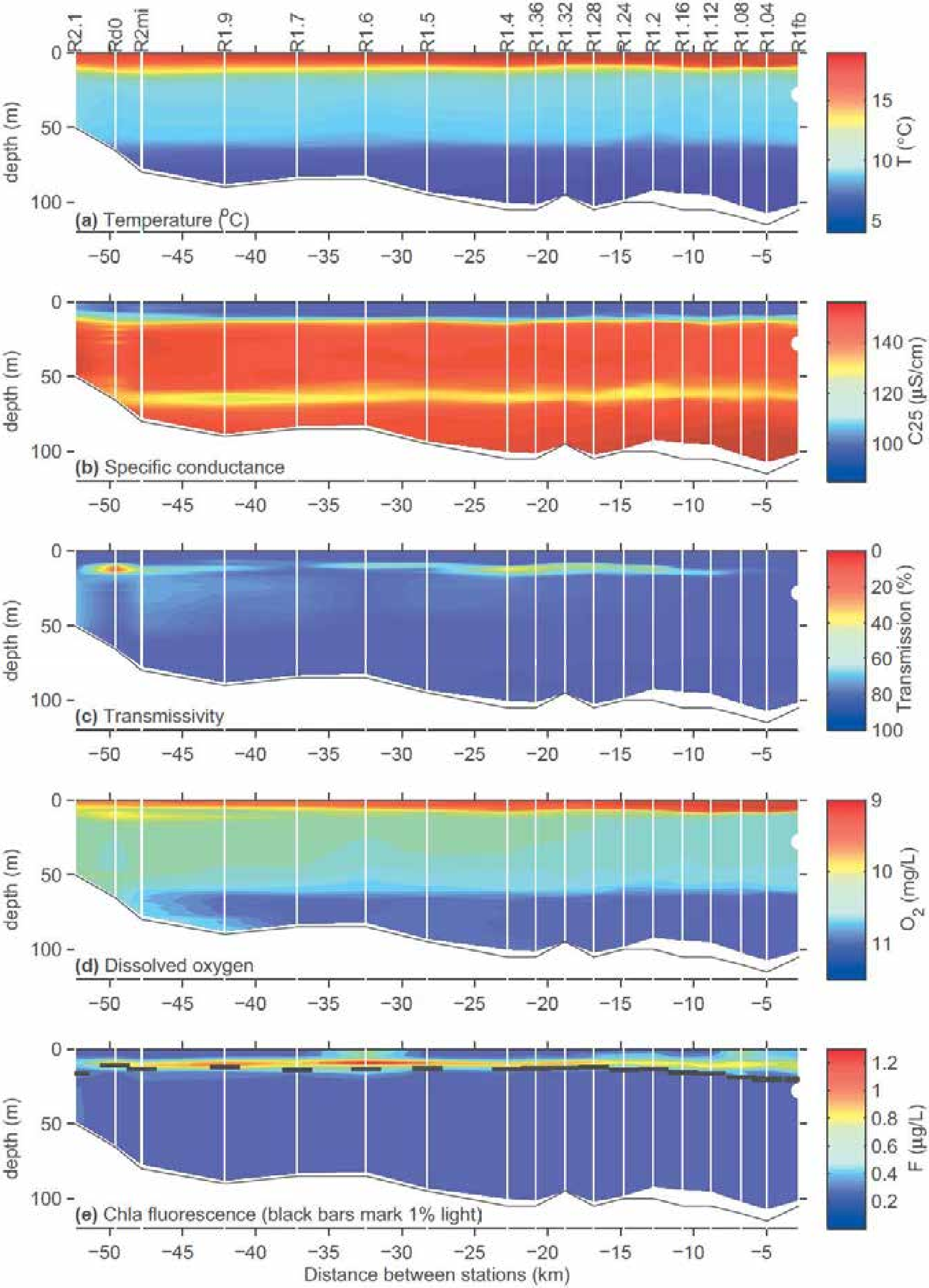


**Figure E9** Revelstoke Reservoir 5 Sep 2017

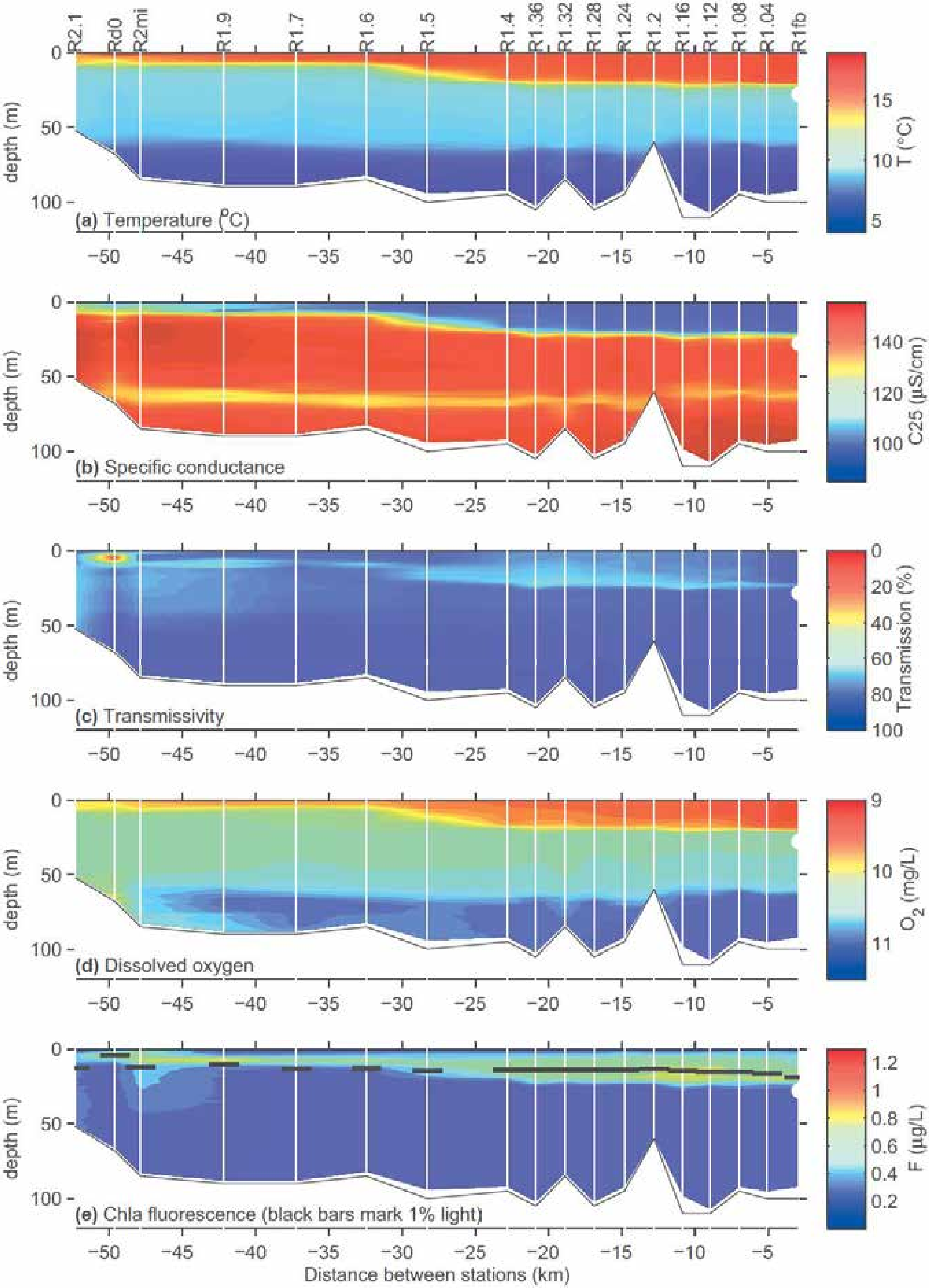


**Figure E10** Revelstoke Reservoir 8 Sep 2017

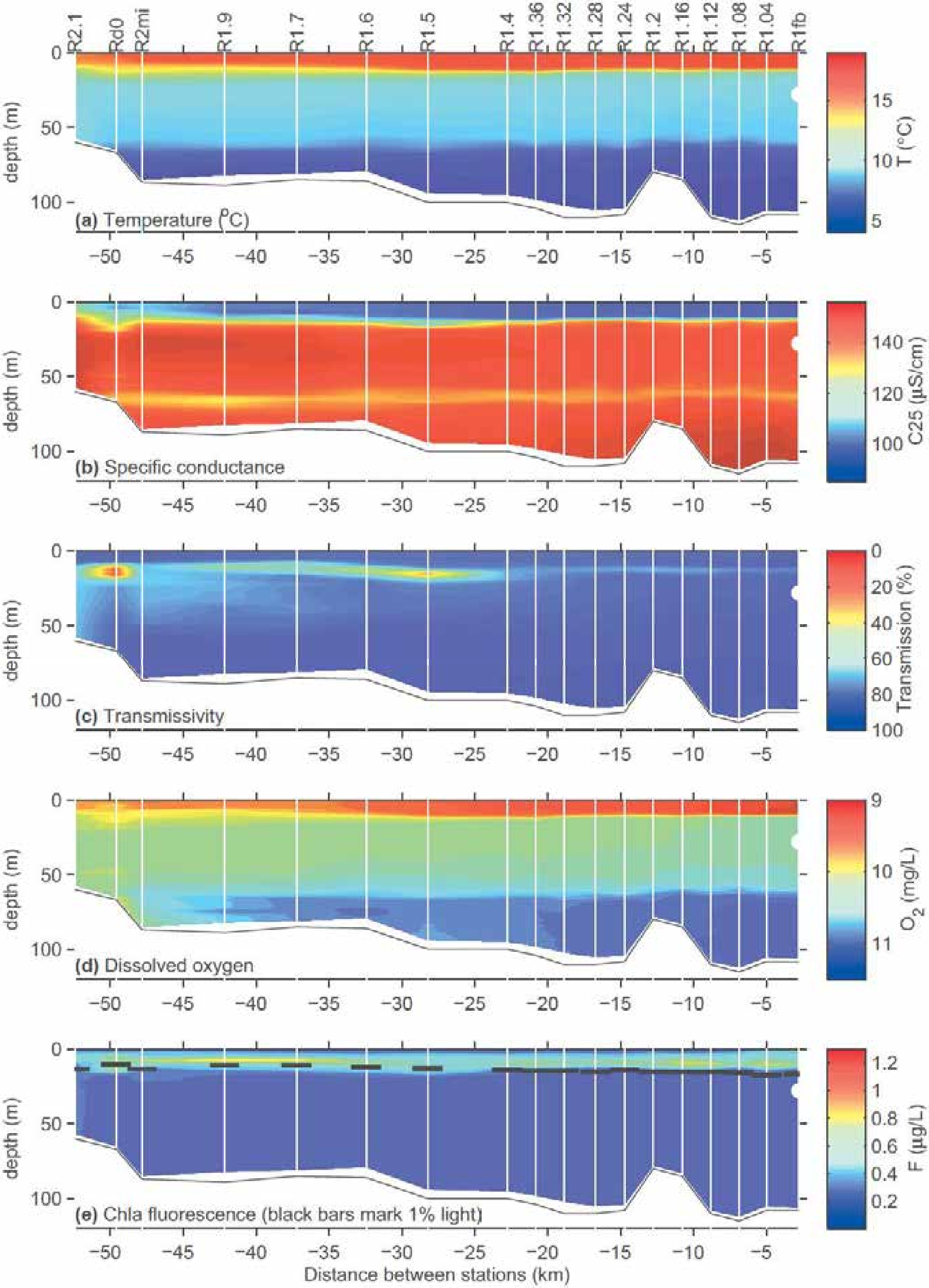


**Figure E11** Revelstoke Reservoir 18−19 Sep 2017

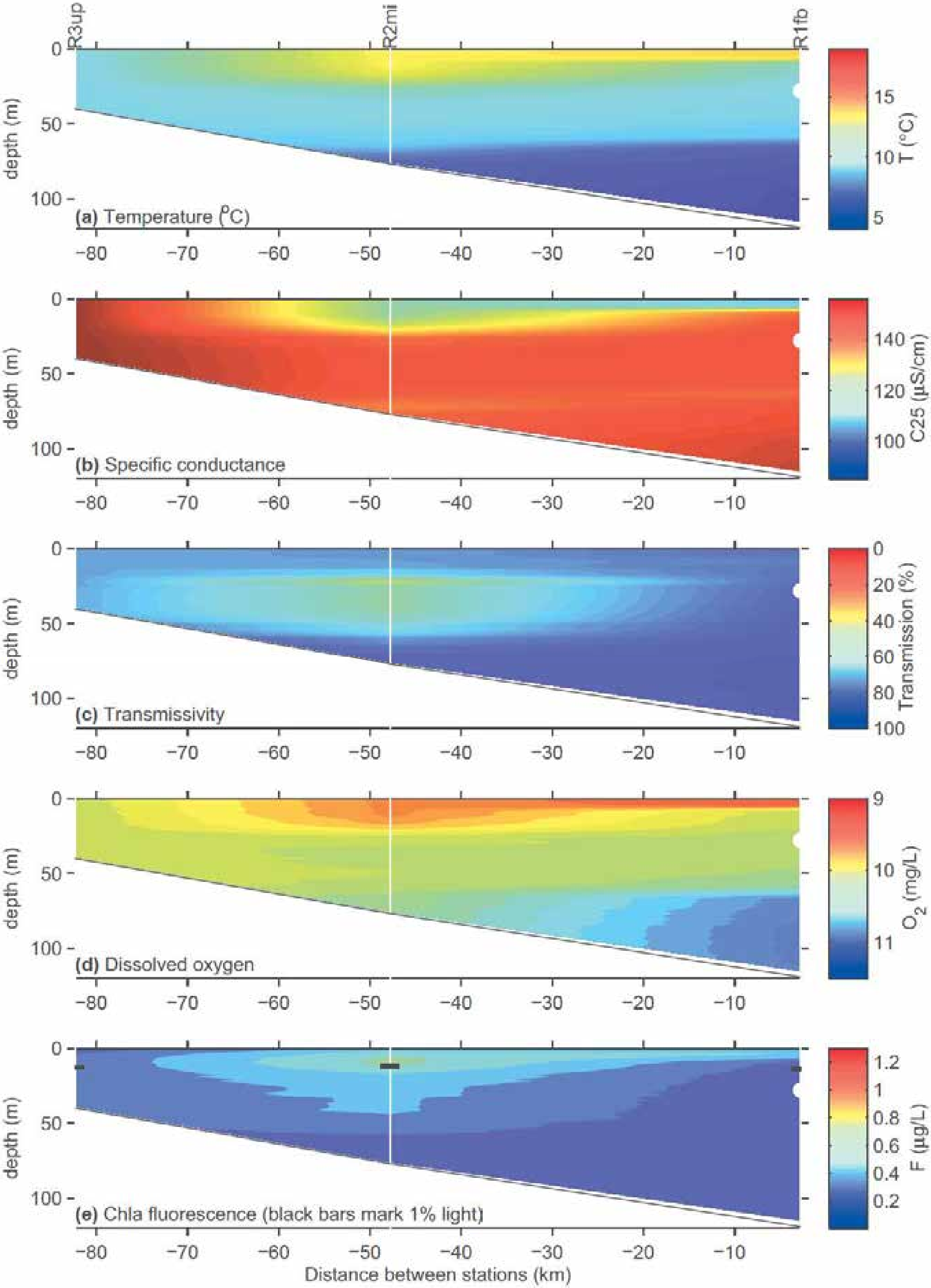
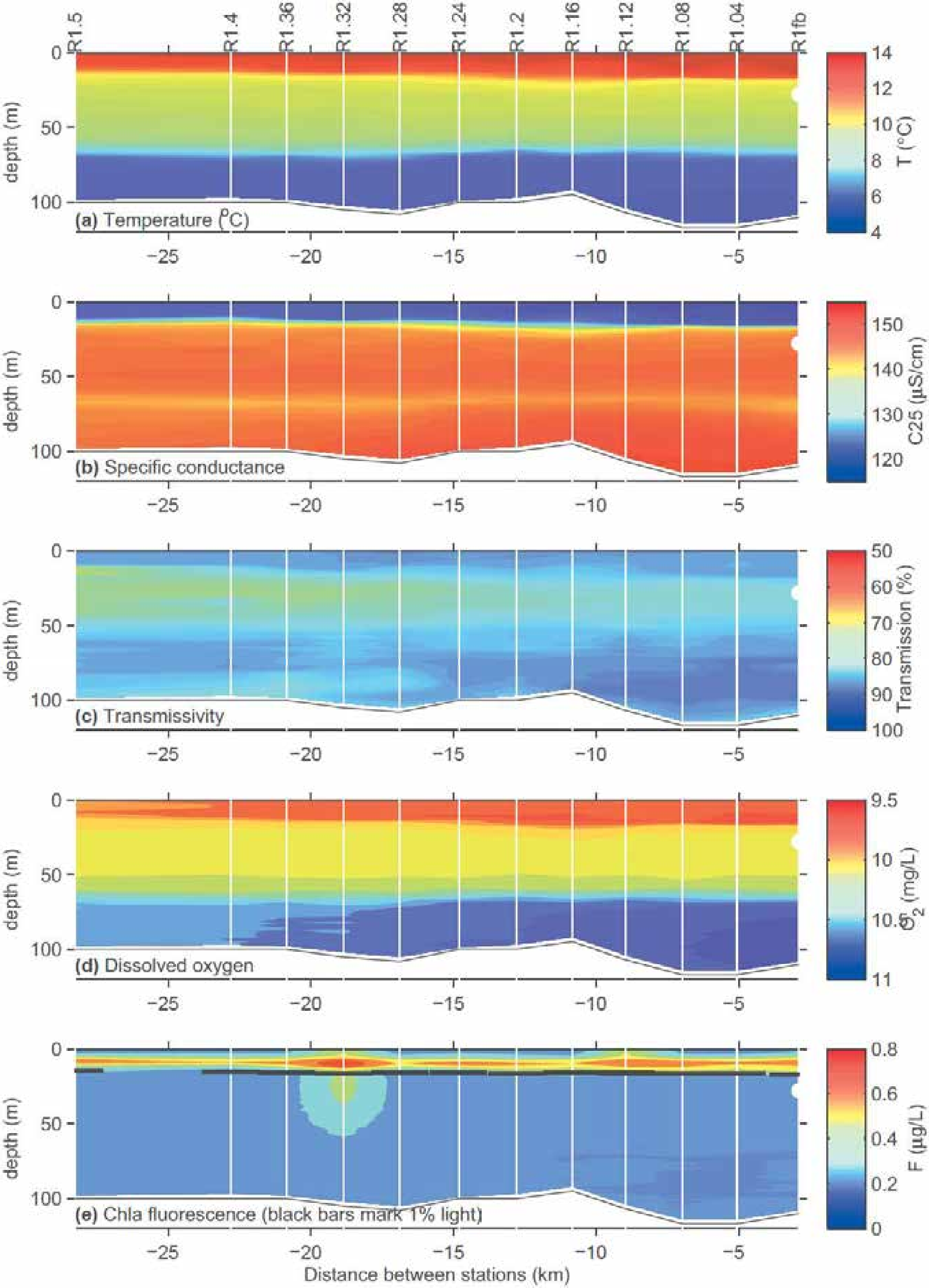


**Figure E12** Revelstoke Reservoir 29 Sep 2017



## Figure E13 Revelstoke Reservoir 2 Oct 2017

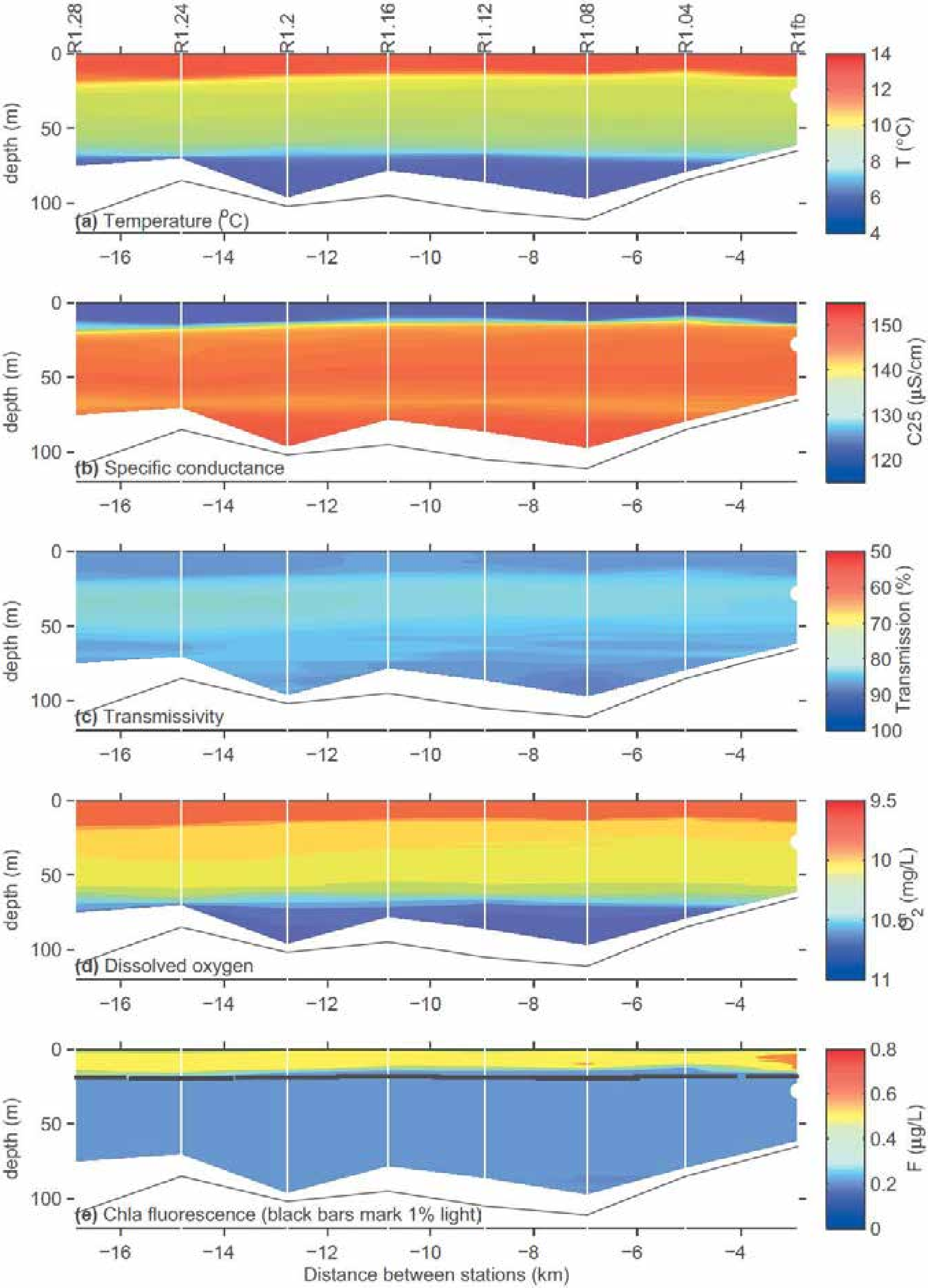
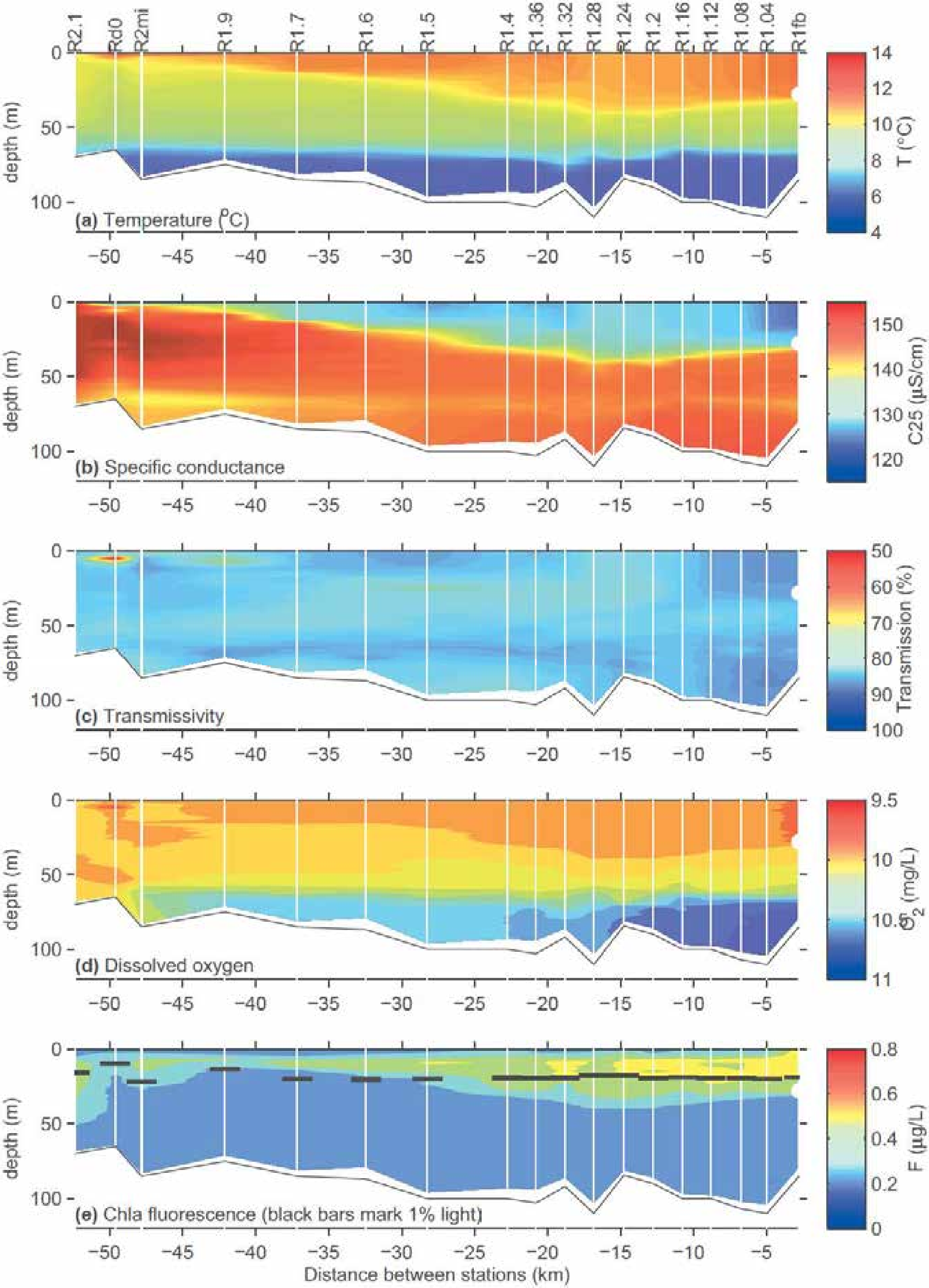


**Figure E14** Revelstoke Reservoir 4 Oct 2017



## Figure E15 Revelstoke Reservoir 6 Oct 2017

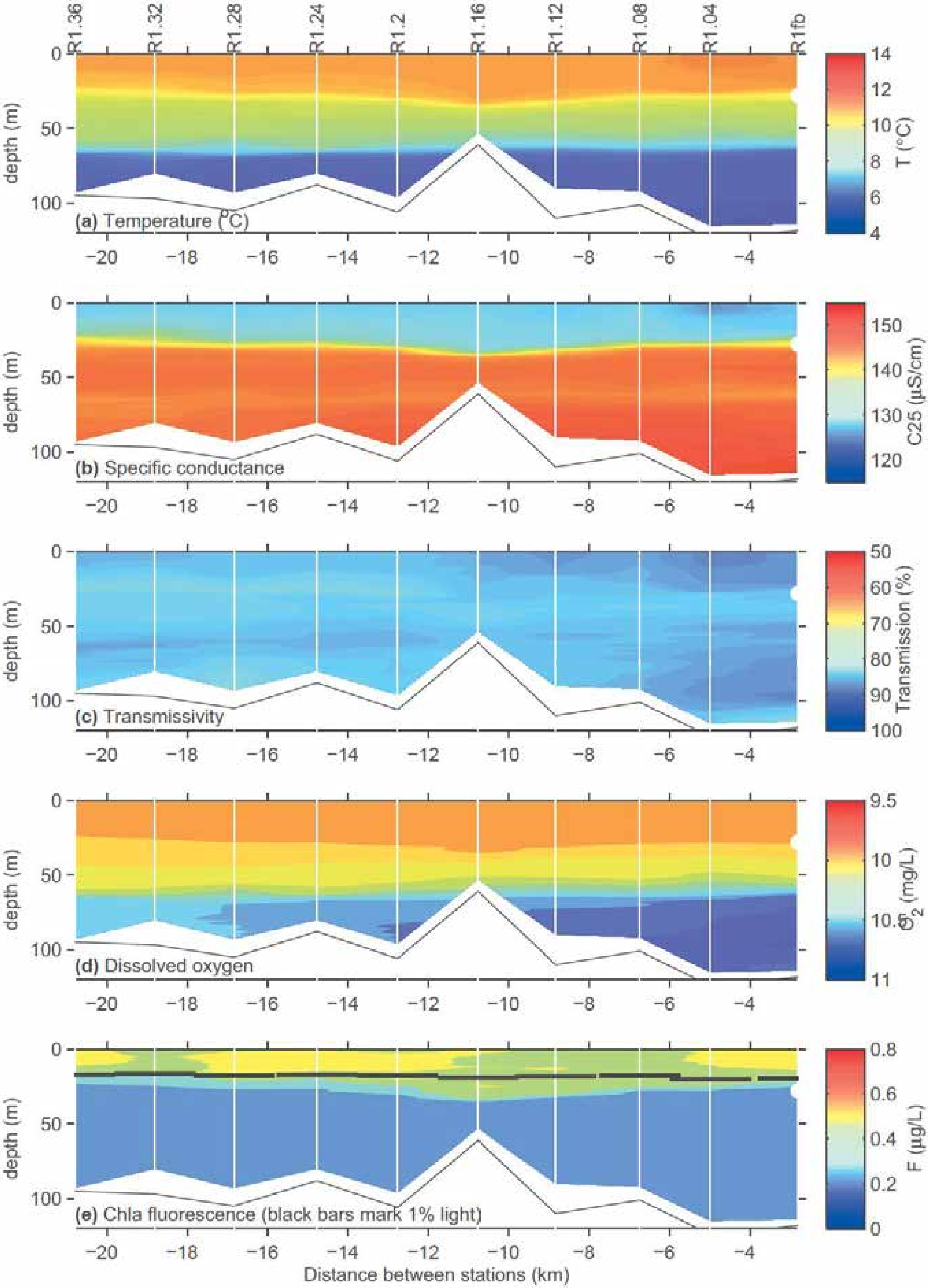


**Figure E16** Revelstoke Reservoir 10 Oct 2017

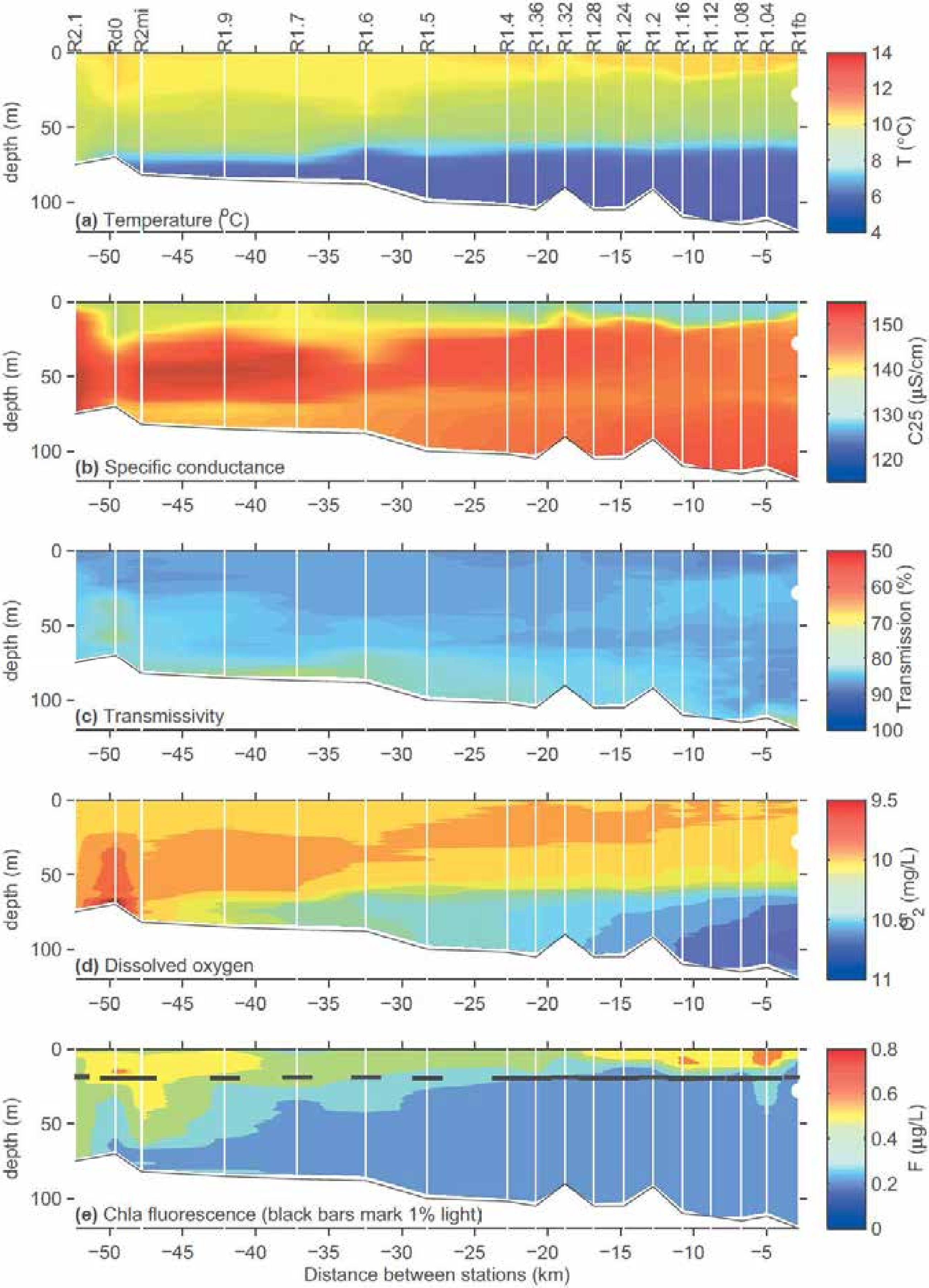


**Figure E17** Revelstoke Reservoir 13 Oct 2017

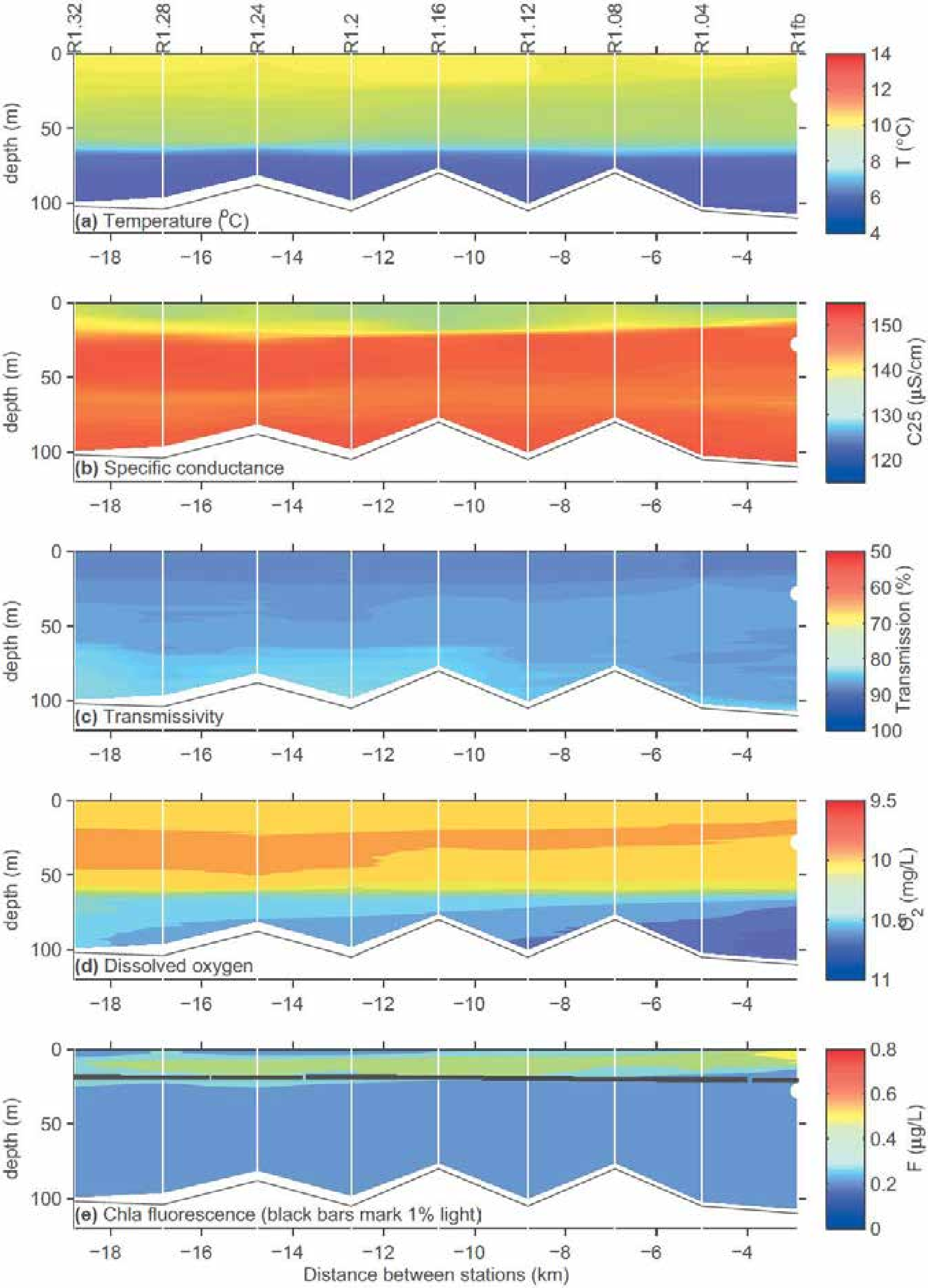


**Figure E18** Revelstoke Reservoir 23−24 Oct 2017

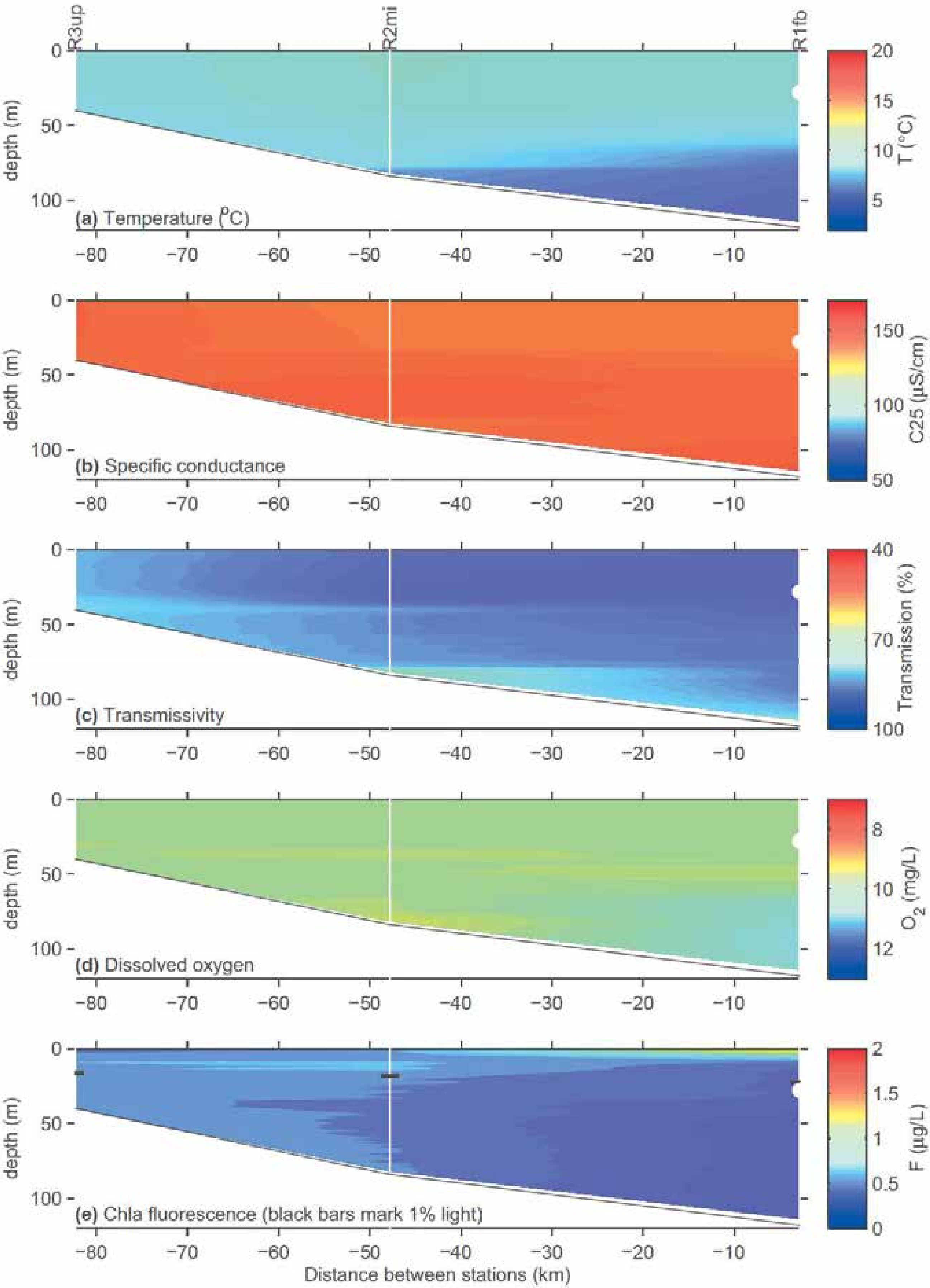
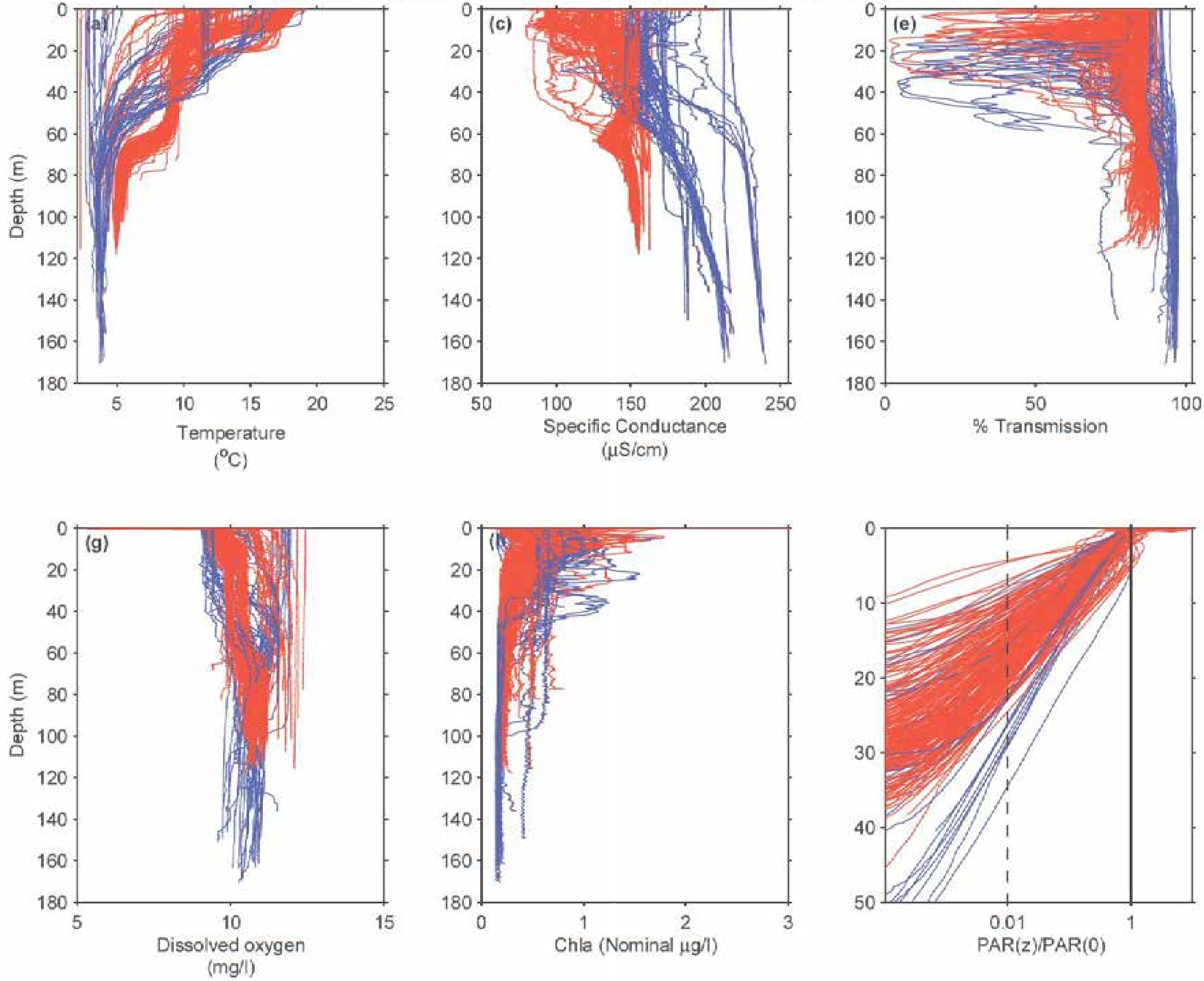


**Figure F1** All Kinbasket (BLU) and Revesltoke (RED) Data, 2017



**Appendix 1**
**Station Names**
**Kinbasket Reservoir**

| Name* | Description | Approximate Location |
|---|---|---|
| ***Kinbasket-Columbia Arm*** | | |
| KTGP | Next to Mica Dam (2016 only) | 52°04.780 118°34.398 |
| **K1fb** | **Forebay** | 52°05.673 118°32.902 |
| K1.5 | Kin-PP | 52°06.889 118°30.501 |
| **K2mi** | **Middle** | 52°07.858 118°26.363 |
| K2.1 | Kin-Mouth of Columbia to Kinbasket | 52°06.044 118°24.264 |
| K2.4 | 10 km from mouth of Columbia | 52°03.246 118°16.766 |
| K2.6 | 15 km from mouth of Columbia | 52°01.673 118°13.192 |
| K2.8 | 20 km from mouth of Columbia | 52°00.219 118°09.401 |
| **K3co** | **Columbia Reach** | 51°58.438 118°05.030 |
| K3.1 | 30 km from mouth of Columbia | 51°57.067 118°02.334 |
| K3.5 | 40 km from mouth of Columbia | 51°53.595 117°55.577 |
| K3.7 | 50 km from mouth of Columbia | 51°50.381 117°48.576 |
| K4 | 60 km from mouth of Columbia | 51°47.010 117°41.750 |
| ***Kinbasket-Wood Arm*** | | |
| Kwo0 | Mouth of Wood to Kinbasket | 52°09.004 118°22.994 |
| **Kwo1** | **Wood Arm** | 52°08.269 118°18.024 |
| Kwo2 | End of Wood Arm | 52°10.738 118°10.020 |
| ***Kinbasket-Canoe Arm*** | | |
| Kca0 | Mouth of Canoe to Kinbasket | 52°10.631 118°27.049 |
| **Kca1** | **Canoe Reach** | 52°12.547 118°28.516 |
| Kca1.5 | 10 km from mouth of Canoe | 52°15.509 118°31.235 |
| Kca2.5 | 20 km from mouth of Canoe | 52°20.025 118°35.804 |
| Kca3 | 30 km from mouth of Canoe | 52°24.198 118°41.857 |
| Kca4 | 40 km from mouth of Canoe | 52°28.714 118°46.355 |
| Kca5 | 50 km from mouth of Canoe | 52°33.452 118°50.709 |

**Appendix 1**
**Station Names**
**Revelstoke Reservoir**

| Name* | Description | Approximate Location |
|---|---|---|
| ***Revelstoke*** | | |
| R1fbbm | Rev-Forebay by log boom mooring | 51°03.222 118°11.383 |
| R1prof | Rev-Forebay by profiler mooring | 51°04.037 118°10.937 |
| R1sub | Rev-Forebay by subsurface mooring | 51°04.272 118°10.919 |
| **R1fb** | **Rev-Forebay** | 51°04.584 118°10.929 |
| R1.04 | Rev-2 km from Forebay | 51°05.670 118°11.000 |
| R1.08 | Rev-4 km from Forebay | 51°06.743 118°11.544 |
| R1.12 | Rev-6km from Forebay | 51°07.756 118°11.886 |
| R1.16 | Rev-8km from Forebay | 51°08.774 118°12.730 |
| R1.2 | Rev-10 km from Forebay | 51°09.988 118°12.677 |
| R1.24 | Rev-12 km from Forebay | 51°10.934 118°12.533 |
| R1.28 | Rev-14 km from Forebay | 51°12.052 118°12.682 |
| R1.32 | Rev-16 km from Forebay | 51°13.085 118°13.249 |
| R1.36 | Rev-18 km from Forebay | 51°14.142 118°13.685 |
| R1.39spar | Rev-Laforme spar | 51°14.667 118°14.054 |
| R1.39prof | Rev-Laforme profiler | 51°14.832 118°14.258 |
| R1.4 | Rev-20 km from Forebay | 51°15.179 118°14.332 |
| R1.44 | Rev-22 km from Forebay | 51°16.131 118°15.288 |
| R1.5 | Rev-25 km from Forebay | 51°17.785 118°17.476 |
| R1.6 | Rev-30 km from Forebay | 51°19.593 118°20.842 |
| R1.7 | Rev-35 km from Forebay | 51°21.467 118°24.153 |
| R1.9 | Rev-40 km from Forebay | 51°23.852 118°26.552 |
| R2miprof | Rev-Middle Profiler | 51°25.931 118°26.597 |
| R2misub | Rev-Mid sub | 51°25.981 118°27.675 |
| **R2mi** | **Rev-Mid** | 51°26.612 118°27.939 |
| Rd0 | Rev-Downie loop across from boat launch | 51°27.929 118°27.109 |
| Rd1 | Rev-Downie Loop 3.35 km from BL site | 51°29.063 118°25.003 |
| R2.1 | Rev-50 km from Forebay | 51°29.082 118°29.093 |
| R2.5 | Rev-60 km from Forebay | 51°33.778 118°33.541 |
| R2.7 | Rev-70 km from Forebay | 51°38.586 118°37.338 |
| **R3up** | **Rev-Upper** | 51°43.891 118°39.633 |

* Main stations are bold

# Appendix 2
## List of Profiles

Appendix 2, List of Profiles 2017

| Cast Number | Date | Site Name | Time On | Time Off | GPS | Depth (m) | Stn |
|---|---|---|---|---|---|---|---|
| 1 | 18/Apr/2017 | Rev- Forebay | 12:34 | 12:49 | 51°04.498 118°10.908 | 120 | R1fb |
| 2 | 19/Apr/2017 | Rev - Middle | 09:15 | 09:28 | 51°26.638 118°28.101 | 80 | R2mi |
| 3 | 19/Apr/2017 | Rev - Upper | 11:32 | 11:39 | 51°43.796 118°39.630 | 40 | R3up |
| 4 | 24/Apr/2017 | Kin - Canoe | 11:14 | 11:28 | 52°12.520 118°28.520 | 105 | Kca1 |
| 5 | 24/Apr/2017 | Kin - Wood | 13:05 | 13:12 | 52°08.275 118°18.625 | 43 | Kwo1 |
| 6 | 24/Apr/2017 | Kin - Forebay | 14:36 | 14:54 | 52°05.618 118°32.976 | 155 | K1fb |
| 7 | 25/Apr/2017 | Kin - Columbia | 08:33 | 08:50 | 51°57.970 118°04.840 | 150 | K3co |
| 8 | 25/Apr/2017 | Kin - Center | 11:28 | 11:46 | 52°07.825 118°26.444 | 140 | K2mi |
| 9 | 15/May/2017 | Kin- Canoe | 11:20 | 11:33 | 52°12.452 118°28.479 | 115 | Kca1 |
| 10 | 15/May/2017 | Kin - Wood | 13:23 | 13:30 | 52°08.314 118°18.606 | 40 | Kwo1 |
| 11 | 15/May/2017 | Kin - Forebay | 14:53 | 15:11 | 52°05.611 118°32.987 | 155 | K1fb |
| 12 | 16/May/2017 | Kin - Columbia | 08:40 | 09:00 | 51°57.967 118°04.874 | 155 | K3co |
| 13 | 16/May/2017 | Kin - Center | 11:46 | 12:03 | 52°07.847 118°26.481 | 140 | K2mi |
| 14 | 23/May/2017 | Rev - Middle | 11:00 | 11:11 | 52°26.620 118°28.143 | 83 | R2mi |
| 15 | 23/May/2017 | Rev - Downie Loop Across from Boat Launch | 12:16 | 12:25 | 51°27.952 118°27.113 | 65 | Rd0 |
| 16 | 23/May/2017 | Rev - Downie Loop 3.35km past BL | 12:32 | 12:38 | 51°29.111 118°24.950 | 30 | Rd1 |
| 17 | 23/May/2017 | Rev - Upper | 13:29 | 13:35 | 51°43.757 118°39.645 | 35 | R3up |
| 18 | 24/May/2017 | Rev - Forebay | 09:23 | 09:35 | 51°04.471 118°10.969 | 95 | R1fb |
| 19 | 12/Jun/2017 | Rev - Middle | 09:49 | 10:00 | 51°26.620 118°28.108 | 80 | R2mi |
| 20 | 12/Jun/2017 | Rev - Upper | 11:48 | 11:55 | 51°43.798 118°39.648 | 35 | R3up |
| 21 | 12/Jun/2017 | Rev - Downie Loop Across from Boat Launch | 13:34 | 13:45 | 51°27.914 118°27.075 | 68 | Rd0 |
| 22 | 12/Jun/2017 | Rev - Downie Loop 3.35km past BL | 13:53 | 13:59 | 51°29.087 118°24.998 | 32 | Rd1 |
| 23 | 13/Jun/2017 | Rev - Forebay | 08:25 | 08:38 | 51°04.431 118°10.944 | 105 | R1fb |
| 24 | 19/Jun/2017 | Kin - Columbia | 10:51 | 11:12 | 51°57.976 118°04.862 | 165 | K3co |
| 25 | 19/Jun/2017 | Kin - Wood | 13:09 | 13:18 | 52°08.263 118°18.655 | 55 | Kwo1 |
| 26 | 19/Jun/2017 | Kin - Canoe | 14:36 | 14:50 | 52°12.485 118°28.460 | 115 | Kca1 |
| 27 | 20/Jun/2017 | Kin - PP | 07:37 | 07:57 | 52°06.908 118°30.055 | 160 | K1.5 |
| 28 | 20/Jun/2017 | Kin - Forebay | 09:04 | 09:25 | 52°05.609 118°32.967 | 170 | K1fb |
| 29 | 20/Jun/2017 | Kin - Center | 11:11 | 11:29 | 52°07.866 118°26.408 | 140 | K2mi |
| 30 | 20/Jun/2017 | Kin - Columbia Mouth | 11:46 | 11:58 | 52°06.060 118°24.314 | 90 | K2.1 |
| 31 | 21/Jun/2017 | Rev - Middle PP | 08:07 | 08:17 | 51°26.609 118°28.101 | 75 | R2mi |
| 32 | 21/Jun/2017 | Rev - 0.3km from mid submerged array | 09:12 | 09:22 | 51°26.131 118°27.676 | 72 | R2misub |
| 33 | 21/Jun/2017 | Rev - Downie Loop Across from Boat Launch | 09:31 | 09:41 | 51°27.913 118°27.128 | 70 | Rd0 |
| 34 | 21/Jun/2017 | Rev - Downie Loop 3.35km past BL | 09:50 | 09:56 | 51°29.065 118°24.970 | 35 | Rd1 |
| 35 | 21/Jun/2017 | Rev - By PP Array | 12:21 | 12:31 | 51°26.524 118°27.781 | 80 | R2mi |
| 36 | 22/Jun/2017 | Rev - Forebay PP | 08:59 | 09:14 | 51°04.447 118°10.947 | 115 | R1fb |
| 37 | 22/Jun/2017 | Rev - 0.26km North from Rev FB submerged Array | 11:41 | 11:54 | 51°03.922 118°11.029 | 110 | R1prof |
| 38 | 22/Jun/2017 | Rev - 0.25km South from Rev FB submerged array | 12:00 | 12:11 | 51°03.669 118°11.190 | 75 | R1prof |
| 39 | 10/Jul/2017 | Kin - Columbia | 13:25 | 13:46 | 51°57.983 118°04.819 | 175 | K3co |
| 40 | 11/Jul/2017 | Kin - Forebay | 07:21 | 07:41 | 52°05.672 118°32.855 | 170 | K1fb |
| 41 | 11/Jul/2017 | Kin - Canoe | 09:50 | 10:03 | 52°12.483 118°28.532 | 110 | Kca1 |
| 42 | 11/Jul/2017 | Kin - Wood | 11:15 | 11:24 | 52°08.264 118°18.586 | 60 | Kwo1 |
| 43 | 11/Jul/2017 | Kin - Center | 12:44 | 13:01 | 52°07.837 118°26.394 | 140 | K2mi |
| 44 | 17/Jul/2017 | Rev - Middle | 09:43 | 09:53 | 51°26.576 118°28.110 | 82 | R2mi |
| 45 | 17/Jul/2017 | Rev - Upper | 12:03 | 12:10 | 51°43.829 118°39.641 | 40 | R3up |
| 46 | 17/Jul/2017 | Rev - Downie Loop Across from Boat Launch | 13:45 | 13:55 | 51°27.913 118°27.113 | 68 | Rd0 |
| 47 | 17/Jul/2017 | Rev - Downie Loop 3.35km past BL | 14:04 | 14:10 | 51°29.089 118°24.962 | 36 | Rd1 |
| 48 | 18/Jul/2017 | Rev - Forebay & PP | 09:16 | 09:29 | 51°04.405 118°10.931 | 111 | R1fb |
| 49 | 19/Jul/2017 | Kin - PP | 07:19 | 07:40 | 52°06.938 118°29.467 | 170 | K1.5 |
| 50 | 19/Jul/2017 | Kin - Columbia Mouth | 11:39 | 11:49 | 52°06.064 118°24.265 | 75 | K2.1 |
| 51 | 19/Jul/2017 | Kin - 0.20 km from Kin-Mid Spar | 11:57 | 12:15 | 52°07.241 118°27.203 | 160 | K2mi |
| 52 | 20/Jul/2017 | Rev - Middle PP | 08:52 | 09:03 | 51°26.619 118°28.131 | 84.3 | R2mi |
| 53 | 14/Aug/2017 | Kin - Canoe | 11:18 | 11:32 | 52°12.494 118°28.472 | 115 | Kca1 |
| 54 | 14/Aug/2017 | Kin - Wood | 13:00 | 13:10 | 52°08.270 118°18.620 | 60 | Kwo1 |
| 55 | 14/Aug/2017 | Kin - Forebay | 14:29 | 14:49 | 52°05.627 118°32.957 | 160 | K1fb |
| 56 | 15/Aug/2017 | Kin - Columbia | 07:52 | 08:14 | 51°57.926 118°04.811 | 170 | K3co |
| 57 | 15/Aug/2017 | Kin - 30km from Columbia Mouth | 09:44 | 10:00 | 51°56.675 118°02.695 | 150 | K3.1 |
| 58 | 15/Aug/2017 | Kin - 15km from Columbia Mouth | 10:22 | 10:30 | 52°01.673 118°13.192 | 55 | K2.6 |

| Cast Number | Date | Site Name | Time On | Time Off | GPS | Depth (m) | Stn |
|---|---|---|---|---|---|---|---|
| 59 | 15/Aug/2017 | Kin - Mouth of Columbia | 10:50 | 11:02 | 52°06.059 118°24.290 | 88 | K2.1 |
| 60 | 15/Aug/2017 | Kin - Center | 11:10 | 11:27 | 52°07.835 118°26.440 | 140 | K2mi |
| 61 | 21/Aug/2017 | Rev - Middle | 09:37 | 09:48 | 51°26.584 118°28.111 | 80 | R2mi |
| 62 | 21/Aug/2017 | Rev - Upper | 12:14 | 12:21 | 51°43.838 118°39.645 | 35 | R3up |
| 63 | 21/Aug/2017 | Rev - Downie Loop Across from Boat Launch | 13:56 | 14:02 | 51°27.929 118°27.130 | 70 | Rd0 |
| 64 | 21/Aug/2017 | Rev - Downie Loop 3.35km past BL | 14:14 | 14:20 | 51°29.106 118°24.903 | 30 | Rd1 |
| 65 | 22/Aug/2017 | Rev - Forebay & PP | 08:02 | 08:14 | 51°04.464 118°10.986 | 90 | R1fb |
| 66 | 23/Aug/2017 | Kin - PP | 08:32 | 08:52 | 52°06.920 118°30.020 | 170 | K1.5 |
| 67 | 24/Aug/2017 | Rev - Middle | 08:47 | 08:59 | 51°26.578 118°28.114 | 80 | R2mi |
| 68 | 29/Aug/2017 | Rev - Forebay | 10:18 | 10:32 | 51°04.450 118°10.944 | 110 | R1fb |
| 69 | 29/Aug/2017 | Rev - 2km from Forebay | 10:41 | 10:54 | 51°05.694 118°10.972 | 105 | R1.04 |
| 70 | 29/Aug/2017 | Rev - 4km from Forebay | 11:10 | 11:24 | 51°06.741 118°11.524 | 115 | R1.08 |
| 71 | 29/Aug/2017 | Rev - 6km from Forebay | 11:31 | 11:45 | 51°07.750 118°11.858 | 110 | R1.12 |
| 72 | 29/Aug/2017 | Rev - 8km from Forebay | 11:54 | 12:07 | 51°08.779 118°12.421 | 110 | R1.16 |
| 73 | 29/Aug/2017 | Rev - 10km from Forebay | 12:13 | 12:25 | 51°09.845 118°12.744 | 100 | R1.2 |
| 74 | 29/Aug/2017 | Rev - 12km from Forebay | 12:32 | 12:44 | 51°10.913 118°12.548 | 90 | R1.24 |
| 75 | 29/Aug/2017 | Rev - 14km from Forebay | 12:49 | 13:02 | 51°12.085 118°12.671 | 105 | R1.28 |
| 76 | 29/Aug/2017 | Rev - 16km from Forebay | 13:08 | 13:21 | 51°13.104 118°13.265 | 100 | R1.32 |
| 77 | 29/Aug/2017 | Rev - 18km from Forebay | 13:27 | 13:39 | 51°14.119 118°13.671 | 100 | R1.36 |
| 78 | 29/Aug/2017 | Rev - 20km from Forebay | 13:46 | 13:57 | 51°15.183 118°14.384 | 100 | R1.4 |
| 79 | 29/Aug/2017 | Rev - 25km from Forebay | 14:09 | 14:22 | 51°17.782 118°17.431 | 95 | R1.5 |
| 80 | 29/Aug/2017 | Rev - 30km from Forebay | 14:30 | 14:42 | 51°19.548 118°20.705 | 85 | R1.6 |
| 81 | 29/Aug/2017 | Rev - 35km from Forebay | 14:51 | 15:02 | 51°21.441 118°24.145 | 85 | R1.7 |
| 82 | 29/Aug/2017 | Rev - 40km from Forebay | 15:12 | 15:22 | 51°23.680 118°26.562 | 85 | R1.9 |
| 83 | 29/Aug/2017 | Rev - Middle | 15:32 | 15:42 | 51°26.609 118°28.135 | 80 | R2mi |
| 84 | 29/Aug/2017 | Rev - 50km from Forebay | 15:50 | 15:59 | 51°29.029 118°29.111 | 55 | R2.1 |
| 85 | 01/Sep/2017 | Rev - Forebay | 07:38 | 07:50 | 51°04.453 118°10.967 | 105 | R1fb |
| 86 | 01/Sep/2017 | Rev - 2km from Forebay | 07:54 | 08:07 | 51°05.656 118°10.958 | 115 | R1.04 |
| 87 | 01/Sep/2017 | Rev - 4km from Forebay | 08:11 | 08:24 | 51°06.635 118°11.536 | 110 | R1.08 |
| 88 | 01/Sep/2017 | Rev - 6km from Forebay | 08:29 | 08:41 | 51°07.761 118°11.880 | 105 | R1.12 |
| 89 | 01/Sep/2017 | Rev - 8km from Forebay | 08:46 | 08:57 | 51°08.786 118°12.422 | 105 | R1.16 |
| 90 | 01/Sep/2017 | Rev - 10km from Forebay | 09:02 | 09:15 | 51°09.853 118°12.744 | 100 | R1.2 |
| 91 | 01/Sep/2017 | Rev - 12km from Forebay | 09:19 | 09:31 | 51°10.952 118°12.504 | 100 | R1.24 |
| 92 | 01/Sep/2017 | Rev - 14km from Forebay | 09:35 | 09:48 | 51°12.059 118°12.665 | 105 | R1.28 |
| 93 | 01/Sep/2017 | Rev - 16km from Forebay | 09:54 | 10:06 | 51°13.093 118°13.236 | 95 | R1.32 |
| 94 | 01/Sep/2017 | Rev - 18km from Forebay | 10:10 | 10:23 | 51°14.148 118°13.672 | 105 | R1.36 |
| 95 | 01/Sep/2017 | Rev - 20km from Forebay | 10:27 | 10:40 | 51°15.172 118°14.354 | 105 | R1.4 |
| 96 | 01/Sep/2017 | Rev - 25km from Forebay | 10:49 | 11:02 | 51°17.797 118°17.474 | 95 | R1.5 |
| 97 | 01/Sep/2017 | Rev - 30km from Forebay | 11:09 | 11:20 | 51°19.551 118°20.714 | 85 | R1.6 |
| 98 | 01/Sep/2017 | Rev - 35km from Forebay | 11:29 | 11:40 | 51°21.440 118°24.172 | 85 | R1.7 |
| 99 | 01/Sep/2017 | Rev - 40km from Forebay | 11:48 | 11:59 | 51°23.702 118°26.553 | 90 | R1.9 |
| 100 | 01/Sep/2017 | Rev - Middle | 12:08 | 12:18 | 51°26.619 118°28.155 | 80 | R2mi |
| 101 | 01/Sep/2017 | Rev - Downie Loop Across from Boat Launch | 12:23 | 12:32 | 51°27.940 118°27.122 | 65.6 | Rd0 |
| 102 | 01/Sep/2017 | Rev - 50km from Forebay | 12:39 | 12:46 | 51°29.051 118°29.117 | 50 | R2.1 |
| 103 | 05/Sep/2017 | Rev - Forebay | 09:03 | 09:16 | 51°04.502 118°10.968 | 100 | R1fb |
| 104 | 05/Sep/2017 | Rev - 2km from Forebay | 09:23 | 09:36 | 51°05.702 118°10.993 | 100 | R1.04 |
| 105 | 05/Sep/2017 | Rev - 4km from Forebay | 09:42 | 09:54 | 51°06.758 118°11.500 | 95 | R1.08 |
| 106 | 05/Sep/2017 | Rev - 6km from Forebay | 10:00 | 10:13 | 51°07.826 118°11.896 | 110 | R1.12 |
| 107 | 05/Sep/2017 | Rev - 8km from Forebay | 10:18 | 10:31 | 51°08.819 118°12.407 | 110 | R1.16 |
| 108 | 05/Sep/2017 | Rev - 10km from Forebay | 10:36 | 10:44 | 51°09.852 118°12.767 | 60 | R1.2 |
| 109 | 05/Sep/2017 | Rev - 12km from Forebay | 10:51 | 11:04 | 51°10.974 118°12.527 | 95 | R1.24 |
| 110 | 05/Sep/2017 | Rev - 14km from Forebay | 11:09 | 11:22 | 51°12.084 118°12.683 | 105 | R1.28 |
| 111 | 05/Sep/2017 | Rev - 16km from Forebay | 11:28 | 11:39 | 51°13.122 118°13.266 | 85 | R1.32 |
| 112 | 05/Sep/2017 | Rev - 18km from Forebay | 11:44 | 11:56 | 51°14.175 118°13.693 | 105 | R1.36 |
| 113 | 05/Sep/2017 | Rev - 20km from Forebay | 12:02 | 12:14 | 51°15.182 118°14.355 | 95 | R1.4 |
| 114 | 05/Sep/2017 | Rev - 25km from Forebay | 12:23 | 12:36 | 51°17.800 118°17.515 | 100 | R1.5 |
| 115 | 05/Sep/2017 | Rev - 30km from Forebay | 12:46 | 12:57 | 51°19.541 118°20.718 | 85 | R1.6 |
| 116 | 05/Sep/2017 | Rev - 35km from Forebay | 13:07 | 13:18 | 51°21.465 118°24.211 | 90 | R1.7 |
| 117 | 05/Sep/2017 | Rev - 40km from Forebay | 13:26 | 13:38 | 51°23.719 118°26.598 | 90 | R1.9 |

| Cast Number | Date | Site Name | Time On | Time Off | GPS | Depth (m) | Stn |
|---|---|---|---|---|---|---|---|
| 118 | 05/Sep/2017 | Rev - Middle | 13:48 | 13:59 | 51°26.643 118°28.175 | 85 | R2mi |
| 119 | 05/Sep/2017 | Rev - Downie Loop Across from Boat Launch | 14:04 | 14:13 | 51°27.940 118°27.140 | 68 | Rd0 |
| 120 | 05/Sep/2017 | Rev - 50km from Forebay | 14:20 | 14:27 | 51°29.040 118°29.096 | 52 | R2.1 |
| 121 | 08/Sep/2017 | Rev - Forebay | 09:37 | 09:50 | 51°04.430 118°10.905 | 108 | R1fb |
| 122 | 08/Sep/2017 | Rev - 2km from Forebay | 09:58 | 10:11 | 51°05.669 118°10.963 | 108 | R1.04 |
| 123 | 08/Sep/2017 | Rev - 4km from Forebay | 10:17 | 10:30 | 51°06.708 118°11.565 | 115 | R1.08 |
| 124 | 08/Sep/2017 | Rev - 6km from Forebay | 10:36 | 10:49 | 51°07.760 118°11.877 | 110 | R1.12 |
| 125 | 08/Sep/2017 | Garbage | | | | | |
| 126 | 08/Sep/2017 | Rev - 8km from Forebay | 10:59 | 11:09 | 51°08.795 118°12.402 | 85 | R1.16 |
| 127 | 08/Sep/2017 | Rev - 10km from Forebay | 11:15 | 11:25 | 51°09.847 118°12.780 | 80 | R1.2 |
| 128 | 08/Sep/2017 | Rev - 12km from Forebay | 11:33 | 11:46 | 51°10.925 118°12.522 | 108 | R1.24 |
| 129 | 08/Sep/2017 | Rev - 14km from Forebay | 11:53 | 12:06 | 51°11.997 118°12.705 | 110 | R1.28 |
| 130 | 08/Sep/2017 | Rev - 16km from Forebay | 12:15 | 12:28 | 51°13.144 118°13.246 | 110 | R1.32 |
| 131 | 08/Sep/2017 | Rev - 18km from Forebay | 12:34 | 12:47 | 51°14.145 118°13.650 | 104 | R1.36 |
| 132 | 08/Sep/2017 | Rev - 20km from Forebay | 12:53 | 13:06 | 51°15.173 118°14.356 | 100 | R1.4 |
| 133 | 08/Sep/2017 | Rev - 25km from Forebay | 13:18 | 13:30 | 51°17.790 118°17.446 | 100 | R1.5 |
| 134 | 08/Sep/2017 | Rev - 30km from Forebay | 13:40 | 13:51 | 51°19.555 118°20.706 | 86 | R1.6 |
| 135 | 08/Sep/2017 | Rev - 35km from Forebay | 14:10 | 14:21 | 51°21.466 118°24.174 | 85 | R1.7 |
| 136 | 08/Sep/2017 | Rev - 40km from Forebay | 14:30 | 14:42 | 51°23.727 118°26.561 | 89 | R1.9 |
| 137 | 08/Sep/2017 | Rev - Middle | 14:56 | 15:09 | 51°26.628 118°28.132 | 87 | R2mi |
| 138 | 08/Sep/2017 | Rev - Downie Loop Across from Boat Launch | 15:16 | 15:25 | 51°24.924 118°27.125 | 67 | Rd0 |
| 139 | 08/Sep/2017 | Rev - 50km from Forebay | 15:36 | 15:45 | 51°29.076 118°29.120 | 60 | R2.1 |
| 140 | 11/Sep/2017 | Kin - Canoe | 11:13 | 11:26 | 52°12.456 118°28.456 | 115 | Kca1 |
| 141 | 11/Sep/2017 | Kin - Wood | 12:57 | 13:06 | 52°08.297 118°18.653 | 60 | Kwo1 |
| 142 | 11/Sep/2017 | Kin - Forebay | 14:20 | 14:40 | 52°05.638 118°32.959 | 175 | K1fb |
| 143 | 12/Sep/2017 | Kin - Columbia | 08:02 | 08:20 | 51°57.944 118°04.859 | 170 | K3co |
| 144 | 18/Sep/2017 | Rev - Middle | 10:59 | 11:10 | 51°26.619 118°28.155 | 77 | R2mi |
| 145 | 18/Sep/2017 | Rev - Upper | 13:12 | 13:19 | 51°43.838 118°39.645 | 40 | R3up |
| 146 | 19/Sep/2017 | Rev - Forebay | 09:15 | 09:30 | 51°04.440 118°10.957 | 119 | R1fb |
| 147 | 20/Sep/2017 | Kin - PP | 08:59 | 09:19 | 52°06.912 118°30.043 | 170 | K1.5 |
| 148 | 21/Sep/2017 | Rev - Middle | 08:50 | 09:00 | 51°26.610 118°28.107 | 82 | R2mi |
| 149 | 29/Sep/2017 | Rev - Forebay | 11:28 | 11:41 | 51°04.502 118°10.968 | 110 | R1fb |
| 150 | 29/Sep/2017 | Rev - 2km from Forebay | 11:47 | 12:01 | 51°05.702 118°10.993 | 117 | R1.04 |
| 151 | 29/Sep/2017 | Rev - 4km from Forebay | 12:06 | 12:21 | 51°06.758 118°11.500 | 117 | R1.08 |
| 152 | 29/Sep/2017 | Rev - 6km from Forebay | 12:25 | 12:38 | 51°07.826 118°11.896 | 107 | R1.12 |
| 153 | 29/Sep/2017 | Rev - 8km from Forebay | 12:43 | 12:54 | 51°08.819 118°12.407 | 95 | R1.16 |
| 154 | 29/Sep/2017 | Rev - 10km from Forebay | 12:59 | 13:12 | 51°09.852 118°12.767 | 100 | R1.2 |
| 155 | 29/Sep/2017 | Rev - 12km from Forebay | 13:16 | 13:29 | 51°10.974 118°12.527 | 100 | R1.24 |
| 156 | 29/Sep/2017 | Rev - 14km from Forebay | 13:35 | 13:48 | 51°12.084 118°12.683 | 108 | R1.28 |
| 157 | 29/Sep/2017 | Rev - 16km from Forebay | 13:53 | 14:06 | 51°13.122 118°13.266 | 105 | R1.32 |
| 158 | 29/Sep/2017 | Rev - 18km from Forebay | 14:11 | 14:23 | 51°14.175 118°13.693 | 100 | R1.36 |
| 159 | 29/Sep/2017 | Rev - 20km from Forebay | 14:27 | 14:40 | 51°15.182 118°14.355 | 100 | R1.4 |
| 160 | 29/Sep/2017 | Rev - 25km from Forebay | 14:29 | 15:01 | 51°17.800 118°17.515 | 100 | R1.5 |
| 161 | 02/Oct/2017 | Rev - Forebay | 08:47 | 08:56 | 51°04.502 118°10.968 | 65 | R1fb |
| 162 | 02/Oct/2017 | Rev - 2km from Forebay | 09:01 | 09:12 | 51°05.702 118°10.993 | 85 | R1.04 |
| 163 | 02/Oct/2017 | Rev - 4km from Forebay | 09:17 | 09:31 | 51°06.758 118°11.500 | 111 | R1.08 |
| 164 | 02/Oct/2017 | Rev - 6km from Forebay | 09:37 | 09:49 | 51°07.826 118°11.896 | 105 | R1.12 |
| 165 | 02/Oct/2017 | Rev - 8km from Forebay | 09:56 | 10:08 | 51°08.819 118°12.407 | 95 | R1.16 |
| 166 | 02/Oct/2017 | Rev - 10km from Forebay | 10:14 | 10:26 | 51°09.852 118°12.767 | 102 | R1.2 |
| 167 | 02/Oct/2017 | Rev - 12km from Forebay | 10:32 | 10:42 | 51°10.974 118°12.527 | 85 | R1.24 |
| 168 | 02/Oct/2017 | Rev - 14km from Forebay | 10:48 | 11:01 | 51°12.084 118°12.683 | 110 | R1.28 |
| 169 | 04/Oct/2017 | Rev - Forebay | 08:44 | 08:55 | 51°04.453 118°10.967 | 85 | R1fb |
| 170 | 04/Oct/2017 | Rev - 2km from Forebay | 09:03 | 09:16 | 51°05.656 118°10.958 | 110 | R1.04 |
| 171 | 04/Oct/2017 | Rev - 4km from Forebay | 09:23 | 09:35 | 51°06.635 118°11.536 | 107 | R1.08 |
| 172 | 04/Oct/2017 | Rev - 6km from Forebay | 09:42 | 09:55 | 51°07.761 118°11.880 | 100 | R1.12 |
| 173 | 04/Oct/2017 | Rev - 8km from Forebay | 10:00 | 10:11 | 51°08.786 118°12.422 | 100 | R1.16 |
| 174 | 04/Oct/2017 | Rev - 10km from Forebay | 10:17 | 10:29 | 51°09.853 118°12.744 | 90 | R1.2 |
| 175 | 04/Oct/2017 | Rev - 12km from Forebay | 10:35 | 10:45 | 51°10.952 118°12.504 | 84.4 | R1.24 |
| 176 | 04/Oct/2017 | Rev - 14km from Forebay | 10:51 | 11:04 | 51°12.059 118°12.665 | 110 | R1.28 |

| Cast Number | Date | Site Name | Time On | Time Off | GPS | Depth (m) | Stn |
|---|---|---|---|---|---|---|---|
| 177 | 04/Oct/2017 | Rev - 16km from Forebay | 11:10 | 11:22 | 51°13.093 118°13.236 | 92 | R1.32 |
| 178 | 04/Oct/2017 | Rev - 18km from Forebay | 11:28 | 11:41 | 51°14.148 118°13.672 | 103 | R1.36 |
| 179 | 04/Oct/2017 | Rev - 20km from Forebay | 11:48 | 12:01 | 51°15.172 118°14.354 | 100 | R1.4 |
| 180 | 04/Oct/2017 | Rev - 25km from Forebay | 12:15 | 12:28 | 51°17.797 118°17.474 | 100 | R1.5 |
| 181 | 04/Oct/2017 | Rev - 30km from Forebay | 12:39 | 12:51 | 51°19.551 118°20.714 | 87 | R1.6 |
| 182 | 04/Oct/2017 | Rev - 35km from Forebay | 13:03 | 13:13 | 51°21.440 118°24.172 | 85 | R1.7 |
| 183 | 04/Oct/2017 | Rev - 40km from Forebay | 13:23 | 13:33 | 51°23.702 118°26.553 | 75 | R1.9 |
| 184 | 04/Oct/2017 | Rev - Middle | 13:42 | 13:52 | 51°26.619 118°28.155 | 85 | R2mi |
| 185 | 04/Oct/2017 | Rev - Downie Loop Across from Boat Launch | 13:58 | 14:06 | 51°27.940 118°27.122 | 65 | Rd0 |
| 186 | 04/Oct/2017 | Rev - 50km from Forebay | 14:13 | 14:23 | 51°29.051 118°29.117 | 70 | R2.1 |
| 187 | 06/Oct/2017 | Rev - Forebay | 08:21 | 08:35 | 51°04.453 118°10.967 | 118 | R1fb |
| 188 | 06/Oct/2017 | Rev - 2km from Forebay | 08:39 | 08:53 | 51°05.656 118°10.958 | 124 | R1.04 |
| 189 | 06/Oct/2017 | Rev - 4km from Forebay | 08:58 | 09:11 | 51°06.635 118°11.536 | 101 | R1.08 |
| 190 | 06/Oct/2017 | Rev - 6km from Forebay | 09:15 | 09:28 | 51°07.761 118°11.880 | 110 | R1.12 |
| 191 | 06/Oct/2017 | Rev - 8km from Forebay | 09:33 | 09:41 | 51°08.786 118°12.422 | 61 | R1.16 |
| 192 | 06/Oct/2017 | Rev - 10km from Forebay | 09:46 | 10:00 | 51°09.853 118°12.744 | 106 | R1.2 |
| 193 | 06/Oct/2017 | Rev - 12km from Forebay | 10:05 | 10:15 | 51°10.952 118°12.504 | 88 | R1.24 |
| 194 | 06/Oct/2017 | Rev - 14km from Forebay | 10:19 | 10:32 | 51°12.059 118°12.665 | 105 | R1.28 |
| 195 | 06/Oct/2017 | Rev - 16km from Forebay | 10:37 | 10:50 | 51°13.093 118°13.236 | 97 | R1.32 |
| 196 | 06/Oct/2017 | Rev - 18km from Forebay | 10:54 | 11:06 | 51°14.148 118°13.672 | 95 | R1.36 |
| 197 | 06/Oct/2017 | Rev - 20km from Forebay | 11:11 | 11:22 | 51°15.172 118°14.354 | 100 | R1.4 |
| 198 | 10/Oct/2017 | Rev - Forebay | 08:59 | 09:14 | 51°04.453 118°10.967 | 120 | R1fb |
| 199 | 10/Oct/2017 | Rev - 2km from Forebay | 09:19 | 09:32 | 51°05.656 118°10.958 | 112 | R1.04 |
| 200 | 10/Oct/2017 | Rev - 4km from Forebay | 09:37 | 09:51 | 51°06.635 118°11.536 | 115 | R1.08 |
| 201 | 10/Oct/2017 | Rev - 6km from Forebay | 09:56 | 10:09 | 51°07.761 118°11.880 | 112 | R1.12 |
| 202 | 10/Oct/2017 | Rev - 8km from Forebay | 10:14 | 10:28 | 51°08.786 118°12.422 | 110 | R1.16 |
| 203 | 10/Oct/2017 | Rev - 10km from Forebay | 10:33 | 10:45 | 51°09.853 118°12.744 | 92 | R1.2 |
| 204 | 10/Oct/2017 | Rev - 12km from Forebay | 10:49 | 11:03 | 51°10.952 118°12.504 | 105 | R1.24 |
| 205 | 10/Oct/2017 | Rev - 14km from Forebay | 11:08 | 11:21 | 51°12.059 118°12.665 | 105 | R1.28 |
| 206 | 10/Oct/2017 | Rev - 16km from Forebay | 11:25 | 11:37 | 51°13.093 118°13.236 | 90 | R1.32 |
| 207 | 10/Oct/2017 | Rev - 18km from Forebay | 11:43 | 11:56 | 51°14.148 118°13.672 | 105 | R1.36 |
| 208 | 10/Oct/2017 | Rev - 20km from Forebay | 12:01 | 12:13 | 51°15.172 118°14.354 | 102 | R1.4 |
| 209 | 10/Oct/2017 | Rev - 25km from Forebay | 12:22 | 12:34 | 51°17.797 118°17.474 | 100 | R1.5 |
| 210 | 10/Oct/2017 | Rev - 30km from Forebay | 12:43 | 12:55 | 51°19.551 118°20.714 | 88 | R1.6 |
| 211 | 10/Oct/2017 | Rev - 35km from Forebay | 13:02 | 13:13 | 51°21.440 118°24.172 | 87 | R1.7 |
| 212 | 10/Oct/2017 | Rev - 40km from Forebay | 13:22 | 13:33 | 51°23.702 118°26.553 | 85.2 | R1.9 |
| 213 | 10/Oct/2017 | Rev - Middle | 13:41 | 13:51 | 51°26.619 118°28.155 | 82 | R2mi |
| 214 | 10/Oct/2017 | Rev - Downie Loop Across from Boat Launch | 13:56 | 14:06 | 51°27.940 118°27.122 | 70 | Rd0 |
| 215 | 10/Oct/2017 | Rev - 50km from Forebay | 14:13 | 14:23 | 51°29.051 118°29.117 | 75 | R2.1 |
| 216 | 13/Oct/2017 | Rev - Forebay | 09:24 | 09:37 | 51°04.486 118°10.890 | 110 | R1fb |
| 217 | 13/Oct/2017 | Rev - 2km from Forebay | 09:42 | 09:54 | 51°05.663 118°10.969 | 105 | R1.04 |
| 218 | 13/Oct/2017 | Rev - 4km from Forebay | 09:59 | 10:09 | 51°06.727 118°11.598 | 80 | R1.08 |
| 219 | 13/Oct/2017 | Rev - 6km from Forebay | 10:13 | 10:26 | 51°07.756 118°11.890 | 105 | R1.12 |
| 220 | 13/Oct/2017 | Rev - 8km from Forebay | 10:30 | 10:41 | 51°08.802 118°12.408 | 80 | R1.16 |
| 221 | 13/Oct/2017 | Rev - 10km from Forebay | 10:46 | 10:59 | 51°09.821 118°12.728 | 105 | R1.2 |
| 222 | 13/Oct/2017 | Rev - 12km from Forebay | 11:04 | 11:14 | 51°10.950 118°12.517 | 88 | R1.24 |
| 223 | 13/Oct/2017 | Rev - 14km from Forebay | 11:19 | 11:32 | 51°12.060 118°12.670 | 104 | R1.28 |
| 224 | 13/Oct/2017 | Rev - 16km from Forebay | 11:37 | 11:48 | 51°13.085 118°13.244 | 102 | R1.32 |
| 225 | 16/Oct/2017 | Kin - Canoe | 11:23 | 11:39 | 52°12.436 118°28.463 | 135 | Kca1 |
| 226 | 16/Oct/2017 | Kin - Forebay | 13:36 | 13:57 | 52°05.608 118°32.983 | 173 | K1fb |
| 227 | 18/Oct/2017 | Kin - Columbia | 09:13 | 09:33 | 51°57.960 118°04.811 | 175 | K3co |
| 228 | 23/Oct/2017 | Rev - Middle | 11:29 | 11:39 | 51°26.619 118°28.155 | 84 | R2mi |
| 229 | 23/Oct/2017 | Rev - Upper | 13:55 | 14:00 | 51°43.838 118°39.645 | 40 | R3up |
| 230 | 24/Oct/2017 | Rev - Forebay | 09:30 | 09:44 | 51°04.451 118°10.922 | 118 | R1fb |

## Appendix 3
## Seabird pump operation

A pump on the Sea-Bird profiler draws water across the temperature sensor, and through the conductivity and dissolved oxygen sensors. Two parameters in the profiler control pump operation. The first is the minimum conductivity frequency. For ocean going vessels it is often hard to tell how much time it will take for the profiler to be lifted from the deck and lowered into the water. To avoid turning on early, the profiler waits for the conductivity to exceed a minimum value before starting the pump. This minimum is set by Sea-Bird to 3,320 Hz, corresponding to a conductivity of about 5,300 µS/cm. For use in freshwater (e.g. in Kinbasket and Revelstoke with a conductivity of 200 µS/cm), this parameter should be set to zero to ensure the pump turns on. If the pump does not turn on, the descent of the instrument will force water through the plumbing and data will still be collected, with slightly reduced vertical resolution. The sensors which are not in the pump path - PAR, fluorescence, OBS and light transmission - are not affected by pump operation.

After the Sea-Bird has been turned on and placed in the water to soak, there is a second delay before the pump begins, controlled by the pump delay setting, to allow air in the plumbing to escape from the bleed valve (pinhole). If the air does not escape before the pump turns on, the pump may not prime properly, and it may draw little or no water across the sensors. The pump will eventually prime, but this may occur well into the downcast.

In 2008 the minimum conductivity frequency was set to zero. However, in 2009, 2010 and 2011, after calibration of the instrument by Sea-Bird, the minimum conductivity frequency was set for ocean use, and the pump did not run. Nevertheless, most of the temperature and conductivity data collected was satisfactory as descent forced water through the plumbing.

To avoid this, the parameters controlling the pump should be checked before each cruise. It may also be necessary to increase the soak time and to clean the pump bleed valve more often. Under calm conditions, the functioning of the bleed valve can be checked by watching the flow of bubbles from the bleed valve during the soak time. If it is possible to reach the pump outlet, the flow from the pump can occasionally be felt to ensure proper operation. Alternatively, the momentary flow of water from the pump outlet can be observed as the profiler is lifted from the water at the end of the cast.

# Appendix 4
# Additional Profiles

Profiles collected during measurement of primary production in Kinbasket Reservoir, see Tables 2.1 and 2.2.

**Figure A4−1** Kinbasket Reservoir, K1.5, 2017

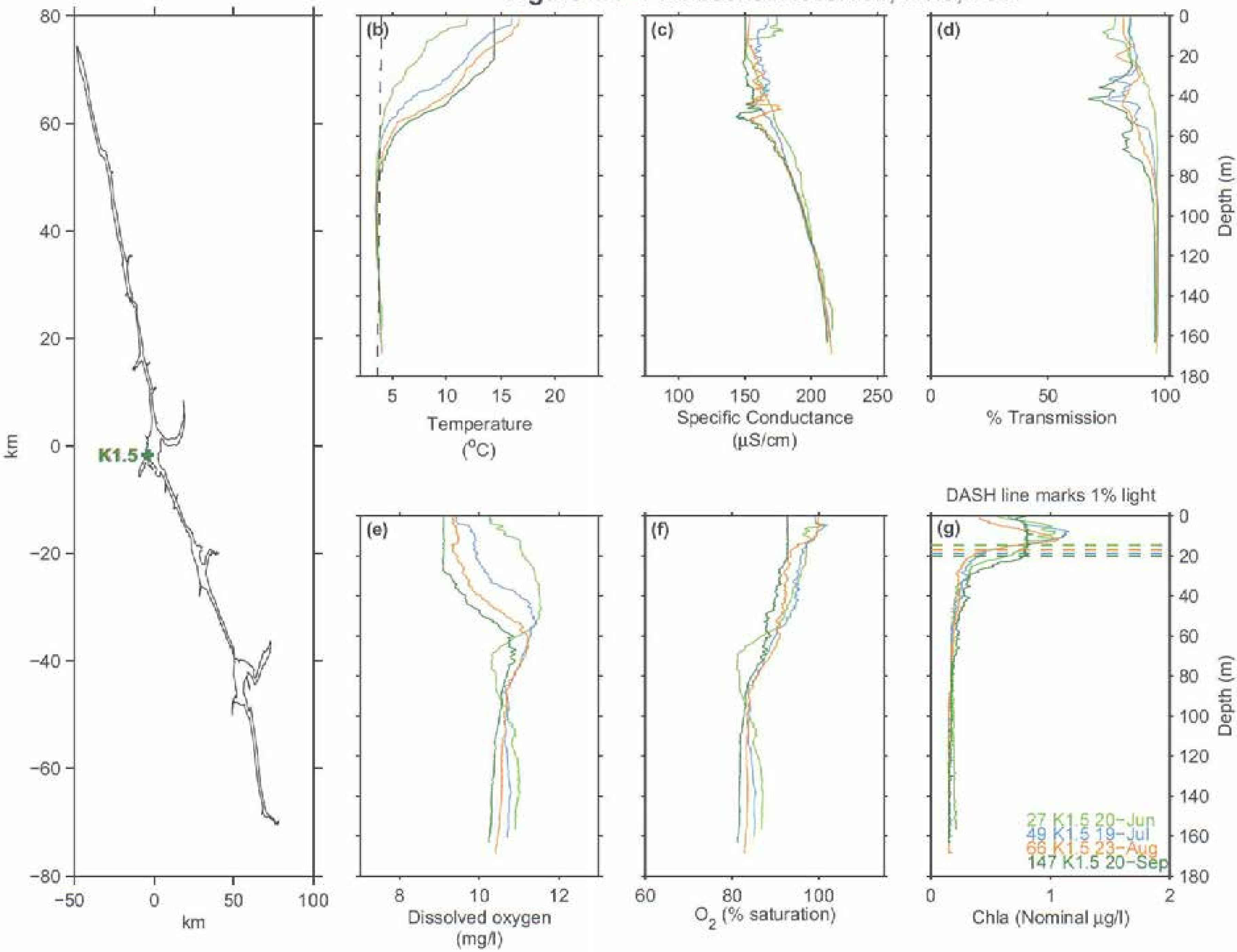


**Figure A4−2** Revelstoke Reservoir, Forebay PP 2017

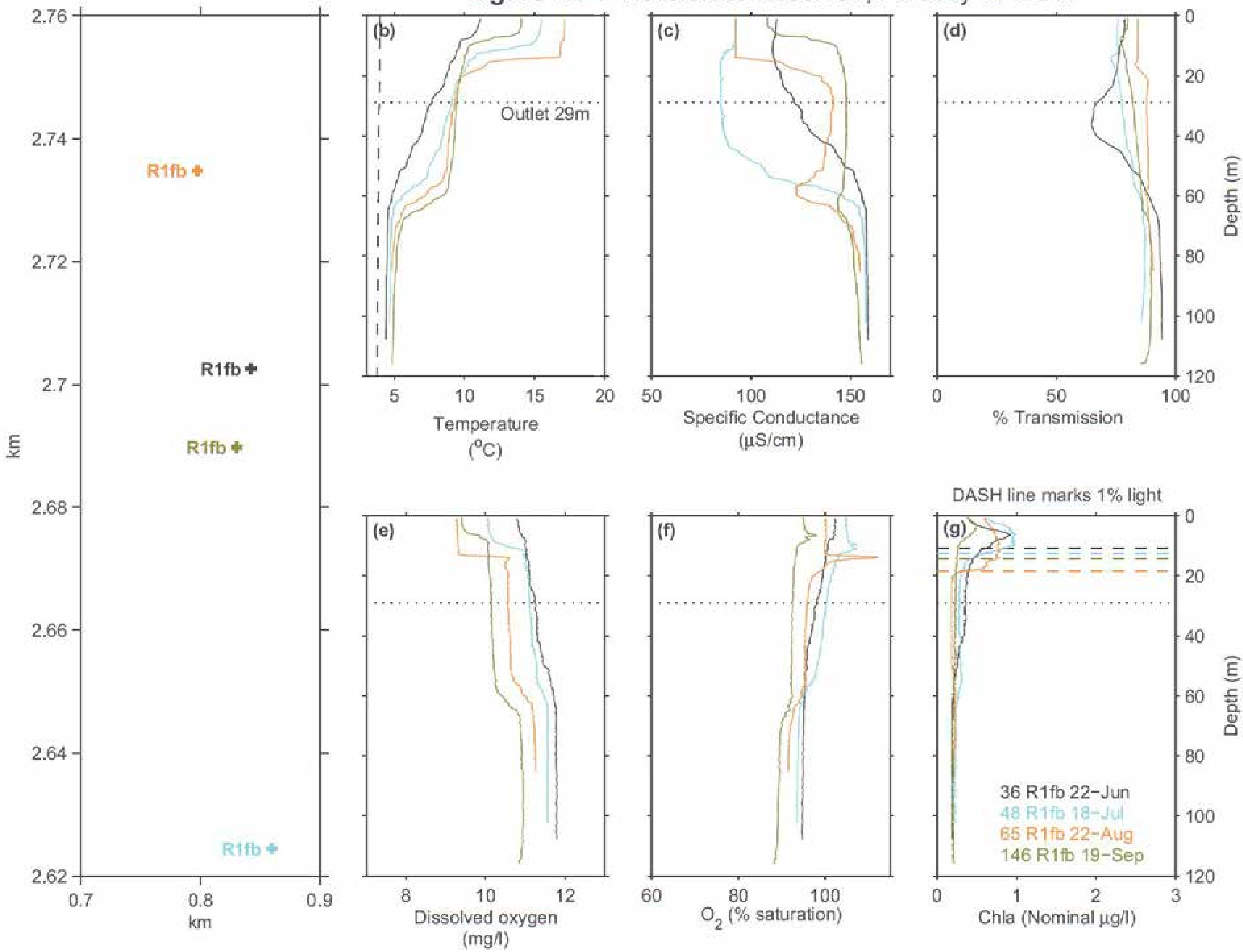
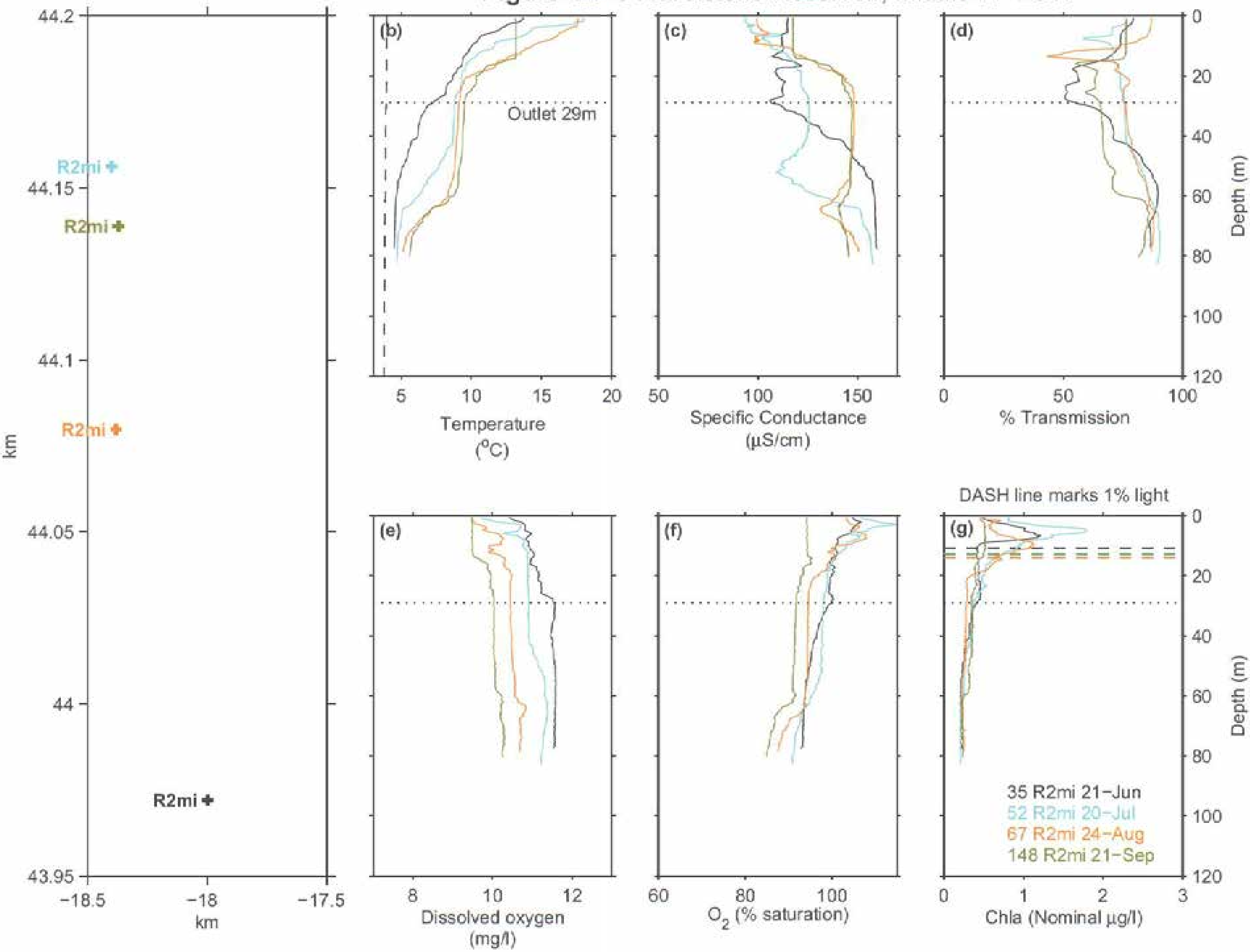


**Figure A4−3** Revelstoke Reservoir, Middle PP 2017

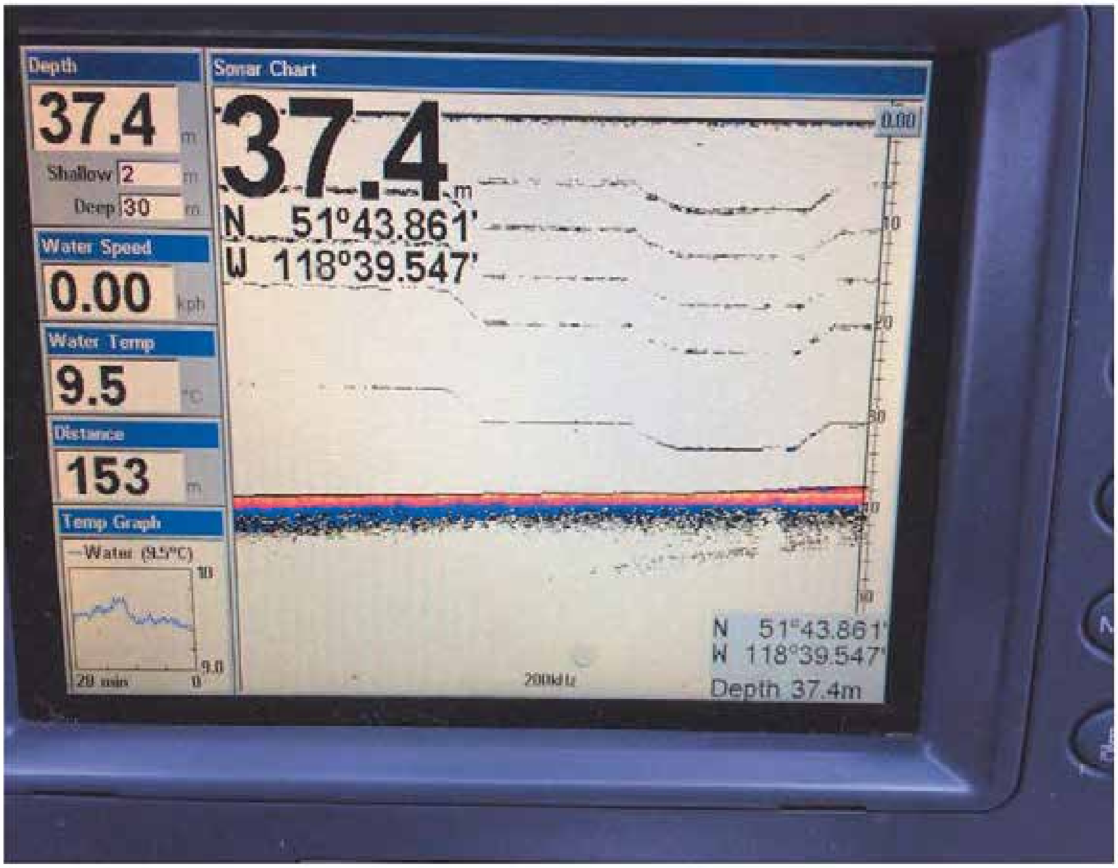


*Appendix 4*

# *Reservoir Water Chemistry Kinbasket and Revelstoke Reservoirs, 2017*

*Karen Bray*
*BC Hydro*

## Reservoir Water Chemistry
## Kinbasket and Revelstoke Reservoirs, 2017




Depth sounder showing Niskin bottles deployed, REV Upper Station, October 2017

*Prepared By:*
Karen Bray
Revelstoke, B.C.

November 2018

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## 1. Introduction

This report summarises Year 10 (2017) water chemistry information from Kinbasket and Revelstoke Reservoirs. These results are a component of the study CLBMON-3 Kinbasket and Revelstoke Reservoirs Ecological Productivity conducted under the Columbia Water Use Plan.

## 2. Methods

Water samples were collected at four stations in Kinbasket reservoir and three stations in Revelstoke reservoir (Table 2, Figure 1). Sampling began in April and concluded in October. All stations were sampled all months in 2017 with the exception of KIN Wood in October due to high winds and unsafe conditions.

Five litre Niskin bottles were lowered by cable in series to collect discrete depth samples at 2, 5, 10, 15, 20, 40, 60 and 80 m. A deep hypolimnetic sample (~5 m above bottom or as conditions permit) was collected at all stations except for REV Upper and KIN Wood that are ~ 40 m and 60 m, respectively. To inform a decision on future silica (Si) sampling, discrete depth samples were taken (2, 5, 10, 15, and 20 m) only in August, the month of lowest historical values. Samples for TDP were field filtered (0.45 µm filter) and all samples were kept cold and packed on ice for shipping to Maxxam Analytics Laboratory (Burnaby) for analyses. From 2008-2012, samples were analysed at the Cultus Lake laboratory; however, in 2013 a change was made to Maxxam Analytics as Cultus Lake was no longer able to process samples.

Discrete depth samples were analysed nitrite and nitrate (NN), total nitrogen (TN), total phosphorus (TP), total dissolved phosphorus (TDP), soluble reactive phosphorus (SRP), alkalinity, conductivity, pH, silica, and turbidity. Where sample bottles were not pre-charged with preservative (TP and TDP), bottles and caps were rinsed prior to filling. TDP samples were filtered in the field using a sterile syringe and .45 µm disposable filter. To minimise contamination, field samplers wore sterile gloves and used a new syringe for each sample depth and site. All samples were kept cold and packed on ice for shipping.

Integrated tube sampling for chlorophyll a and soluble reactive silica (SRS) was discontinued in 2017 due to concerns that the tube was not capturing a representative epilimnetic sample in all months. In cold conditions, the tube may not fully uncoil and thus not sample the full depth. A one litre chlorophyll a sample was composited from five 200 mL samples taken from epilimnetic discrete depths (2,5,10,15, and 20m). Samples for SRS were taken in August at discrete epilimnetic depths to examine the uniformity of SRS concentrations and determine if previous tube samples could have misrepresented results. From previous years, August SRS results are normally low following a peak in spring; therefore, a silica limitation for diatom growth would be expected to be evident in August. The results from this analysis will be used to determine if future SRS analyses are warranted.

Note that all alkalinity samples done previously by Cultus Lake were treated as from low alkalinity sources and titrated with additional acid to a pH 4.2 endpoint. This method returned roughly double $mgCaCO_3/L$ values, and therefore, results from 2008-2012 were adjusted in the 2016 report to reflect a standard titration to 4.5 pH as per standard analytical methods (APHA 2012).

Investigations are continuing into the differences in results for phosphorus fractions between Cultus Lake Lab and Maxxam Analytics. Results for TP, TDP, SRP, and other parameters may be adjusted in future reports if analytical method differences are found between labs. The ratio of $NO_2$+$NO_3$ to TDP is no longer calculated as TDP values are almost uniformly near the detection limit of 2 µg/L. All results reported at less than detection limits are transformed to the detection limit for analysis and display purposes.

Secchi disk readings were taken at each site using a standard 20cm Secchi disk. The disk was lowered on the shady side of the boat to a depth where it could no longer be seen by the naked eye (i.e., no sunglasses) and then raised to where it became visible; the two depths were averaged to arrive at the final reading.

Table 1. Summary of reservoir station coordinates, maximum sampled depths, and survey dates, 2017.

| Station | Coordinates | Max Depth Sampled (m) | Dates Sampled in 2017 |
|---|---|---|---|
| KIN Forebay | 52°05.611 118°32.932 | 175 | April 24, May 15, June 19, July 10, Aug 14, Sep 11, Oct 16 |
| KIN Canoe Reach | 52°12.400 118°28.417 | 120 | April 24, May 15, June 19, July 10, Aug 14, Sep 11, Oct 16 |
| KIN Wood Arm | 52°08.314 118°18.637 | 60 | April 24, May 15, June 19, July 10, Aug 14, Sep 14 |
| KIN Columbia Reach | 51°58.448 118°05.061 | 175 | April 25, May 16, June 20, July 11, Aug 15, Sep 12, Oct 18 |
| REV Forebay | 51°04.504 118°10.981 | 115 | April 18, May 24, June 13, July 18, Aug 22, Sep 19, Oct 24 |
| REV Middle | 51°26.495 118°28.116 | 80 | April 19, May 23, June 12, July 17, Aug 21, Sep 18, Oct 23 |
| REV Upper | 51°43.797 118°39.579 | 40 | April 19, May 23, June 12, July 17, Aug 21, Sep 18, Oct 23 |

## 3. Results and Discussion

Stations were sampled at Kinbasket Reservoir forebay elevations between 729 m and 758.5 m; full pool is 754.4m and minimum level is 707.1 m (cf. Figure 2 of main report). The reservoir reached its daily minimum level (728.7 m) for the year on May 4, 2017, and its daily maximum level (752.2 m) on August 20, 2017. The total range of elevation in 2017 was 23.5 m whereas the normal maximum licenced range is 47 m (i.e., without surcharge). From 1977 to 2017, the average reservoir elevation range was 25.3 m. See Appendix 1 – Hydrology for more information on conditions in 2017.

In 2017, Revelstoke Reservoir elevation fluctuated by 1.4 m between 571.6 m (June) and 573 m (April). Full pool is 573 m and the normal operating range is within 1.5 m (to 571.5 m), although the water licence allowable minimum level is much lower.

### *a) Nitrogen (TN/NN-Nitrate)*

*Total Nitrogen* – Total nitrogen is a measure of dissolved inorganic nitrogen (DIN=nitrate, nitrite, ammonia) and organic nitrogen. Ammonia is not measured as results from earlier limnological sampling in 2003-05 (BC Hydro data on file) were consistently at or below detection (5 µg/L). Nitrite and nitrate results (NN) here are a measure predominantly of nitrate, nitrite being almost negligible in samples, which is typical of oligotrophic waters where oxygen is not limiting (Wetzel 2001). As both nitrite and ammonia are low in these reservoirs, the difference between TN and NN can be considered a representation of organic nitrogen. Average total nitrogen ranged from 202 to 218 µg/L in Kinbasket Reservoir and was lower in Revelstoke Reservoir at 179 to 200 µg/L (Table 2). TN peaked in May at all stations with the exception of REV Forebay where the high value was driven by higher hypolimnetic depth (>40 m) concentrations.

*NN (Nitrate)* – Average nitrate was similar across stations in Kinbasket reservoir (117-122 µg/L), with the greatest seasonal variation at KIN Columbia (Table 2, Figures 2 and 6). Average nitrate was also similar across stations in Revelstoke Reservoir (127-143 µg/L) and higher than in Kinbasket, with the greatest seasonal variation at REV Middle station (Table 2, Figures 3 and 6). This difference between TN and nitrate indicated less organic nitrogen in Revelstoke Reservoir.

Overall, nitrate tends to peak in spring (late May/early June) and decline into the summer and fall, a trend that remains consistent across reservoirs and years (Figures 2 and 3). Early season peaks in nitrate were evident in surface waters (Figure 6) particularly at KIN Columbia and REV Upper and Middle stations.

***b) Phosphorus (TP/TDP/SRP)***

*Total phosphorus* includes both dissolved and particulate phosphorus and in glacial systems, such as Kinbasket and Revelstoke Reservoirs, can be high due to fine glacial flour particulates. Average Total Phosphorus (TP) across Kinbasket stations ranged from 2.8 to 4.0 µg/L with the greatest within station range at KIN Wood (Table 2). In Revelstoke Reservoir, average TP ranged from 3.1 to 3.7 µg/L, the highest seasonal average at REV Middle station (Table 2).

*Total dissolved phosphorus* is a measure of inorganic and organic phosphorus in solution; i.e., not attached to particles. Average Total Dissolved Phosphorus (TDP) across stations in Kinbasket and Revelstoke Reservoirs was low (3.0 to 3.3 µg/L and 2.8 to 3.0 µg/L, respectively) (Table 2). Occasionally TP values returned are lower than TDP which can happen in systems that have particularly low phosphorus levels or can occur through lab or field contamination. Compared with 2016, a lower proportion of samples from each reservoir were <2.0 µg/L detection: 17% in Kinbasket Reservoir (compared with 77% in 2016) and 22% in Revelstoke Reservoir (compared with 71% in 2016).

*Soluble reactive phosphorus* is a form of dissolved inorganic phosphorus that is readily available to and cycles rapidly through biota. Average SRP results across Kinbasket and Revelstoke Reservoir stations ranged from 1.3 to 1.9 µg/L with 45% of values below the detection limit of 1.0 µg/L in Kinbasket and 29% in Revelstoke reservoir. Highest values in Kinbasket occurred at KIN Wood (7.9 µg/L in August at 60 m) and at REV Middle (3.8 µg/L in September at 20 m) (Table 2). As with TDP, high values could be anomalies or errors as they are often isolated peaks and sometimes are higher than TDP or even TP from the same sample. These is little seasonal or depth trend evident in SRP values and the high values are not usually mirrored in the TP or TDP data (Figures 2, 3, and 7).

***c) Alkalinity and Conductivity*** – Alkalinity was higher in Kinbasket Reservoir with seasonal values ranging from 47 to 101 $mgCaCO_3$/L and in Revelstoke Reservoir from 30 to 67 $mgCaCO_3$/L (Table 2). Seasonal conductivity was also higher in Kinbasket (range 119-233 µS/cm) than in Revelstoke (range 81-163 µS/cm) (Table 2; Figures 4, 5).

***d) pH and Turbidity*** - pH varies little and is always slightly alkaline (~8). Average turbidity was similar across most stations (0.3 to 1.6 NTU) (Table 2) although KIN Wood and KIN Columbia stations had the highest point sample turbidity levels (10 and 4.3 NTU, respectively). Spikes in turbidity are not uncommon at interflow depths, e.g. at 40 m at KIN Wood in July and at 20 m at KIN Columbia in June.

***e) Soluble Reactive Silica (SRS)*** – Silica is used primarily by diatoms and concentrations below 0.5 mg/L can limit growth rates (Wetzel 2001). Results for discrete depths in August were uniform through the epilimnion (Figure 8). Reservoir silica concentrations ranged from 2.1 to 3.5 mg/L (Table 2). Silica results as reported from Cultus Lake lab (2009-2012) and Maxxam Analytics (2013-2016) are presented in Figure 9. Cultus Lake reported SRS as Si whereas Maxxam reported as $SiO_2$ (Figure 9a). To convert Cultus Lake values (Si) for comparison with Maxxam (SiO2), results are divided by 46.75% (G. Block, pers. comm., DFO, Cultus Lake Laboratories).

***f) Secchi*** – Secchi depths ranged from 1.3 to 13 m across the four Kinbasket Reservoir stations in 2017 and from 2 to 11 m in Revelstoke (Table 2; Figure 10). Secchi values were generally lowest in June at Kinbasket stations with increasing depth into the fall. In Revelstoke Reservoir, Secchi depths were fairly consistently low from May through to September in 2017. Forebay stations and KIN Canoe generally have the greatest transparency (highest Secchi depth) as they are the least influenced by turbid tributary inputs (Figure 10).

Table 2. Average water chemistry values for all depths combined at Kinbasket (Apr-Oct) and Revelstoke (Apr-Oct) Reservoir stations, 2017. Range of values in parentheses.

| Parameter | Units | STATIONS | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | *KIN Forebay* | *KIN Canoe* | *KIN Wood* | *KIN Columbia* | *REV Forebay* | *REV Middle* | *REV Upper* |
| NN (Nitrate) | µg/L | 121 (93-203) | 117 (94-144) | 119 (70-174) | 122 (57-209) | 127 (61-197) | 131 (60-242) | 143 (95-235) |
| TN | µg/L | 202 (124-372) | 202 (104-342) | 208 (93-371) | 216 (98-437) | 179 (121-266) | 200 (110-401) | 199 (140-308) |
| TP* | µg/L | 3.1 (2.0 - 9.5) | 2.8 (2.0 - 9.8) | 4.0 (2.0 - 12) | 3.2 (2.0 - 6.9) | 3.1 (2.0 - 9.9) | 3.5 (2.0 - 6.7) | 3.7 (2.0 - 7.4) |
| TDP* | µg/L | 3.0 (2.0 – 9.0) | 3.1 (2.0 – 9.5) | 3.0 (2.0 - 9.6) | 3.3 (2.0 - 8.9) | 3.0 (2.0 - 9.4) | 2.8 (2.0 - 7.6) | 2.8 (2.0 - 6.9) |
| SRP* | µg/L | 1.4 (1.0 - 3.4) | 1.3 (1.0 - 3.2) | 1.9 (1.0 - 7.9) | 1.6 (1.0 - 4.7) | 1.3 (1.0 - 2.5) | 1.7 (1.0 - 3.8) | 1.7 (1.0 - 3.7) |
| Alkalinity | mg $CaCO_3$/L | 69 (58 - 91) | 64 (47 - 82) | 67 (60 - 74) | 83 (66 - 101) | 56 (34 - 66) | 56 (39 - 67) | 55 (30 - 67) |
| pH | | 8.0 (7.9 - 8.2) | 8.0 (7.9 - 8.1) | 8.1 (7.9 - 8.2) | 8.1 (8.0 - 8.3) | 8.0 (7.8 - 8.1) | 8.0 (7.9 - 8.1) | 8.0 (7.8 - 8.1) |
| Conductivity | µS/cm | 166 (146 -213) | 155 (119 - 196) | 159 (143 - 173) | 193 (153 - 233) | 136 (83 - 160) | 135 (92 - 160) | 136 (81-163) |
| Turbidity | NTU | 0.4 (0.1 - 1.2) | 0.4 (0.2 - 1.9) | 1.7 (0.2 - 10) | 0.9 (0.2 - 4.3) | 0.5 (0.2 - 1.5) | 0.9 (0.2 - 2.4) | 1.0 (0.2 - 2.8) |
| SRS** | mg/L $SiO_2$ | 3.0 (2.4 - 3.3) | 3.0 (2.1 - 3.6) | 3.1 (3.0 - 3.2) | 2.9 (2.7 - 3.0) | 3.0 (2.9 - 3.4) | 3.1 (2.8 - 3.4) | 2.8 (3.2 - 3.5) |
| Secchi | m | 7.1 (4.1 - 13) | 6.3 (4.6 - 7.7) | 5.0 (1.3 - 10) | 5.2 (2.4 - 8.0) | 6.0 (3.8 - 11) | 4.8 (3.0 - 8.5) | 3.8 (2.0 - 8.1) |

*Laboratory detection limit for SRP=1.0 µg/L, for TP/TDP=2.0 µg/L

**Soluble reactive silica values are from discrete depth samples in August. See text for detail.

The 2017 results represent the tenth year of sampling sessions on Kinbasket and Revelstoke Reservoirs, adding to the dataset begun in 2008. Results from 2008 are not included in summary charts as the sampling season began in July. Phosphorus fraction results from different laboratories continue to be complicated and under investigation. A laboratory comparison is planned for 2018 to help resolve the data issues. Total nitrogen analyses will continue in the 2018 field year to provide more data for comparison. Silica analyses can be discontinued as results to date demonstrate no silica limitation. Seasonal and spatial comparisons and trends will be the subject of analysis in the final synthesis report following the 2019 monitoring year.

## 5. References

APHA. 2012. Standard Methods for the Examination of Water and Wastewater, 22nd Edition. American Public Health Association, American Water Works Association, Water Environment Federation. 1496 pp.

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## Acknowledgements

Much appreciation and thanks are extended to Beth Manson and Ed Marriott for sample collection and field processing and to Beth Manson for data entry.

Figure 1. Location of sampling stations on Kinbasket and Revelstoke Reservoirs, 2017.

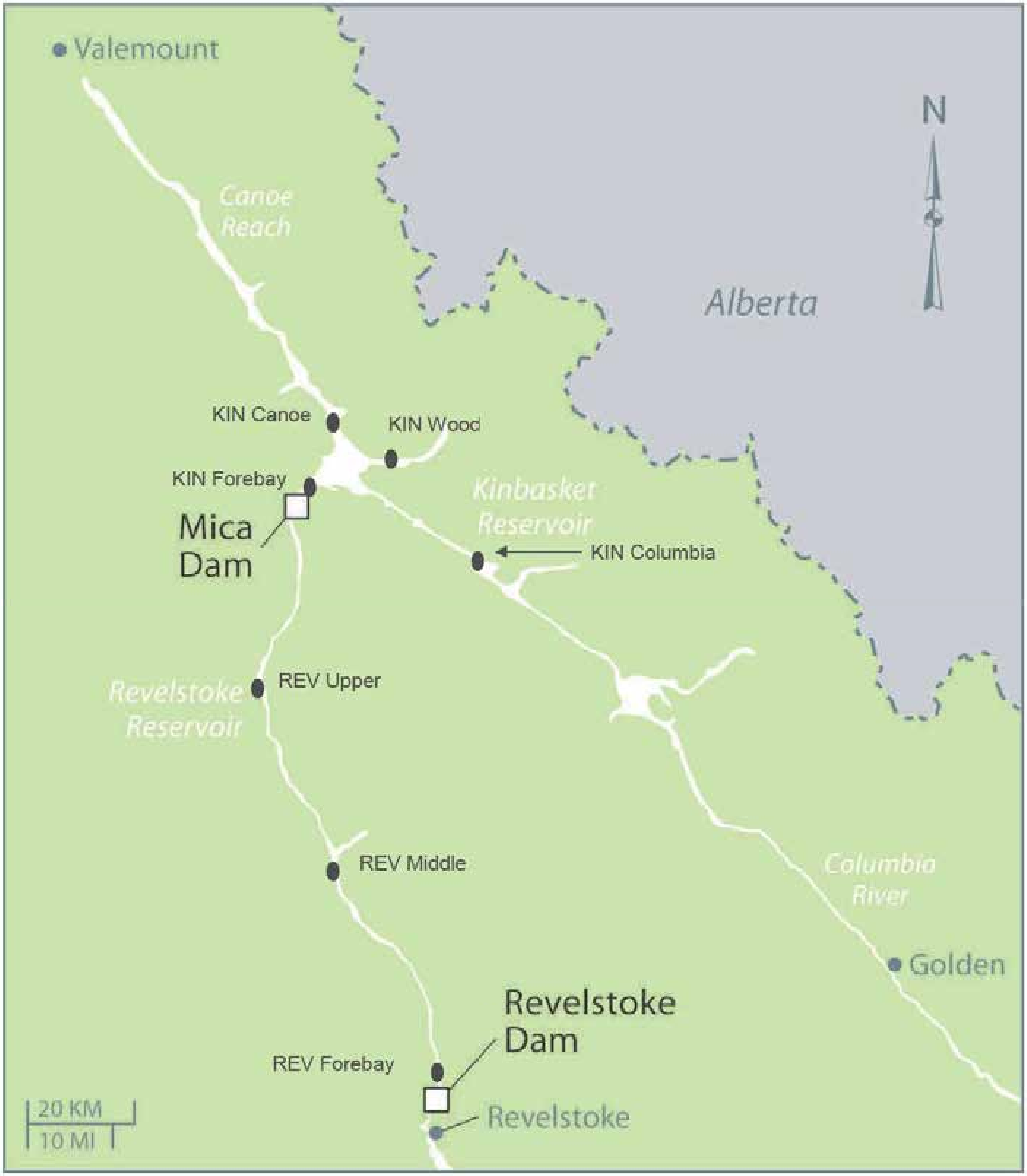


Figure 2. Seasonal average NN, TN,TP, TDP, and SRP (µg/L) at Kinbasket Reservoir stations, 2009-2017. Note change in laboratory in 2013.

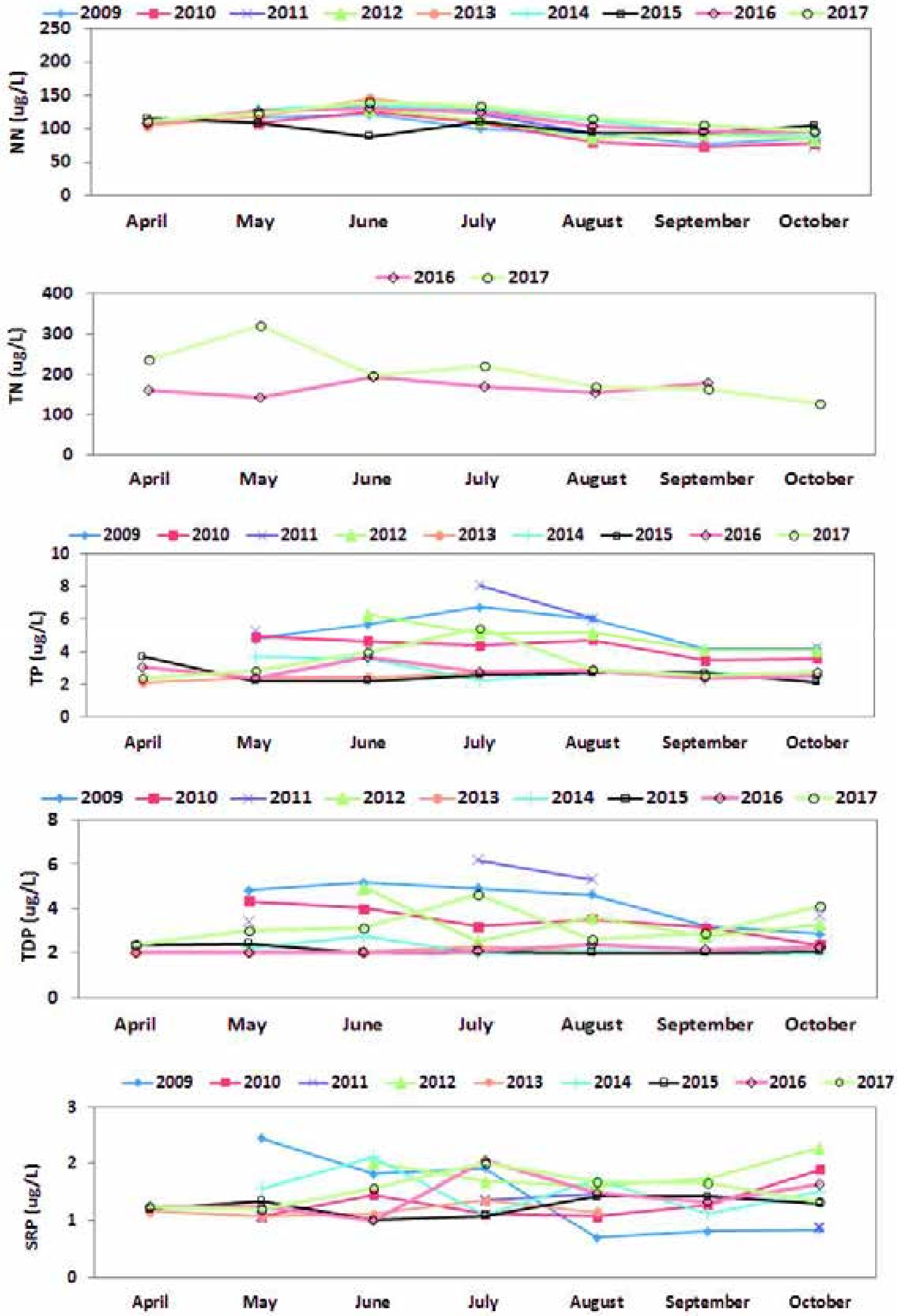


Figure 3. Seasonal average NN, TN, TP, TDP, and SRP (µg/L) at Revelstoke Reservoir stations, 2009-2017. Note change in laboratory in 2013.

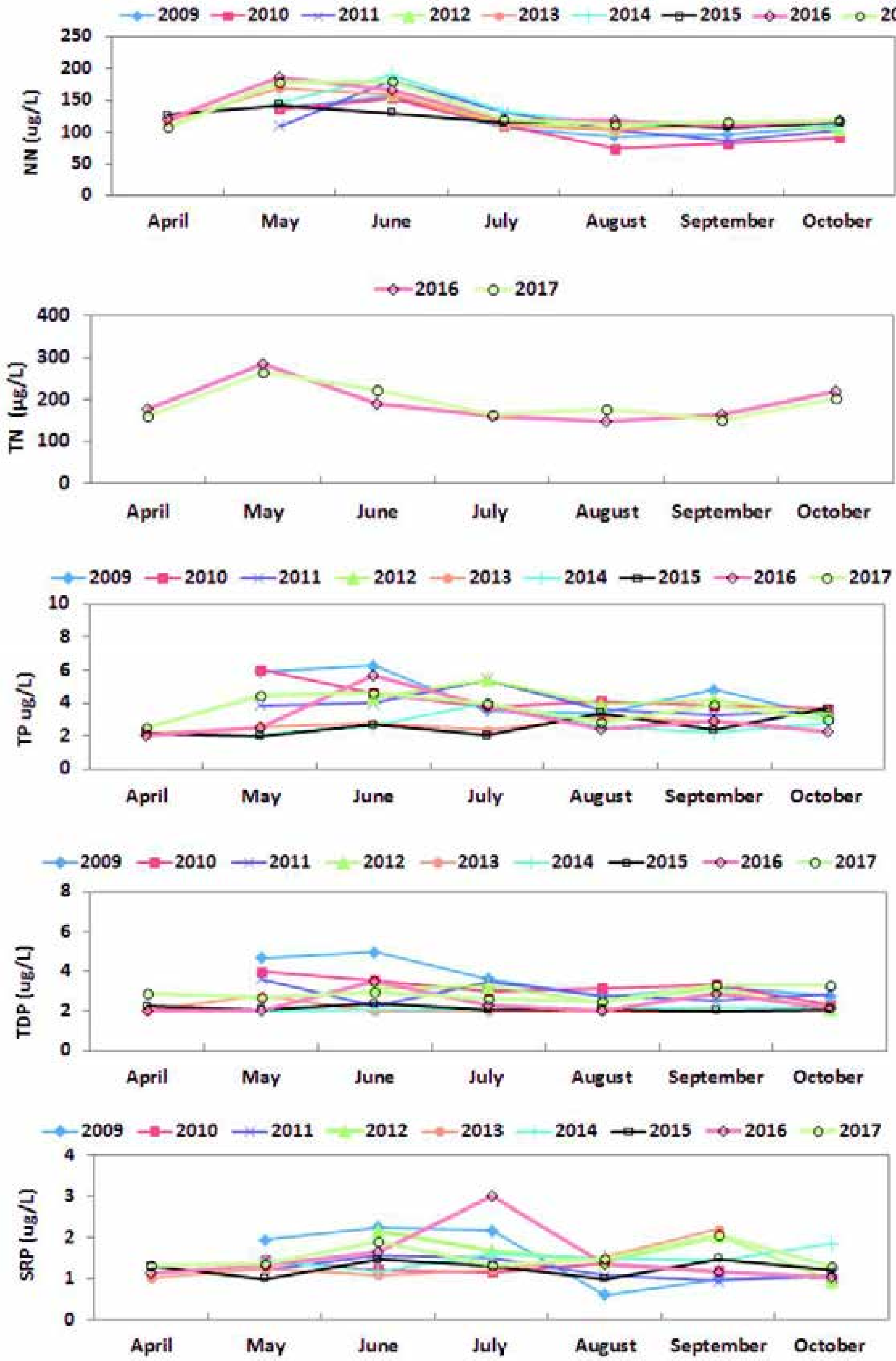
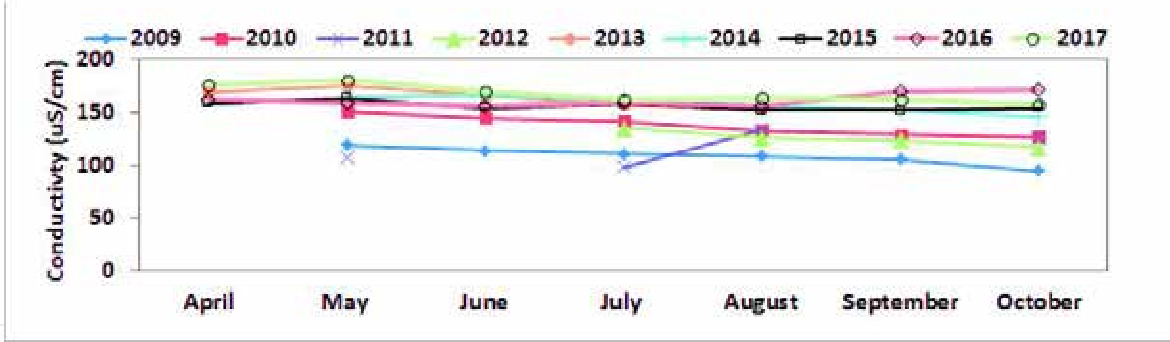
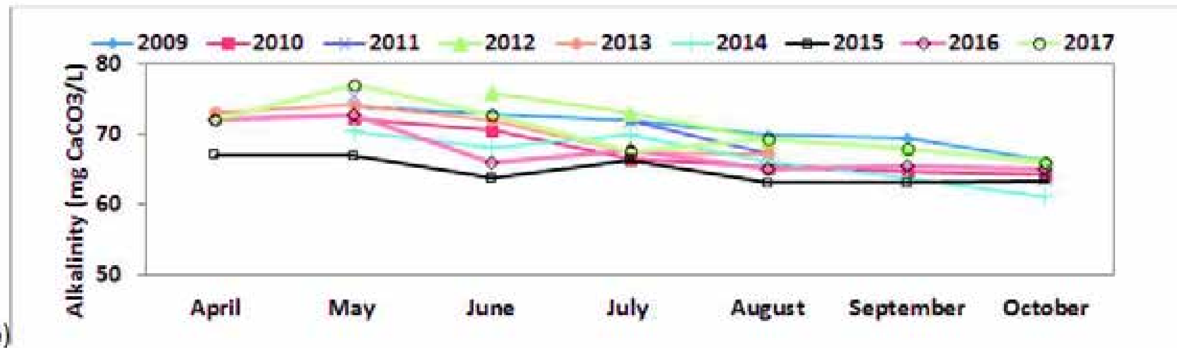


Figure 4. Seasonal average (a) conductivity (µS/cm) and (b) alkalinity (mgCaCO$_3$/L) at Kinbasket Reservoir stations, 2009-2017. Note change in laboratory in 2013.

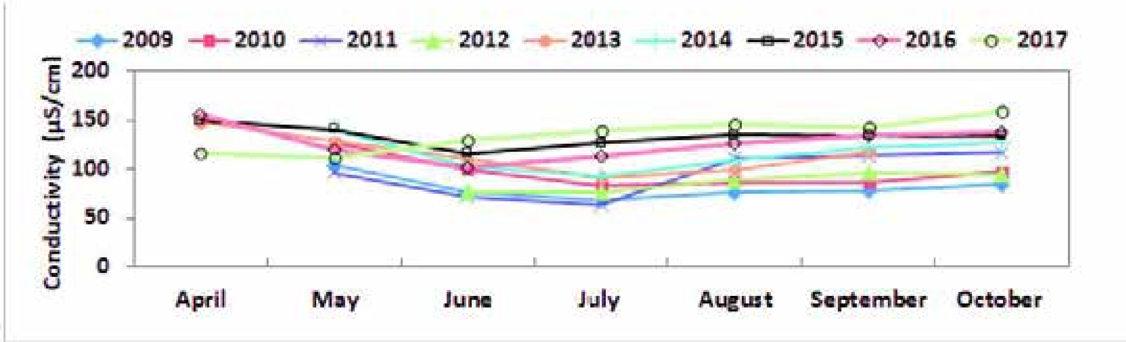



(a)

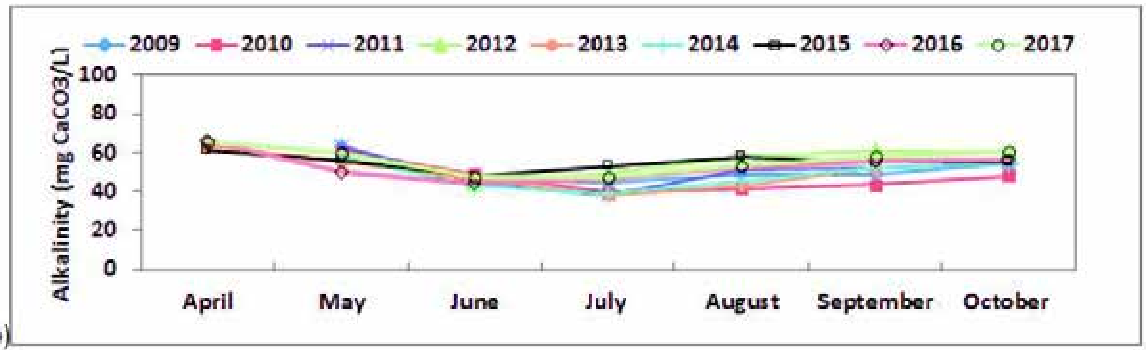



(b)

Figure 5. Seasonal average (a) conductivity (µS/cm) and (b) alkalinity ($mgCaCO_3$/L) at Revelstoke Reservoir stations, 2009-2017. Note change in laboratory in 2013.

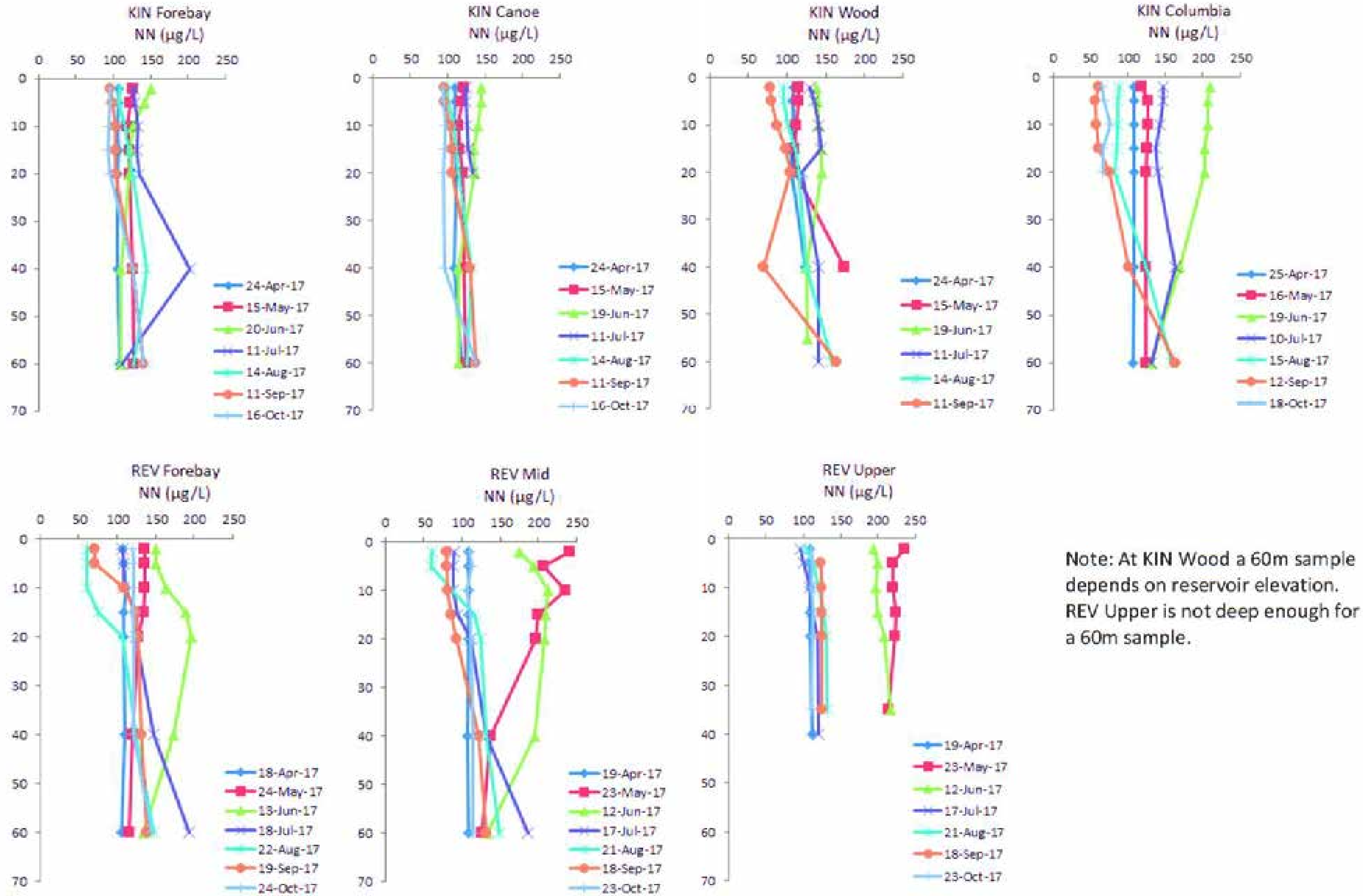



(a)




(b)

Figure 6. NN (µg/L) depth profiles (0-60m) for Kinbasket and Revelstoke Reservoir stations, 2017.




Note: At KIN Wood a 60m sample depends on reservoir elevation. REV Upper is not deep enough for a 60m sample.

Figure 7. SRP (µg/L) depth profiles (0-60m) for Kinbasket and Revelstoke Reservoir stations, 2017.

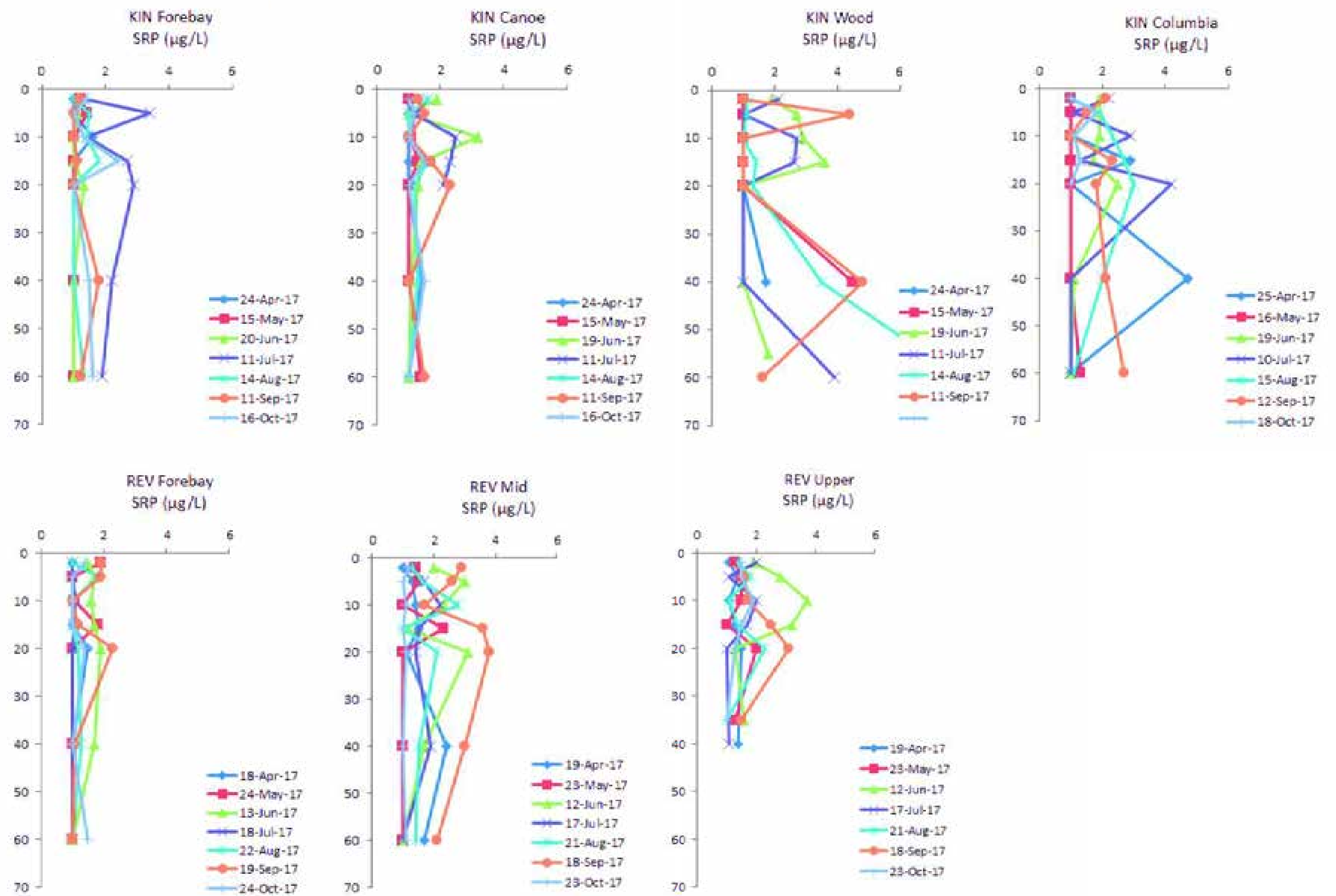


Figure 8. Epilimnetic silica (mg/L) at (a) Kinbasket and (b) Revelstoke stations, August 2017. Reported as $SiO_2$.

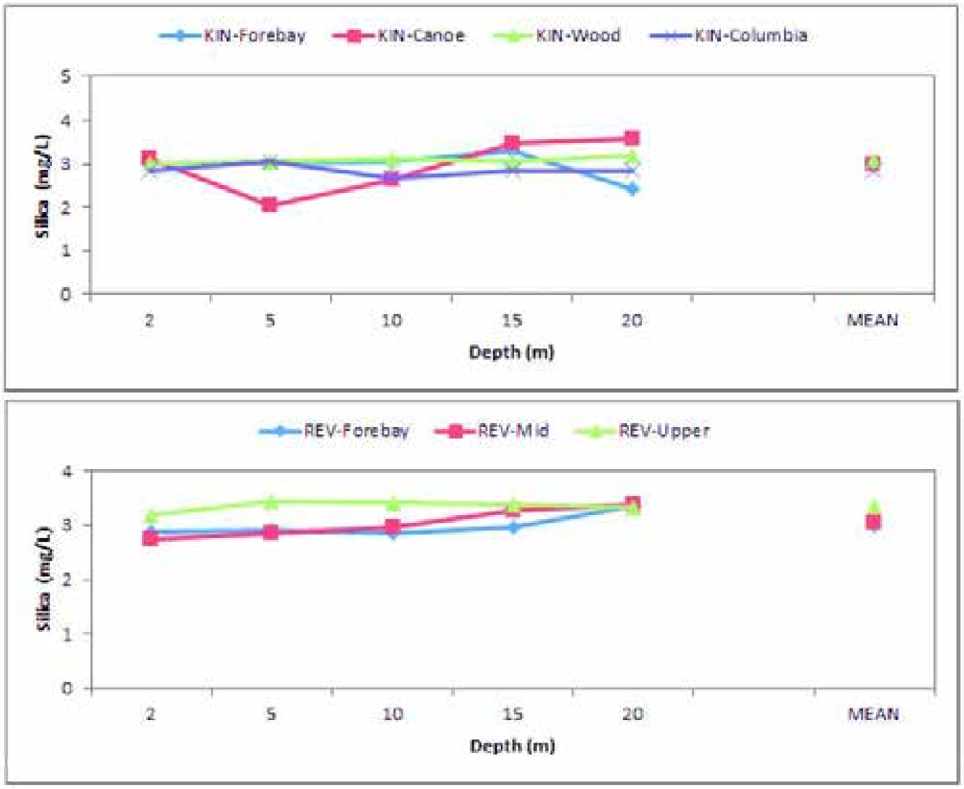



Figure 9. Silica results for Kinbasket and Revelstoke Reservoirs from Cultus Lake lab and Maxxam Analytics Laboratories. Previously reported values of Si for 2009-2012 (cultus) and $SiO_2$ (Maxxam) for 2013-2016 (left) and all values reported as $SiO_2$ (right). See text for more detail.

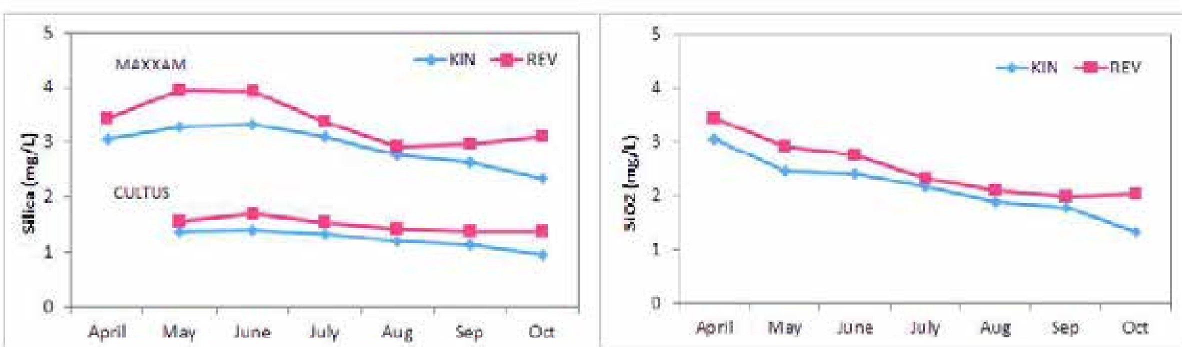
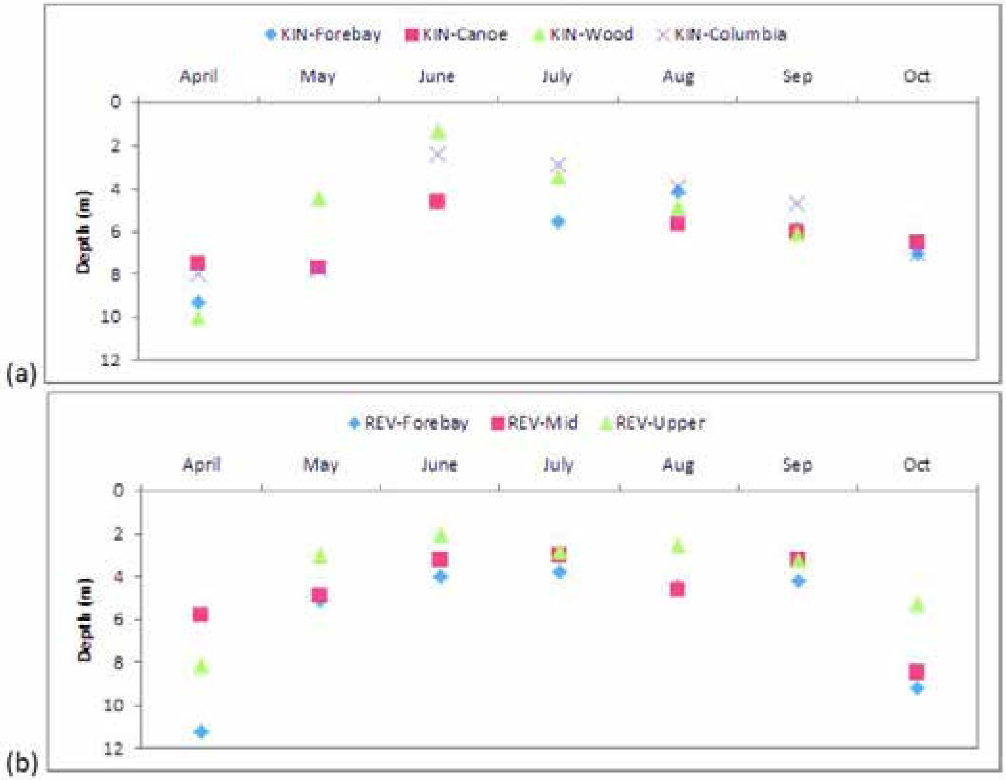


Figure 10. Seasonal Secchi depth (m) at (a) Kinbasket and (b) Revelstoke stations, 2017.



# Appendix 1 – Data

| Site | Depth | Date | NN | SRP | TP | TDP | SRS | TN | Alkalinity | pH | Turbidity | Cond. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | ug/L | ug/L | ug/L | ug/L | mgSi/L | ug/L | mgCaCO$_3$/L | | (NTU) | µS/cm |
| KIN FB | 2 | 24-Apr-17 | 107.00 | 1.00 | 2.50 | 2.00 | | 253.00 | 69.80 | 8.02 | 0.20 | 171.00 |
| | 5 | 24-Apr-17 | 107.00 | 1.00 | 2.50 | 2.00 | | 215.00 | 69.40 | 8.04 | 0.21 | 172.00 |
| | 10 | 24-Apr-17 | 106.00 | 1.60 | 2.20 | 2.00 | | 248.00 | 68.20 | 8.01 | 0.19 | 169.00 |
| | 15 | 24-Apr-17 | 107.00 | 1.00 | 3.20 | 2.10 | | 144.00 | 69.10 | 8.02 | 0.18 | 170.00 |
| | 20 | 24-Apr-17 | 106.00 | 1.00 | 2.70 | 2.30 | | 192.00 | 69.40 | 8.03 | 0.18 | 170.00 |
| | 40 | 24-Apr-17 | 106.00 | 1.00 | 2.40 | 3.40 | | 140.00 | 69.60 | 8.02 | 0.22 | 170.00 |
| | 60 | 24-Apr-17 | 109.00 | 1.00 | 2.50 | 2.70 | | 257.00 | 69.90 | 7.99 | 0.20 | 169.00 |
| | 80 | 24-Apr-17 | 124.00 | 1.00 | 2.30 | 2.20 | | 268.00 | 74.10 | 8.01 | 0.17 | 177.00 |
| | 155 | 24-Apr-17 | 129.00 | 2.20 | 2.00 | 2.30 | | 245.00 | 74.80 | 8.03 | 0.16 | 182.00 |
| | 2 | 15-May-17 | 126.00 | 1.20 | 2.00 | 3.10 | | 317.00 | 75.50 | 8.01 | 0.15 | 177.00 |
| | 5 | 15-May-17 | 123.00 | 1.40 | 2.70 | 2.60 | | 261.00 | 75.30 | 7.98 | 0.17 | 176.00 |
| | 10 | 15-May-17 | 119.00 | 1.00 | 2.00 | 2.00 | | 313.00 | 75.60 | 8.00 | 0.15 | 175.00 |
| | 15 | 15-May-17 | 121.00 | 1.00 | 2.00 | 2.00 | | 307.00 | 75.70 | 8.00 | 0.35 | 175.00 |
| | 20 | 15-May-17 | 122.00 | 1.00 | 2.20 | 3.90 | | 344.00 | 75.90 | 8.01 | 0.22 | 175.00 |
| | 40 | 15-May-17 | 126.00 | 1.00 | 2.80 | 2.20 | | 346.00 | 75.80 | 7.99 | 0.13 | 178.00 |
| | 60 | 15-May-17 | 128.00 | 1.00 | 2.10 | 3.10 | | 372.00 | 75.90 | 7.95 | 0.19 | 178.00 |
| | 80 | 15-May-17 | 127.00 | 1.00 | 2.00 | 3.20 | | 362.00 | 78.30 | 7.97 | 0.17 | 180.00 |
| | 155 | 15-May-17 | 129.00 | 1.00 | 2.00 | 2.20 | | 281.00 | 79.00 | 7.98 | 0.16 | 183.00 |
| | 2 | 20-Jun-17 | 151.00 | 1.20 | 3.30 | 2.00 | | 198.00 | 68.00 | 8.10 | 0.70 | 165.00 |
| | 5 | 20-Jun-17 | 142.00 | 1.10 | 3.20 | 2.40 | | 198.00 | 66.40 | 8.11 | 0.63 | 159.00 |
| | 10 | 20-Jun-17 | 126.00 | 1.00 | 4.30 | 3.70 | | 179.00 | 62.20 | 8.06 | 0.42 | 149.00 |
| | 15 | 20-Jun-17 | 123.00 | 1.00 | 2.50 | 2.50 | | 184.00 | 61.80 | 8.05 | 0.41 | 149.00 |
| | 20 | 20-Jun-17 | 121.00 | 1.30 | 3.10 | 2.00 | | 166.00 | 62.10 | 8.04 | 0.33 | 149.00 |
| | 40 | 20-Jun-17 | 110.00 | 1.00 | 4.80 | 2.40 | | 168.00 | 66.70 | 8.09 | 0.15 | 159.00 |
| | 60 | 20-Jun-17 | 110.00 | 1.00 | 2.00 | 2.30 | | 140.00 | 69.70 | 8.08 | 0.16 | 168.00 |
| | 80 | 20-Jun-17 | 121.00 | 1.20 | 2.00 | 2.20 | | 164.00 | 75.80 | 8.09 | 0.18 | 179.00 |
| | 170 | 20-Jun-17 | 121.00 | 1.10 | 2.30 | 3.40 | | 177.00 | 84.70 | 8.15 | 0.18 | 201.00 |
| | 2 | 11-Jul-17 | 128.00 | 1.30 | 9.20 | 9.00 | | 228.00 | 66.90 | 8.09 | 0.96 | 159.00 |
| | 5 | 11-Jul-17 | 129.00 | 3.40 | 7.60 | 4.90 | | 253.00 | 68.10 | 8.10 | 0.38 | 158.00 |
| | 10 | 11-Jul-17 | 133.00 | 1.40 | 3.50 | 4.10 | | 210.00 | 67.10 | 8.10 | 0.68 | 159.00 |
| | 15 | 11-Jul-17 | 132.00 | 2.70 | 23.70 | 24.80 | | 228.00 | 64.60 | 8.10 | 0.50 | 158.00 |
| | 20 | 11-Jul-17 | 135.00 | 2.90 | 8.50 | 3.40 | | 242.00 | 64.70 | 8.06 | 0.48 | 158.00 |
| | 40 | 11-Jul-17 | 203.00 | 2.20 | 3.90 | 4.10 | | 203.00 | 62.10 | 8.09 | 0.39 | 151.00 |
| | 60 | 11-Jul-17 | 112.00 | 1.90 | 5.60 | 3.00 | | 177.00 | 68.60 | 8.13 | 1.18 | 168.00 |
| | 80 | 11-Jul-17 | 117.00 | 1.90 | 4.40 | 4.20 | | 196.00 | 73.90 | 8.14 | 0.19 | 177.00 |
| | 170 | 11-Jul-17 | 125.00 | 2.20 | 4.00 | 4.10 | | 199.00 | 87.80 | 8.20 | 0.38 | 207.00 |
| | 2 | 14-Aug-17 | 108.00 | 1.00 | 2.50 | 2.00 | | 174.00 | 62.70 | 8.04 | 0.52 | 150.00 |
| | 5 | 14-Aug-17 | 107.00 | 1.50 | 2.00 | 2.00 | | 173.00 | 63.50 | 8.06 | 0.52 | 149.00 |
| | 10 | 14-Aug-17 | 116.00 | 1.40 | 5.10 | 3.10 | | 172.00 | 62.30 | 8.03 | 0.44 | 150.00 |
| | 15 | 14-Aug-17 | 120.00 | 1.80 | 2.20 | 2.90 | | 168.00 | 62.80 | 8.07 | 0.47 | 150.00 |
| | 20 | 14-Aug-17 | 126.00 | 1.00 | 2.60 | 2.00 | | 192.00 | 64.40 | 8.06 | 0.36 | 151.00 |
| | 40 | 14-Aug-17 | 144.00 | 1.00 | 2.60 | 2.10 | | 184.00 | 72.10 | 8.11 | 0.68 | 163.00 |
| | 60 | 14-Aug-17 | 127.00 | 1.30 | 2.00 | 2.20 | | 169.00 | 63.10 | 7.96 | 0.48 | 158.00 |
| | 80 | 14-Aug-17 | 120.00 | 1.00 | 2.30 | 2.60 | | 148.00 | 72.10 | 8.08 | 0.19 | 173.00 |
| | 170 | 14-Aug-17 | 140.00 | 1.00 | 2.00 | 2.20 | | 165.00 | 91.00 | 8.19 | 0.19 | 213.00 |
| | 2 | 11-Sep-17 | 95.00 | 1.20 | 2.00 | 2.60 | | 154.00 | 63.50 | 8.05 | 0.40 | 152.00 |
| | 5 | 11-Sep-17 | 98.90 | 1.00 | 2.00 | 3.00 | | 149.00 | 61.60 | 8.04 | 0.39 | 150.00 |
| | 10 | 11-Sep-17 | 103.00 | 1.00 | 2.00 | 2.00 | | 170.00 | 62.70 | 8.05 | 0.39 | 151.00 |
| | 15 | 11-Sep-17 | 103.00 | 1.10 | 2.00 | 2.70 | | 145.00 | 63.30 | 8.06 | 0.35 | 151.00 |
| | 20 | 11-Sep-17 | 103.00 | 1.00 | 2.00 | 2.40 | | 164.00 | 61.60 | 8.05 | 0.36 | 150.00 |
| | 40 | 11-Sep-17 | 126.00 | 1.80 | 2.80 | 3.50 | | 181.00 | 65.80 | 8.07 | 0.66 | 156.00 |
| | 60 | 11-Sep-17 | 140.00 | 1.20 | 2.40 | 2.00 | | 179.00 | 65.20 | 8.05 | 0.41 | 160.00 |
| | 80 | 11-Sep-17 | 129.00 | 1.40 | 2.00 | 7.00 | | 170.00 | 72.40 | 8.09 | 0.26 | 176.00 |
| | 175 | 11-Sep-17 | 143.00 | 1.30 | 2.00 | 2.00 | | 173.00 | 86.40 | 8.11 | 0.21 | 207.00 |
| | 2 | 16-Oct-17 | 95.00 | 1.40 | 2.90 | 4.60 | | 124.00 | 60.10 | 8.00 | 0.29 | 148.00 |
| | 5 | 16-Oct-17 | 95.20 | 1.00 | 2.00 | 3.50 | | 133.00 | 60.70 | 8.01 | 0.30 | 148.00 |
| | 10 | 16-Oct-17 | 93.90 | 1.30 | 3.50 | 4.50 | | 136.00 | 62.50 | 8.02 | 0.29 | 148.00 |
| | 15 | 16-Oct-17 | 93.40 | 2.40 | 2.20 | 3.60 | | 126.00 | 62.50 | 8.00 | 0.36 | 148.00 |
| | 20 | 16-Oct-17 | 95.40 | 1.00 | 2.20 | 7.70 | | 129.00 | 61.80 | 8.02 | 0.30 | 148.00 |
| | 40 | 16-Oct-17 | 126.00 | 1.50 | 3.50 | 3.90 | | 153.00 | 57.70 | 7.88 | 0.53 | 146.00 |
| | 60 | 16-Oct-17 | 141.00 | 1.60 | 2.00 | 2.00 | | 157.00 | 61.80 | 7.99 | 0.30 | 157.00 |

| Site | Depth | Date | NN | SRP | TP | TDP | SRS | TN | Alkalinity | pH | Turbidity | Cond. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | ug/L | ug/L | ug/L | ug/L | mgSi/L | ug/L | $mgCaCO_3/L$ | | (NTU) | µS/cm |
| | 80 | 16-Oct-17 | 127.00 | 2.10 | 9.50 | 2.70 | | 171.00 | 70.40 | 8.00 | 0.26 | 175.00 |
| | 170 | 16-Oct-17 | 142.00 | 1.00 | 2.20 | 2.40 | | 167.00 | 84.60 | 8.10 | 0.14 | 208.00 |
| | 2 | 14-Aug-17 | | | | | 3.03 | | | | | |
| | 5 | 14-Aug-17 | | | | | 3.01 | | | | | |
| | 10 | 14-Aug-17 | | | | | 3.06 | | | | | |
| | 15 | 14-Aug-17 | | | | | 3.31 | | | | | |
| | 20 | 14-Aug-17 | | | | | 2.44 | | | | | |
| KIN | 2 | 24-Apr-17 | 110.00 | 1.00 | 2.10 | 3.50 | | 258.00 | 61.50 | 7.94 | 0.38 | 153.00 |
| Canoe | 5 | 24-Apr-17 | 110.00 | 1.00 | 2.60 | 2.60 | | 224.00 | 61.60 | 7.94 | 0.29 | 152.00 |
| | 10 | 24-Apr-17 | 109.00 | 1.00 | 2.00 | 2.00 | | 255.00 | 61.50 | 7.91 | 0.33 | 150.00 |
| | 15 | 24-Apr-17 | 110.00 | 1.00 | 2.30 | 2.00 | | 232.00 | 61.80 | 7.93 | 0.32 | 151.00 |
| | 20 | 24-Apr-17 | 111.00 | 1.00 | 2.20 | 2.10 | | 227.00 | 59.90 | 7.93 | 0.28 | 151.00 |
| | 40 | 24-Apr-17 | 109.00 | 1.40 | 2.70 | 2.10 | | 217.00 | 59.40 | 7.93 | 0.33 | 152.00 |
| | 60 | 24-Apr-17 | 118.00 | 1.00 | 3.00 | 2.00 | | 240.00 | 71.70 | 8.03 | 0.19 | 174.00 |
| | 80 | 24-Apr-17 | 122.00 | 1.00 | 2.20 | 2.50 | | 212.00 | 73.50 | 8.02 | 0.17 | 176.00 |
| | 105 | 24-Apr-17 | 125.00 | 1.00 | 2.20 | 3.00 | | 195.00 | 75.00 | 8.03 | 0.17 | 179.00 |
| | 2 | 15-May-17 | 122.00 | 1.00 | 3.40 | 2.00 | | 266.00 | 62.60 | 7.93 | 0.27 | 153.00 |
| | 5 | 15-May-17 | 118.00 | 1.20 | 2.40 | 2.00 | | 291.00 | 62.10 | 7.91 | 0.27 | 152.00 |
| | 10 | 15-May-17 | 114.00 | 1.10 | 2.20 | 2.50 | | 342.00 | 61.50 | 7.88 | 0.34 | 151.00 |
| | 15 | 15-May-17 | 116.00 | 1.30 | 2.90 | 2.30 | | 302.00 | 61.70 | 7.90 | 0.23 | 152.00 |
| | 20 | 15-May-17 | 120.00 | 1.00 | 2.30 | 2.40 | | 330.00 | 62.60 | 7.91 | 0.29 | 152.00 |
| | 40 | 15-May-17 | 121.00 | 1.00 | 2.60 | 2.00 | | 323.00 | 65.80 | 7.94 | 0.28 | 158.00 |
| | 60 | 15-May-17 | 124.00 | 1.40 | 2.70 | 5.00 | | 315.00 | 72.90 | 7.98 | 0.69 | 172.00 |
| | 80 | 15-May-17 | 112.00 | 1.00 | 2.00 | 3.00 | | 243.00 | 79.20 | 8.02 | 0.18 | 187.00 |
| | 100 | 15-May-17 | 125.00 | 1.00 | 2.50 | 5.90 | | 326.00 | 77.90 | 8.00 | 0.28 | 183.00 |
| | 2 | 19-Jun-17 | 144.00 | 1.90 | 3.80 | 2.60 | | 208.00 | 68.80 | 8.11 | 0.58 | 158.00 |
| | 5 | 19-Jun-17 | 144.00 | 1.00 | 3.60 | 2.10 | | 230.00 | 66.90 | 8.09 | 0.64 | 157.00 |
| | 10 | 19-Jun-17 | 141.00 | 3.20 | 3.30 | 3.40 | | 200.00 | 59.60 | 8.09 | 0.64 | 145.00 |
| | 15 | 19-Jun-17 | 134.00 | 1.40 | 2.80 | 3.20 | | 211.00 | 52.40 | 8.06 | 0.75 | 123.00 |
| | 20 | 19-Jun-17 | 136.00 | 1.30 | 3.90 | 2.30 | | 180.00 | 46.80 | 7.95 | 0.88 | 119.00 |
| | 40 | 19-Jun-17 | 114.00 | 1.10 | 2.40 | 3.20 | | 173.00 | 66.70 | 8.14 | 0.36 | 159.00 |
| | 60 | 19-Jun-17 | 114.00 | 1.00 | 2.00 | 2.70 | | 167.00 | 72.30 | 8.09 | 0.28 | 169.00 |
| | 80 | 19-Jun-17 | 113.00 | 1.00 | 2.10 | 3.00 | | 144.00 | 75.20 | 8.12 | 0.18 | 178.00 |
| | 115 | 19-Jun-17 | 113.00 | 1.00 | 2.00 | 3.00 | | 153.00 | 82.20 | 8.12 | 0.28 | 193.00 |
| | 2 | 11-Jul-17 | 125.00 | 1.60 | 5.60 | 9.30 | | 221.00 | 47.00 | 7.97 | 0.74 | 125.00 |
| | 5 | 11-Jul-17 | 125.00 | 1.20 | 6.00 | 9.50 | | 209.00 | 49.80 | 7.96 | 0.89 | 124.00 |
| | 10 | 11-Jul-17 | 126.00 | 2.50 | 9.80 | 3.10 | | 220.00 | 48.90 | 7.99 | 0.77 | 124.00 |
| | 15 | 11-Jul-17 | 128.00 | 2.30 | 5.20 | 5.50 | | 216.00 | 51.00 | 7.98 | 0.73 | 127.00 |
| | 20 | 11-Jul-17 | 133.00 | 2.10 | 4.20 | 5.30 | | 222.00 | 53.10 | 7.99 | 0.87 | 135.00 |
| | 2 | 14-Aug-17 | 100.00 | 1.60 | 2.40 | 2.80 | | 166.00 | 63.00 | 8.06 | 0.45 | 152.00 |
| | 5 | 14-Aug-17 | 99.60 | 1.00 | 2.30 | 2.20 | | 182.00 | 64.40 | 8.07 | 0.54 | 150.00 |
| | 10 | 14-Aug-17 | 108.00 | 1.00 | 2.70 | 2.00 | | 166.00 | 61.60 | 8.06 | 0.62 | 147.00 |
| | 15 | 14-Aug-17 | 111.00 | 1.60 | 2.50 | 3.80 | | 163.00 | 62.10 | 8.03 | 0.53 | 145.00 |
| | 20 | 14-Aug-17 | 115.00 | 1.20 | 2.50 | 2.60 | | 168.00 | 62.80 | 8.06 | 0.46 | 149.00 |
| | 40 | 14-Aug-17 | 132.00 | 1.30 | 2.00 | 2.90 | | 184.00 | 53.60 | 7.97 | 0.65 | 131.00 |
| | 60 | 14-Aug-17 | 126.00 | 1.00 | 2.00 | 2.60 | | 163.00 | 67.50 | 8.06 | 0.39 | 163.00 |
| | 80 | 14-Aug-17 | 120.00 | 1.00 | 2.30 | 2.40 | | 167.00 | 72.80 | 8.06 | 0.19 | 174.00 |
| | 115 | 14-Aug-17 | 118.00 | 1.00 | 2.20 | 2.00 | | 152.00 | 81.00 | 8.14 | 0.24 | 193.00 |
| | 2 | 11-Sep-17 | 95.90 | 1.30 | 2.00 | 2.50 | | 283.00 | 61.00 | 8.03 | 0.41 | 151.00 |
| | 5 | 11-Sep-17 | 95.70 | 1.50 | 2.70 | 2.40 | | 184.00 | 60.70 | 8.03 | 0.40 | 149.00 |
| | 10 | 11-Sep-17 | 103.00 | 1.00 | 2.00 | 2.00 | | 144.00 | 61.20 | 7.98 | 0.46 | 149.00 |
| | 15 | 11-Sep-17 | 106.00 | 1.70 | 2.60 | 2.00 | | 155.00 | 61.90 | 8.04 | 0.43 | 149.00 |
| | 20 | 11-Sep-17 | 106.00 | 2.30 | 3.90 | 2.50 | | 171.00 | 60.90 | 8.01 | 1.85 | 146.00 |
| | 40 | 11-Sep-17 | 130.00 | 1.00 | 2.00 | 2.00 | | 187.00 | 56.60 | 7.98 | 1.04 | 138.00 |
| | 60 | 11-Sep-17 | 137.00 | 1.50 | 2.50 | 3.90 | | 174.00 | 60.90 | 8.03 | 0.22 | 151.00 |
| | 80 | 11-Sep-17 | 132.00 | 1.50 | 2.00 | 2.90 | | 166.00 | 71.30 | 8.06 | 0.22 | 173.00 |
| | 115 | 11-Sep-17 | 130.00 | 1.10 | 2.30 | 4.20 | | 183.00 | 81.20 | 8.10 | 0.16 | 195.00 |
| | 2 | 16-Oct-17 | 94.10 | 1.00 | 2.50 | 19.60 | | 104.000 | 60.50 | 7.98 | 0.33 | 145.00 |
| | 5 | 16-Oct-17 | 94.00 | 1.20 | 2.20 | 4.70 | | 114.000 | 60.50 | 8.03 | 0.25 | 145.00 |
| | 10 | 16-Oct-17 | 96.30 | 1.00 | 3.00 | 3.70 | | 134.000 | 60.30 | 7.99 | 0.45 | 146.00 |
| | 15 | 16-Oct-17 | 95.20 | 1.50 | 2.10 | 2.50 | | 130.000 | 60.70 | 8.02 | 0.35 | 145.00 |

| Site | Depth | Date | NN | SRP | TP | TDP | SRS | TN | Alkalinity | pH | Turbidity | Cond. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | ug/L | ug/L | ug/L | ug/L | mgSi/L | ug/L | mgCaCO$_3$/L | | (NTU) | µS/cm |
| | 20 | 16-Oct-17 | 94.40 | 1.00 | 2.10 | 4.10 | | 121.000 | 60.20 | 7.98 | 0.34 | 145.00 |
| | 40 | 16-Oct-17 | 95.20 | 1.50 | 2.80 | 2.90 | | 120.000 | 59.90 | 8.00 | 0.30 | 146.00 |
| | 60 | 16-Oct-17 | 137.00 | 1.00 | 3.40 | 2.20 | | 158.000 | 60.90 | 7.94 | 0.24 | 152.00 |
| | 80 | 16-Oct-17 | 133.00 | 1.00 | 2.00 | 2.00 | | 150.000 | 71.20 | 8.00 | 0.28 | 174.00 |
| | 120 | 16-Oct-17 | 133.00 | 2.00 | 2.00 | 4.40 | | 150.000 | 81.10 | 8.04 | 0.17 | 196.00 |
| | 2 | 14-Aug-17 | | | | | 3.11 | | | | | |
| | 5 | 14-Aug-17 | | | | | 2.06 | | | | | |
| | 10 | 14-Aug-17 | | | | | 2.65 | | | | | |
| | 15 | 14-Aug-17 | | | | | 3.47 | | | | | |
| | 20 | 14-Aug-17 | | | | | 3.57 | | | | | |
| KIN | 2 | 24-Apr-17 | 109.00 | 1.00 | 2.40 | 2.20 | | 243.00 | 67.30 | 8.00 | 0.27 | 163.00 |
| Wood | 5 | 24-Apr-17 | 107.00 | 1.00 | 2.00 | 2.00 | | 210.00 | 67.00 | 8.00 | 0.25 | 164.00 |
| | 10 | 24-Apr-17 | 108.00 | 1.00 | 2.00 | 2.50 | | 241.00 | 65.70 | 7.93 | 0.26 | 163.00 |
| | 15 | 24-Apr-17 | 106.00 | 1.00 | 2.00 | 2.00 | | 247.00 | 65.80 | 7.97 | 0.21 | 161.00 |
| | 20 | 24-Apr-17 | 105.00 | 1.00 | 2.00 | 2.00 | | 214.00 | 66.60 | 7.97 | 0.25 | 161.00 |
| | 40 | 24-Apr-17 | 123.00 | 1.70 | 2.80 | 2.00 | | 350.00 | 70.60 | 8.03 | 0.68 | 171.00 |
| | 2 | 15-May-17 | 114.00 | 1.00 | 2.00 | 2.00 | | 371.00 | 70.50 | 7.98 | 0.40 | 167.00 |
| | 5 | 15-May-17 | 115.00 | 1.00 | 2.40 | 2.30 | | 315.00 | 69.40 | 7.97 | 0.36 | 166.00 |
| | 10 | 15-May-17 | 112.00 | 1.00 | 2.80 | 2.10 | | 251.00 | 70.80 | 7.99 | 0.43 | 166.00 |
| | 15 | 15-May-17 | 109.00 | 1.00 | 2.60 | 2.30 | | 309.00 | 72.80 | 7.90 | 0.48 | 166.00 |
| | 20 | 15-May-17 | 110.00 | 1.00 | 2.90 | 2.00 | | 357.00 | 71.20 | 8.00 | 0.49 | 167.00 |
| | 40 | 15-May-17 | 174.00 | 4.50 | 7.60 | 2.00 | | 361.00 | 72.70 | 7.91 | 5.75 | 170.00 |
| | 2 | 19-Jun-17 | 137.00 | 1.90 | 4.50 | 3.00 | | 193.00 | 68.80 | 8.18 | 2.36 | 157.00 |
| | 5 | 19-Jun-17 | 139.00 | 2.70 | 4.00 | 5.60 | | 204.00 | 65.50 | 8.05 | 3.03 | 157.00 |
| | 10 | 19-Jun-17 | 141.00 | 2.90 | 4.50 | 4.10 | | 207.00 | 65.10 | 8.13 | 2.67 | 155.00 |
| | 15 | 19-Jun-17 | 143.00 | 3.60 | 6.00 | 2.10 | | 183.00 | 66.00 | 8.10 | 3.63 | 151.00 |
| | 20 | 19-Jun-17 | 144.00 | 1.00 | 7.20 | 2.20 | | 191.00 | 66.80 | 8.13 | 7.40 | 150.00 |
| | 40 | 19-Jun-17 | 124.00 | 1.00 | 11.90 | 4.30 | | 171.00 | 69.00 | 8.12 | 1.45 | 165.00 |
| | 55 | 19-Jun-17 | 126.00 | 1.80 | 2.10 | 2.30 | | 181.00 | 72.10 | 8.15 | 0.73 | 167.00 |
| | 2 | 11-Jul-17 | 129.00 | 2.10 | 2.50 | 3.10 | | 221.00 | 67.50 | 8.11 | 0.82 | 160.00 |
| | 5 | 11-Jul-17 | 134.00 | 1.00 | 4.20 | 3.90 | | 227.00 | 65.50 | 8.09 | 0.59 | 160.00 |
| | 10 | 11-Jul-17 | 141.00 | 2.70 | 6.80 | 4.60 | | 247.00 | 65.00 | 8.10 | 0.40 | 159.00 |
| | 15 | 11-Jul-17 | 143.00 | 2.60 | 2.90 | 2.90 | | 227.00 | 68.00 | 8.12 | 0.60 | 159.00 |
| | 20 | 11-Jul-17 | 118.00 | 1.00 | 8.10 | 3.00 | | 209.00 | 66.70 | 8.09 | 3.80 | 153.00 |
| | 40 | 11-Jul-17 | 141.00 | 1.00 | 9.80 | 3.10 | | 223.00 | 68.20 | 8.11 | 10.30 | 156.00 |
| | 60 | 11-Jul-17 | 140.00 | 3.90 | 4.90 | 3.50 | | 192.00 | 72.50 | 8.15 | 1.25 | 173.00 |
| | 2 | 14-Aug-17 | 95.50 | 1.10 | 2.60 | 2.00 | | 160.00 | 67.20 | 8.08 | 0.50 | 157.00 |
| | 5 | 14-Aug-17 | 95.90 | 1.10 | 4.00 | 2.60 | | 167.00 | 65.70 | 8.07 | 0.42 | 157.00 |
| | 10 | 14-Aug-17 | 102.00 | 1.00 | 3.20 | 2.60 | | 173.00 | 62.70 | 8.07 | 0.49 | 151.00 |
| | 15 | 14-Aug-17 | 110.00 | 1.40 | 2.60 | 3.60 | | 195.00 | 64.20 | 8.05 | 0.49 | 149.00 |
| | 20 | 14-Aug-17 | 114.00 | 1.30 | 3.40 | 4.10 | | 171.00 | 64.20 | 8.03 | 0.70 | 151.00 |
| | 40 | 14-Aug-17 | 124.00 | 3.50 | 5.30 | 3.30 | | 178.00 | 67.30 | 8.06 | 2.70 | 154.00 |
| | 60 | 14-Aug-17 | 158.00 | 7.90 | 4.40 | 3.00 | | 200.00 | 73.30 | 8.09 | 2.13 | 170.00 |
| | 2 | 11-Sep-17 | 78.00 | 1.00 | 2.00 | 3.30 | | 186.00 | 63.30 | 8.06 | 0.44 | 153.00 |
| | 5 | 11-Sep-17 | 79.70 | 4.40 | 3.10 | 2.60 | | 148.00 | 63.90 | 8.07 | 0.52 | 153.00 |
| | 10 | 11-Sep-17 | 86.40 | 1.00 | 2.00 | 3.30 | | 149.00 | 62.70 | 8.00 | 0.47 | 152.00 |
| | 15 | 11-Sep-17 | 98.80 | 1.00 | 3.00 | 6.70 | | 179.00 | 60.30 | 8.05 | 0.42 | 149.00 |
| | 20 | 11-Sep-17 | 104.00 | 1.00 | 2.50 | 2.00 | | 150.00 | 63.90 | 8.06 | 0.36 | 151.00 |
| | 40 | 11-Sep-17 | 70.20 | 4.80 | 3.30 | 2.00 | | 93.00 | 62.60 | 8.06 | 6.39 | 143.00 |
| | 60 | 11-Sep-17 | 164.00 | 1.60 | 4.30 | 2.20 | | 214.00 | 73.70 | 8.11 | 2.47 | 173.00 |
| | 2 | 14-Aug-17 | | | | | 3.01 | | | | | |
| | 5 | 14-Aug-17 | | | | | 3.07 | | | | | |
| | 10 | 14-Aug-17 | | | | | 3.11 | | | | | |
| | 15 | 14-Aug-17 | | | | | 3.06 | | | | | |
| | 20 | 14-Aug-17 | | | | | 3.19 | | | | | |
| KIN | 2 | 25-Apr-17 | 109.00 | 1.00 | 2.00 | 2.30 | | 279.00 | 84.90 | 8.07 | 0.23 | 204.00 |
| Columbia | 5 | 25-Apr-17 | 108.00 | 1.00 | 2.00 | 3.60 | | 205.00 | 86.10 | 8.07 | 0.18 | 209.00 |
| | 10 | 25-Apr-17 | 108.00 | 1.00 | 2.10 | 2.60 | | 247.00 | 85.80 | 8.11 | 0.23 | 208.00 |
| | 15 | 25-Apr-17 | 109.00 | 2.90 | 2.80 | 2.60 | | 217.00 | 85.60 | 8.18 | 0.19 | 208.00 |
| | 20 | 25-Apr-17 | 108.00 | 1.00 | 2.60 | 2.00 | | 276.00 | 84.10 | 8.10 | 0.25 | 206.00 |
| | 40 | 25-Apr-17 | 108.00 | 4.70 | 2.10 | 2.70 | | 278.00 | 84.70 | 8.06 | 0.25 | 203.00 |

| Site | Depth | Date | NN | SRP | TP | TDP | SRS | TN | Alkalinity | pH | Turbidity | Cond. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | ug/L | ug/L | ug/L | ug/L | mgSi/L | ug/L | mgCaCO$_3$/L | | (NTU) | µS/cm |
| | 60 | 25-Apr-17 | 107.00 | 1.00 | 2.00 | 2.10 | | 276.00 | 85.20 | 8.06 | 0.27 | 206.00 |
| | 80 | 25-Apr-17 | 107.00 | 1.00 | 3.60 | 2.30 | | 281.00 | 86.00 | 8.12 | 0.19 | 209.00 |
| | 150 | 25-Apr-17 | 136.00 | 1.00 | 2.30 | 3.80 | | 224.00 | 88.90 | 8.15 | 0.43 | 214.00 |
| | 2 | 16-May-17 | 118.00 | 1.00 | 2.90 | 2.00 | | 273.00 | 90.30 | 8.00 | 0.31 | 211.00 |
| | 5 | 16-May-17 | 127.00 | 1.00 | 6.90 | 2.80 | | 343.00 | 90.80 | 8.07 | 0.30 | 211.00 |
| | 10 | 16-May-17 | 128.00 | 1.00 | 2.50 | 2.30 | | 303.00 | 91.40 | 8.09 | 0.28 | 212.00 |
| | 15 | 16-May-17 | 126.00 | 1.00 | 2.10 | 3.50 | | 288.00 | 91.30 | 8.08 | 0.37 | 211.00 |
| | 20 | 16-May-17 | 125.00 | 1.00 | 2.10 | 3.00 | | 296.00 | 90.70 | 8.09 | 0.47 | 211.00 |
| | 40 | 16-May-17 | 124.00 | 1.00 | 2.40 | 8.30 | | 370.00 | 91.30 | 8.07 | 0.33 | 213.00 |
| | 60 | 16-May-17 | 125.00 | 1.30 | 3.00 | 2.30 | | 333.00 | 93.50 | 8.08 | 0.57 | 218.00 |
| | 80 | 16-May-17 | 128.00 | 1.00 | 4.40 | 4.20 | | 437.00 | 96.80 | 8.08 | 0.72 | 223.00 |
| | 155 | 16-May-17 | 128.00 | 1.10 | 2.90 | 8.40 | | 302.00 | 101.00 | 8.11 | 0.50 | 230.00 |
| | 2 | 19-Jun-17 | 209.00 | 1.90 | 4.50 | 4.90 | | 266.00 | 86.40 | 8.20 | 1.82 | 193.00 |
| | 5 | 19-Jun-17 | 206.00 | 1.90 | 4.20 | 2.50 | | 272.00 | 85.90 | 8.19 | 1.75 | 192.00 |
| | 10 | 19-Jun-17 | 207.00 | 1.90 | 4.10 | 4.20 | | 272.00 | 86.70 | 8.21 | 2.33 | 189.00 |
| | 15 | 19-Jun-17 | 202.00 | 1.70 | 5.60 | 3.20 | | 274.00 | 85.90 | 8.20 | 2.86 | 190.00 |
| | 20 | 19-Jun-17 | 202.00 | 2.50 | 6.10 | 3.70 | | 268.00 | 85.90 | 8.16 | 4.28 | 190.00 |
| | 40 | 19-Jun-17 | 169.00 | 1.10 | 5.40 | 2.70 | | 221.00 | 88.10 | 8.21 | 2.34 | 199.00 |
| | 60 | 19-Jun-17 | 131.00 | 1.00 | 2.60 | 2.00 | | 187.00 | 90.70 | 8.15 | 0.38 | 215.00 |
| | 80 | 19-Jun-17 | 126.00 | 1.00 | 3.60 | 3.20 | | 178.00 | 92.90 | 8.23 | 1.02 | 216.00 |
| | 165 | 19-Jun-17 | 119.00 | 1.20 | 2.00 | 2.40 | | 165.00 | 95.90 | 8.22 | 0.38 | 227.00 |
| | 2 | 10-Jul-17 | 148.00 | 2.20 | 4.20 | 3.20 | | 248.00 | 75.30 | 8.18 | 1.13 | 177.00 |
| | 5 | 10-Jul-17 | 148.00 | 1.10 | 4.80 | 3.60 | | 265.00 | 75.90 | 8.08 | 1.05 | 175.00 |
| | 10 | 10-Jul-17 | 143.00 | 2.90 | 4.00 | 3.10 | | 258.00 | 75.90 | 8.13 | 1.19 | 175.00 |
| | 15 | 10-Jul-17 | 138.00 | 1.30 | 5.80 | 3.10 | | 244.00 | 76.90 | 8.13 | 2.14 | 174.00 |
| | 20 | 10-Jul-17 | 140.00 | 4.20 | 6.00 | 4.40 | | 208.00 | 77.00 | 8.14 | 2.23 | 175.00 |
| | 40 | 10-Jul-17 | 164.00 | 1.00 | 2.70 | 2.60 | | 255.00 | 84.30 | 8.22 | 0.92 | 198.00 |
| | 60 | 10-Jul-17 | 131.00 | 1.00 | 3.70 | 8.90 | | 212.00 | 90.20 | 8.20 | 0.39 | 217.00 |
| | 80 | 10-Jul-17 | 127.00 | 1.00 | 2.00 | 3.50 | | 217.00 | 92.90 | 8.21 | 0.18 | 221.00 |
| | 175 | 10-Jul-17 | 132.00 | 1.70 | 2.60 | 3.60 | | 196.00 | 98.80 | 8.22 | 0.34 | 232.00 |
| | 2 | 15-Aug-17 | 88.40 | 1.00 | 2.60 | 2.60 | | 153.00 | 69.20 | 8.11 | 1.06 | 164.00 |
| | 5 | 15-Aug-17 | 86.60 | 1.90 | 2.90 | 2.40 | | 136.00 | 69.60 | 8.11 | 0.96 | 162.00 |
| | 10 | 15-Aug-17 | 87.00 | 2.30 | 3.00 | 2.20 | | 143.00 | 69.40 | 8.11 | 1.11 | 161.00 |
| | 15 | 15-Aug-17 | 86.10 | 2.70 | 3.50 | 2.70 | | 139.00 | 68.40 | 8.11 | 1.91 | 158.00 |
| | 20 | 15-Aug-17 | 83.10 | 3.00 | 4.70 | 2.50 | | 130.00 | 66.50 | 8.09 | 1.83 | 153.00 |
| | 40 | 15-Aug-17 | 124.00 | 2.00 | 3.50 | 2.50 | | 162.00 | 72.80 | 8.11 | 1.12 | 165.00 |
| | 60 | 15-Aug-17 | 159.00 | 1.10 | 2.30 | 2.00 | | 187.00 | 90.50 | 8.25 | 0.39 | 209.00 |
| | 80 | 15-Aug-17 | 146.00 | 1.00 | 2.90 | 3.80 | | 202.00 | 93.40 | 8.22 | 0.20 | 221.00 |
| | 170 | 15-Aug-17 | 147.00 | 1.40 | 2.50 | 2.00 | | 174.00 | 98.80 | 8.22 | 0.28 | 232.00 |
| | 2 | 12-Sep-17 | 60.90 | 2.10 | 1.00 | 2.10 | | 111.00 | 68.90 | 8.09 | 0.67 | 159.00 |
| | 5 | 12-Sep-17 | 57.20 | 1.50 | 2.60 | 2.00 | | 118.00 | 68.50 | 8.10 | 0.54 | 160.00 |
| | 10 | 12-Sep-17 | 57.90 | 1.00 | 2.90 | 2.90 | | 121.00 | 67.80 | 8.08 | 0.57 | 160.00 |
| | 15 | 12-Sep-17 | 61.50 | 2.30 | 2.30 | 3.90 | | 151.00 | 66.40 | 8.09 | 0.58 | 161.00 |
| | 20 | 12-Sep-17 | 75.70 | 1.80 | 2.50 | 2.00 | | 115.00 | 65.80 | 8.07 | 1.41 | 156.00 |
| | 40 | 12-Sep-17 | 102.00 | 2.10 | 3.00 | 2.00 | | 133.00 | 70.70 | 8.12 | 1.65 | 161.00 |
| | 60 | 12-Sep-17 | 163.00 | 2.70 | 4.00 | 2.50 | | 252.00 | 87.40 | 8.19 | 1.18 | 202.00 |
| | 80 | 12-Sep-17 | 149.00 | 1.40 | 3.90 | 2.40 | | 186.00 | 94.80 | 8.21 | 0.44 | 221.00 |
| | 170 | 12-Sep-17 | 144.00 | 1.80 | 2.10 | 3.10 | | 171.00 | 98.70 | 8.23 | 0.20 | 233.00 |
| | 2 | 18-Oct-17 | 64.90 | 1.00 | 2.20 | 4.30 | | 98.00 | 69.60 | 8.01 | 0.35 | 162.00 |
| | 5 | 18-Oct-17 | 68.60 | 1.80 | 2.80 | 4.20 | | 109.00 | 68.20 | 8.06 | 0.29 | 162.00 |
| | 10 | 18-Oct-17 | 76.50 | 1.10 | 2.40 | 8.00 | | 101.00 | 70.50 | 8.04 | 0.29 | 162.00 |
| | 15 | 18-Oct-17 | 67.20 | 1.30 | 3.20 | 4.20 | | 111.00 | 68.30 | 8.05 | 0.55 | 162.00 |
| | 20 | 18-Oct-17 | 66.00 | 1.00 | 2.20 | 5.10 | | 124.00 | 68.50 | 8.04 | 0.32 | 163.00 |
| | 2 | 15-Aug-17 | | | | | 2.83 | | | | | |
| | 5 | 15-Aug-17 | | | | | 3.04 | | | | | |
| | 10 | 15-Aug-17 | | | | | 2.67 | | | | | |
| | 15 | 15-Aug-17 | | | | | 2.84 | | | | | |
| | 20 | 15-Aug-17 | | | | | 2.85 | | | | | |
| REV | 2 | 18-Apr-17 | 107.00 | 1.00 | 2.40 | 2.20 | | 150.00 | 64.60 | 8.09 | 0.24 | 157.00 |
| FB | 5 | 18-Apr-17 | 108.00 | 1.00 | 3.00 | 2.20 | | 159.00 | 65.40 | 8.08 | 0.20 | 157.00 |
| | 10 | 18-Apr-17 | 111.00 | 1.00 | 2.90 | 2.30 | | 157.00 | 63.90 | 8.08 | 0.23 | 158.00 |

| Site | Depth | Date | NN | SRP | TP | TDP | SRS | TN | Alkalinity | pH | Turbidity | Cond. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | ug/L | ug/L | ug/L | ug/L | mgSi/L | ug/L | $mgCaCO_3/L$ | | (NTU) | µS/cm |
| | 15 | 18-Apr-17 | 109.00 | 1.00 | 2.70 | 2.50 | | 148.00 | 65.30 | 8.09 | 0.27 | 157.00 |
| | 20 | 18-Apr-17 | 109.00 | 1.50 | 2.00 | 2.80 | | 161.00 | 64.30 | 8.08 | 0.23 | 158.00 |
| | 40 | 18-Apr-17 | 110.00 | 1.00 | 2.70 | 5.40 | | 151.00 | 64.70 | 8.09 | 0.22 | 158.00 |
| | 60 | 18-Apr-17 | 106.00 | 1.00 | 2.00 | 2.10 | | 176.00 | 65.40 | 8.08 | 0.22 | 159.00 |
| | 80 | 18-Apr-17 | 112.00 | 1.70 | 2.40 | 2.00 | | 187.00 | 64.20 | 8.05 | 0.23 | 158.00 |
| | 120 | 18-Apr-17 | 112.00 | 1.40 | 2.20 | 2.00 | | 151.00 | 65.90 | 8.09 | 0.24 | 160.00 |
| | 2 | 24-May-17 | 136.00 | 1.90 | 4.10 | 2.00 | | 199.00 | 60.70 | 8.02 | 0.42 | 144.00 |
| | 5 | 24-May-17 | 136.00 | 1.00 | 3.70 | 2.00 | | 215.00 | 60.80 | 8.05 | 0.61 | 144.00 |
| | 10 | 24-May-17 | 136.00 | 1.10 | 9.90 | 2.00 | | 203.00 | 60.30 | 8.06 | 0.48 | 144.00 |
| | 15 | 24-May-17 | 135.00 | 1.80 | 3.90 | 2.00 | | 243.00 | 57.10 | 8.04 | 0.44 | 142.00 |
| | 20 | 24-May-17 | 128.00 | 1.00 | 2.10 | 2.00 | | 266.00 | 60.80 | 8.04 | 0.46 | 148.00 |
| | 40 | 24-May-17 | 120.00 | 1.00 | 2.00 | 2.00 | | 156.00 | 63.80 | 8.08 | 0.19 | 153.00 |
| | 60 | 24-May-17 | 116.00 | 1.00 | 2.00 | 2.00 | | 158.00 | 64.10 | 8.07 | 0.31 | 154.00 |
| | 80 | 24-May-17 | 119.00 | 1.00 | 2.50 | 2.20 | | 182.00 | 64.40 | 8.08 | 0.28 | 154.00 |
| | 105 | 24-May-17 | 120.00 | 1.00 | 2.00 | 9.40 | | 163.00 | 65.10 | 8.07 | 0.26 | 154.00 |
| | 2 | 13-Jun-17 | 150.00 | 1.50 | 3.80 | 3.10 | | 197.00 | 49.10 | 7.96 | 0.64 | 121.00 |
| | 5 | 13-Jun-17 | 151.00 | 1.70 | 4.00 | 3.30 | | 201.00 | 51.10 | 7.98 | 0.65 | 121.00 |
| | 10 | 13-Jun-17 | 163.00 | 1.60 | 4.20 | 2.90 | | 206.00 | 50.00 | 7.97 | 0.70 | 121.00 |
| | 15 | 13-Jun-17 | 189.00 | 1.70 | 2.80 | 2.60 | | 257.00 | 51.20 | 7.96 | 0.78 | 126.00 |
| | 20 | 13-Jun-17 | 197.00 | 1.90 | 4.70 | 3.60 | | 223.00 | 53.30 | 7.99 | 0.79 | 128.00 |
| | 40 | 13-Jun-17 | 174.00 | 1.70 | 4.00 | 2.80 | | 226.00 | 59.80 | 8.01 | 0.67 | 146.00 |
| | 60 | 13-Jun-17 | 135.00 | 1.00 | 2.50 | 2.90 | | 150.00 | 63.40 | 8.06 | 0.96 | 154.00 |
| | 80 | 13-Jun-17 | 127.00 | 1.00 | 2.70 | 2.30 | | 167.00 | 63.70 | 8.06 | 0.17 | 155.00 |
| | 105 | 13-Jun-17 | 124.00 | 1.00 | 2.40 | 2.50 | | 147.00 | 63.30 | 8.01 | 0.20 | 156.00 |
| | 2 | 18-Jul-17 | 107.00 | 1.00 | 3.40 | 2.90 | | 144.00 | 39.10 | 7.88 | 1.14 | 91.80 |
| | 5 | 18-Jul-17 | 109.00 | 1.00 | 3.60 | 2.00 | | 141.00 | 38.30 | 7.88 | 1.04 | 90.20 |
| | 10 | 18-Jul-17 | 109.00 | 1.10 | 3.50 | 3.30 | | 181.00 | 38.20 | 7.90 | 1.09 | 89.90 |
| | 15 | 18-Jul-17 | 126.00 | 1.10 | 6.30 | 4.00 | | 142.00 | 38.00 | 7.83 | 1.01 | 84.80 |
| | 20 | 18-Jul-17 | 125.00 | 1.00 | 3.20 | 2.50 | | 154.00 | 35.90 | 7.83 | 0.92 | 83.20 |
| | 40 | 18-Jul-17 | 148.00 | 1.00 | 3.00 | 2.60 | | 156.00 | 33.70 | 7.83 | 0.74 | 84.20 |
| | 60 | 18-Jul-17 | 193.00 | 1.00 | 2.60 | 2.00 | | 218.00 | 47.90 | 7.96 | 0.80 | 114.00 |
| | 80 | 18-Jul-17 | 150.00 | 1.00 | 2.60 | 2.30 | | 187.00 | 64.00 | 8.05 | 0.61 | 150.00 |
| | 115 | 18-Jul-17 | 147.00 | 1.00 | 2.90 | 2.50 | | 170.00 | 65.50 | 8.07 | 0.53 | 151.00 |
| | 2 | 22-Aug-17 | 61.60 | 1.00 | 2.50 | 2.50 | | 130.00 | 38.70 | 7.86 | 0.56 | 92.10 |
| | 5 | 22-Aug-17 | 61.50 | 1.80 | 2.20 | 2.00 | | 127.00 | 37.60 | 7.85 | 0.58 | 92.40 |
| | 10 | 22-Aug-17 | 60.80 | 1.00 | 3.70 | 2.00 | | 141.00 | 39.20 | 7.81 | 0.54 | 92.80 |
| | 15 | 22-Aug-17 | 75.40 | 1.00 | 3.50 | 2.60 | | 138.00 | 42.00 | 7.88 | 0.73 | 98.70 |
| | 20 | 22-Aug-17 | 107.00 | 1.20 | 2.10 | 2.00 | | 160.00 | 51.10 | 7.95 | 0.42 | 125.00 |
| | 40 | 22-Aug-17 | 125.00 | 1.30 | 2.10 | 3.60 | | 183.00 | 57.10 | 7.99 | 0.40 | 140.00 |
| | 60 | 22-Aug-17 | 148.00 | 1.00 | 2.80 | 2.40 | | 205.00 | 51.00 | 7.93 | 0.48 | 125.00 |
| | 80 | 22-Aug-17 | 159.00 | 1.00 | 2.00 | 3.00 | | 202.00 | 60.60 | 8.02 | 0.37 | 152.00 |
| | 105 | 22-Aug-17 | 154.00 | 2.50 | 2.60 | 4.70 | | 188.00 | 61.80 | 7.99 | 0.34 | 153.00 |
| | 2 | 19-Sep-17 | 70.90 | 1.90 | 3.40 | 3.10 | | 121.000 | 47.80 | 7.92 | 1.45 | 108.00 |
| | 5 | 19-Sep-17 | 70.80 | 1.90 | 3.90 | 3.10 | | 149.000 | 44.10 | 7.92 | 0.90 | 109.00 |
| | 10 | 19-Sep-17 | 109.00 | 1.00 | 4.60 | 2.80 | | 141.000 | 53.90 | 7.94 | 0.78 | 134.00 |
| | 15 | 19-Sep-17 | 124.00 | 1.20 | 3.50 | 3.30 | | 170.000 | 60.50 | 8.02 | 0.65 | 144.00 |
| | 20 | 19-Sep-17 | 128.00 | 2.30 | 4.10 | 5.10 | | 166.000 | 60.30 | 8.02 | 0.56 | 146.00 |
| | 40 | 19-Sep-17 | 132.00 | 1.10 | 4.10 | 3.70 | | 154.000 | 61.90 | 8.04 | 0.73 | 147.00 |
| | 60 | 19-Sep-17 | 139.00 | 1.00 | 4.00 | 3.50 | | 172.000 | 59.60 | 8.02 | 0.42 | 146.00 |
| | 80 | 19-Sep-17 | 165.00 | 1.00 | 3.60 | 4.60 | | 182.000 | 63.30 | 8.02 | 0.38 | 148.00 |
| | 115 | 19-Sep-17 | 172.00 | 1.20 | 4.10 | 3.50 | | 176.000 | 64.00 | 8.05 | 0.48 | 152.00 |
| | 2 | 24-Oct-17 | 120.00 | 1.40 | 2.00 | 3.40 | | 180.00 | 60.20 | 7.98 | 0.35 | 144.00 |
| | 5 | 24-Oct-17 | 122.00 | 1.00 | 2.60 | 5.40 | | 212.00 | 66.20 | 8.00 | 0.36 | 144.00 |
| | 10 | 24-Oct-17 | 122.00 | 1.00 | 3.00 | 3.00 | | 186.00 | 57.90 | 7.98 | 0.31 | 145.00 |
| | 15 | 24-Oct-17 | 120.00 | 1.00 | 2.30 | 4.10 | | 192.00 | 57.30 | 7.98 | 0.35 | 145.00 |
| | 20 | 24-Oct-17 | 121.00 | 1.40 | 2.30 | 2.70 | | 186.00 | 60.10 | 7.98 | 0.30 | 146.00 |
| | 40 | 24-Oct-17 | 122.00 | 1.00 | 2.00 | 2.00 | | 215.00 | 60.20 | 7.98 | 0.34 | 145.00 |
| | 60 | 24-Oct-17 | 144.00 | 1.50 | 2.00 | 2.50 | | 240.00 | 59.10 | 7.97 | 0.35 | 149.00 |
| | 80 | 24-Oct-17 | 162.00 | 1.40 | 2.50 | 2.00 | | 253.00 | 61.00 | 7.96 | 0.45 | 149.00 |
| | 115 | 24-Oct-17 | 164.00 | 1.70 | 3.70 | 5.40 | | 236.00 | 63.90 | 7.97 | 0.60 | 152.00 |
| | 2 | 22-Aug-17 | | | | | 2.90 | | | | | |

| Site | Depth | Date | NN | SRP | TP | TDP | SRS | TN | Alkalinity | pH | Turbidity | Cond. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | ug/L | ug/L | ug/L | ug/L | mgSi/L | ug/L | mgCaCO$_3$/L | | (NTU) | µS/cm |
| | 5 | 22-Aug-17 | | | | | 2.91 | | | | | |
| | 10 | 22-Aug-17 | | | | | 2.87 | | | | | |
| | 15 | 22-Aug-17 | | | | | 2.96 | | | | | |
| | 20 | 22-Aug-17 | | | | | 3.36 | | | | | |
| REV | 2 | 19-Apr-17 | 108.00 | 1.00 | 2.30 | 2.00 | | 191.00 | 65.80 | 8.07 | 0.36 | 159.00 |
| Middle | 5 | 19-Apr-17 | 109.00 | 1.30 | 2.80 | 2.00 | | 161.00 | 64.10 | 8.09 | 0.30 | 159.00 |
| | 10 | 19-Apr-17 | 108.00 | 1.40 | 2.80 | 2.50 | | 162.00 | 65.90 | 8.10 | 0.32 | 158.00 |
| | 15 | 19-Apr-17 | 109.00 | 1.50 | 2.70 | 2.80 | | 173.00 | 65.50 | 8.08 | 0.32 | 159.00 |
| | 20 | 19-Apr-17 | 108.00 | 1.10 | 2.50 | 2.50 | | 136.00 | 64.30 | 8.10 | 0.35 | 160.00 |
| | 40 | 19-Apr-17 | 107.00 | 2.40 | 3.90 | 3.30 | | 151.00 | 65.70 | 8.11 | 0.32 | 160.00 |
| | 60 | 19-Apr-17 | 108.00 | 1.70 | 2.00 | 2.50 | | 163.00 | 65.70 | 8.06 | 0.31 | 160.00 |
| | 80 | 19-Apr-17 | 106.00 | 1.40 | 2.40 | 2.50 | | 163.00 | 64.40 | 8.08 | 0.37 | 159.00 |
| | 2 | 23-May-17 | 242.00 | 1.40 | 2.60 | 2.70 | | 401.00 | 63.60 | 8.07 | 0.76 | 149.00 |
| | 5 | 23-May-17 | 207.00 | 1.50 | 3.20 | 2.70 | | 262.00 | 60.20 | 8.04 | 0.84 | 141.00 |
| | 10 | 23-May-17 | 235.00 | 1.00 | 3.40 | 3.10 | | 377.00 | 64.00 | 8.07 | 0.89 | 148.00 |
| | 15 | 23-May-17 | 200.00 | 2.30 | 3.20 | 4.50 | | 382.00 | 60.00 | 8.06 | 0.75 | 146.00 |
| | 20 | 23-May-17 | 197.00 | 1.00 | 3.00 | 2.20 | | 364.00 | 62.40 | 8.05 | 0.79 | 147.00 |
| | 40 | 23-May-17 | 137.00 | 1.00 | 2.70 | 2.50 | | 204.00 | 64.30 | 8.07 | 0.47 | 155.00 |
| | 60 | 23-May-17 | 126.00 | 1.00 | 2.60 | 2.00 | | 301.00 | 66.20 | 8.08 | 0.23 | 158.00 |
| | 80 | 23-May-17 | 126.00 | 2.10 | 6.70 | 2.00 | | 302.00 | 67.20 | 8.09 | 0.29 | 158.00 |
| | 2 | 12-Jun-17 | 175.00 | 2.00 | 4.60 | 2.90 | | 195.00 | 48.90 | 7.96 | 0.93 | 123.00 |
| | 5 | 12-Jun-17 | 193.00 | 3.00 | 5.50 | 2.30 | | 300.00 | 48.70 | 7.95 | 1.34 | 118.00 |
| | 10 | 12-Jun-17 | 212.00 | 2.30 | 5.40 | 3.60 | | 233.00 | 49.90 | 7.98 | 1.49 | 120.00 |
| | 15 | 12-Jun-17 | 210.00 | 1.10 | 5.50 | 3.70 | | 225.00 | 46.10 | 7.94 | 1.86 | 110.00 |
| | 20 | 12-Jun-17 | 208.00 | 3.10 | 6.10 | 2.50 | | 255.00 | 43.50 | 7.89 | 2.43 | 105.00 |
| | 40 | 12-Jun-17 | 195.00 | 1.70 | 4.40 | 2.70 | | 256.00 | 58.20 | 8.00 | 1.37 | 139.00 |
| | 60 | 12-Jun-17 | 133.00 | 1.00 | 3.30 | 2.90 | | 170.00 | 62.60 | 7.99 | 0.43 | 155.00 |
| | 80 | 12-Jun-17 | 125.00 | 1.00 | 2.80 | 2.00 | | 125.00 | 63.80 | 8.05 | 0.47 | 158.00 |
| | 2 | 17-Jul-17 | 89.30 | 1.20 | 4.40 | 5.50 | | 156.00 | 41.70 | 7.87 | 1.31 | 91.50 |
| | 5 | 17-Jul-17 | 88.60 | 1.70 | 4.70 | 2.40 | | 215.00 | 38.80 | 7.87 | 1.55 | 91.70 |
| | 10 | 17-Jul-17 | 88.30 | 2.20 | 3.50 | 2.00 | | 144.00 | 44.00 | 7.92 | 2.10 | 100.00 |
| | 15 | 17-Jul-17 | 93.60 | 1.50 | 3.30 | 2.10 | | 159.00 | 42.80 | 7.90 | 1.14 | 97.50 |
| | 20 | 17-Jul-17 | 111.00 | 1.40 | 2.50 | 2.50 | | 136.00 | 44.20 | 7.90 | 1.01 | 105.00 |
| | 40 | 17-Jul-17 | 132.00 | 1.90 | 2.50 | 2.00 | | 162.00 | 40.70 | 7.89 | 0.72 | 100.00 |
| | 60 | 17-Jul-17 | 187.00 | 1.00 | 4.60 | 2.10 | | 224.00 | 51.80 | 7.96 | 0.70 | 120.00 |
| | 80 | 17-Jul-17 | 144.00 | 1.00 | 18.50 | 2.70 | | 190.00 | 61.90 | 8.03 | 0.52 | 150.00 |
| | 2 | 21-Aug-17 | 61.00 | 1.30 | 3.70 | 2.00 | | 178.00 | 42.40 | 7.85 | 0.80 | 101.00 |
| | 5 | 21-Aug-17 | 59.60 | 1.60 | 2.00 | 4.20 | | 175.00 | 42.50 | 7.86 | 0.96 | 99.90 |
| | 10 | 21-Aug-17 | 87.60 | 2.80 | 3.30 | 2.00 | | 145.00 | 49.50 | 7.96 | 1.19 | 120.00 |
| | 15 | 21-Aug-17 | 116.00 | 1.00 | 3.50 | 2.00 | | 174.00 | 56.90 | 8.02 | 1.57 | 139.00 |
| | 20 | 21-Aug-17 | 125.00 | 2.10 | 2.20 | 2.00 | | 175.00 | 59.90 | 8.03 | 1.09 | 145.00 |
| | 40 | 21-Aug-17 | 131.00 | 1.50 | 2.50 | 2.90 | | 167.00 | 60.50 | 8.01 | 1.05 | 148.00 |
| | 60 | 21-Aug-17 | 149.00 | 1.40 | 2.00 | 2.00 | | 216.00 | 54.30 | 7.97 | 0.51 | 135.00 |
| | 80 | 21-Aug-17 | 165.00 | 1.10 | 2.20 | 2.60 | | 238.00 | 61.20 | 8.02 | 0.49 | 147.00 |
| | 2 | 18-Sep-17 | 79.70 | 2.90 | 4.90 | 3.70 | | 113.00 | 49.50 | 7.94 | 1.10 | 116.00 |
| | 5 | 18-Sep-17 | 79.20 | 2.60 | 4.20 | 4.10 | | 120.00 | 50.10 | 7.94 | 1.23 | 117.00 |
| | 10 | 18-Sep-17 | 81.70 | 1.70 | 4.00 | 3.70 | | 144.00 | 46.90 | 7.97 | 1.29 | 118.00 |
| | 15 | 18-Sep-17 | 85.00 | 3.60 | 4.10 | 3.70 | | 110.00 | 48.80 | 7.95 | 1.33 | 118.00 |
| | 20 | 18-Sep-17 | 92.30 | 3.80 | 4.50 | 2.00 | | 134.00 | 51.30 | 7.98 | 1.74 | 125.00 |
| | 40 | 18-Sep-17 | 122.00 | 3.00 | 4.20 | 3.50 | | 143.00 | 61.70 | 8.05 | 1.65 | 145.00 |
| | 60 | 18-Sep-17 | 131.00 | 2.10 | 2.90 | 3.40 | | 175.00 | 60.00 | 8.01 | 1.00 | 144.00 |
| | 75 | 18-Sep-17 | 156.00 | 1.90 | 2.80 | 2.30 | | 175.00 | 56.90 | 8.01 | 0.42 | 140.00 |
| | 2 | 23-Oct-17 | 110.00 | 1.20 | 3.20 | 3.50 | | 161.00 | 57.20 | 7.98 | 0.40 | 143.00 |
| | 5 | 23-Oct-17 | 113.00 | 1.00 | 4.10 | 3.50 | | 199.00 | 58.00 | 7.98 | 0.31 | 142.00 |
| | 10 | 23-Oct-17 | 106.00 | 1.10 | 3.20 | 2.50 | | 166.00 | 59.60 | 7.99 | 0.30 | 145.00 |
| | 15 | 23-Oct-17 | 112.00 | 1.00 | 2.90 | 2.40 | | 241.00 | 59.10 | 7.97 | 0.30 | 143.00 |
| | 20 | 23-Oct-17 | 111.00 | 1.10 | 3.30 | 7.60 | | 263.00 | 58.50 | 7.97 | 0.38 | 144.00 |
| | 40 | 23-Oct-17 | 114.00 | 1.00 | 4.10 | 2.00 | | 191.00 | 61.60 | 7.97 | 0.40 | 147.00 |
| | 60 | 23-Oct-17 | 115.00 | 1.10 | 2.50 | 3.00 | | 186.00 | 60.00 | 7.99 | 0.37 | 150.00 |
| | 80 | 23-Oct-17 | 116.00 | 1.60 | 3.90 | 2.50 | | 203.00 | 61.50 | 7.95 | 0.56 | 151.00 |
| | 2 | 21-Aug-17 | | | | | 2.75 | | | | | |

| Site | Depth | Date | NN | SRP | TP | TDP | SRS | TN | Alkalinity | pH | Turbidity | Cond. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | | ug/L | ug/L | ug/L | ug/L | mgSi/L | ug/L | mgCaCO$_3$/L | | (NTU) | µS/cm |
| | 5 | 21-Aug-17 | | | | | 2.86 | | | | | |
| | 10 | 21-Aug-17 | | | | | 2.97 | | | | | |
| | 15 | 21-Aug-17 | | | | | 3.27 | | | | | |
| | 20 | 21-Aug-17 | | | | | 3.40 | | | | | |
| REV | 2 | 19-Apr-17 | 109.00 | 1.10 | 2.80 | 2.10 | | 157.00 | 67.30 | 8.11 | 0.52 | 163.00 |
| Upper | 5 | 19-Apr-17 | 108.00 | 1.40 | 2.60 | 2.20 | | 153.00 | 66.00 | 8.11 | 0.23 | 163.00 |
| | 10 | 19-Apr-17 | 108.00 | 1.10 | 2.60 | 2.00 | | 172.00 | 67.00 | 8.08 | 0.24 | 162.00 |
| | 15 | 19-Apr-17 | 109.00 | 1.30 | 2.00 | 2.90 | | 164.00 | 66.80 | 8.06 | 0.48 | 161.00 |
| | 20 | 19-Apr-17 | 108.00 | 1.50 | 2.70 | 2.40 | | 146.00 | 65.40 | 8.09 | 0.29 | 162.00 |
| | 40 | 19-Apr-17 | 112.00 | 1.40 | 2.30 | 6.90 | | 166.00 | 66.20 | 8.08 | 0.32 | 162.00 |
| | 2 | 23-May-17 | 235.00 | 1.30 | 15.90 | 3.00 | | 272.00 | 51.10 | 7.96 | 0.97 | 125.00 |
| | 5 | 23-May-17 | 219.00 | 1.50 | 3.50 | 2.00 | | 308.00 | 53.00 | 8.00 | 1.08 | 133.00 |
| | 10 | 23-May-17 | 219.00 | 1.50 | 5.60 | 3.10 | | 270.00 | 53.40 | 8.03 | 1.06 | 133.00 |
| | 15 | 23-May-17 | 224.00 | 1.00 | 3.60 | 2.00 | | 290.00 | 53.30 | 8.01 | 1.48 | 133.00 |
| | 20 | 23-May-17 | 222.00 | 2.00 | 5.80 | 2.00 | | 287.00 | 55.60 | 7.99 | 1.19 | 133.00 |
| | 35 | 23-May-17 | 214.00 | 1.30 | 3.90 | 2.80 | | 214.00 | 54.40 | 8.00 | 1.18 | 137.00 |
| | 2 | 12-Jun-17 | 193.00 | 1.90 | 4.20 | 2.40 | | 256.00 | 34.00 | 7.81 | 1.64 | 88.70 |
| | 5 | 12-Jun-17 | 199.00 | 2.80 | 6.10 | 2.20 | | 257.00 | 31.00 | 7.77 | 2.58 | 83.90 |
| | 10 | 12-Jun-17 | 197.00 | 3.70 | 5.80 | 3.20 | | 254.00 | 30.20 | 7.75 | 2.81 | 81.00 |
| | 15 | 12-Jun-17 | 200.00 | 3.20 | 7.40 | 4.00 | | 266.00 | 29.90 | 7.76 | 2.71 | 81.50 |
| | 20 | 12-Jun-17 | 208.00 | 1.30 | 5.30 | 3.10 | | 261.00 | 37.40 | 7.82 | 2.33 | 94.40 |
| | 35 | 12-Jun-17 | 217.00 | 1.60 | 5.00 | 4.10 | | 240.00 | 37.50 | 7.83 | 1.74 | 99.50 |
| | 2 | 17-Jul-17 | 94.90 | 2.00 | 3.50 | 3.30 | | 140.00 | 43.50 | 7.93 | 0.93 | 112.00 |
| | 5 | 17-Jul-17 | 99.50 | 1.10 | 2.00 | 2.40 | | 142.00 | 46.50 | 7.93 | 0.92 | 116.00 |
| | 10 | 17-Jul-17 | 108.00 | 2.00 | 2.00 | 2.00 | | 149.00 | 53.00 | 7.97 | 0.71 | 126.00 |
| | 15 | 17-Jul-17 | 112.00 | 1.70 | 2.90 | 3.10 | | 148.00 | 54.70 | 7.97 | 0.69 | 130.00 |
| | 20 | 17-Jul-17 | 118.00 | 1.00 | 3.80 | 2.00 | | 167.00 | 55.80 | 8.03 | 0.62 | 136.00 |
| | 40 | 17-Jul-17 | 120.00 | 1.10 | 4.10 | 2.20 | | 185.00 | 56.70 | 8.02 | 0.63 | 141.00 |
| | 2 | 21-Aug-17 | 103.00 | 1.40 | 3.10 | 2.00 | | 164.00 | 54.00 | 7.92 | 1.35 | 132.00 |
| | 5 | 21-Aug-17 | 113.00 | 1.80 | 3.00 | 2.00 | | 187.00 | 55.70 | 8.00 | 1.54 | 139.00 |
| | 10 | 21-Aug-17 | 120.00 | 1.10 | 2.80 | 2.70 | | 172.00 | 58.50 | 8.02 | 1.52 | 143.00 |
| | 15 | 21-Aug-17 | 128.00 | 1.40 | 3.00 | 2.00 | | 262.00 | 59.20 | 8.03 | 1.38 | 149.00 |
| | 20 | 21-Aug-17 | 130.00 | 2.30 | 3.00 | 2.10 | | 184.00 | 62.30 | 8.04 | 1.24 | 151.00 |
| | 35 | 21-Aug-17 | 132.00 | 1.00 | 4.50 | 2.60 | | 181.00 | 61.30 | 8.04 | 1.24 | 151.00 |
| | 2 | 18-Sep-17 | | | 3.20 | 2.00 | | 159.00 | | | | |
| | 5 | 18-Sep-17 | 123.00 | 1.60 | 2.50 | 3.00 | | 158.00 | 64.10 | 7.99 | 0.86 | 155.00 |
| | 10 | 18-Sep-17 | 125.00 | 1.70 | 3.30 | 2.80 | | 177.00 | 64.20 | 8.05 | 0.80 | 154.00 |
| | 15 | 18-Sep-17 | 124.00 | 2.50 | 3.90 | 3.20 | | 162.00 | 65.40 | 8.05 | 0.91 | 154.00 |
| | 20 | 18-Sep-17 | 124.00 | 3.10 | 4.20 | 4.20 | | 146.00 | 66.20 | 8.07 | 0.83 | 154.00 |
| | 35 | 18-Sep-17 | 124.00 | 1.50 | 5.60 | 2.00 | | 155.00 | 64.70 | 8.06 | 0.95 | 155.00 |
| | 2 | 23-Oct-17 | 110.00 | 1.50 | 4.60 | 4.00 | | 212.00 | 60.60 | 8.00 | 0.43 | 149.00 |
| | 5 | 23-Oct-17 | 112.00 | 1.50 | 2.40 | 3.30 | | 202.00 | 61.70 | 7.98 | 0.47 | 148.00 |
| | 10 | 23-Oct-17 | 110.00 | 1.90 | 2.40 | 2.50 | | 202.00 | 62.10 | 7.99 | 0.38 | 147.00 |
| | 15 | 23-Oct-17 | 113.00 | 1.50 | 2.80 | 2.50 | | 207.00 | 60.50 | 7.98 | 0.43 | 148.00 |
| | 20 | 23-Oct-17 | 111.00 | 1.30 | 2.80 | 3.60 | | 178.00 | 60.70 | 7.99 | 0.39 | 148.00 |
| | 35 | 23-Oct-17 | 110.00 | 1.00 | 4.00 | 2.30 | | 202.00 | 61.90 | 7.95 | 0.43 | 147.00 |
| | 2 | 21-Aug-17 | | | | | 3.21 | | | | | |
| | 5 | 21-Aug-17 | | | | | 3.45 | | | | | |
| | 10 | 21-Aug-17 | | | | | 3.42 | | | | | |
| | 15 | 21-Aug-17 | | | | | 3.38 | | | | | |
| | 20 | 21-Aug-17 | | | | | 3.35 | | | | | |

# *Appendix 5*

## *Primary Productivity*
## *Kinbasket and Revelstoke Reservoirs, 2017*

*Jennifer Sarchuk*
*Ministry of Environment and Climate Change*

# PRIMARY PRODUCTIVITY IN KINBASKET AND REVELSTOKE RESERVOIRS, 2017-2018

Jennifer Sarchuk
Ministry of Environment & Climate Change Strategy (ENV)

2019

**Acknowledgements**

Our thanks are extended to our boat operators for 2017 and 2018 – Ed Marriot and Cyrille Marcil and to Beth Manson of Manson Environmental for assistance with the delivery of the field component of this project. Many thanks to Heather Vainionpaa (BCCF-2017 and ENV – 2018) for assisting with the processing of the primary productivity and chlorophyll samples. Funding was provided by the Columbia River Water Use Plan-Kinbasket Reservoir Fish and Wildlife Information Plan – Monitoring Program – study number: CLBMON-3, Kinbasket and Revelstoke Reservoirs Ecological Productivity Monitoring Program to MOE by a contribution agreement (#0046004).

## Introduction

In order to determine trophic status of a lake or reservoir there are a number of criteria that can be used such as chemical characteristics (Total Phosphorus, Total Nitrogen, Total Dissolved Solid, etc.) or dominance of particular biological organisms from bacteria to fish. However, it is generally acknowledged that the best methodology for determination of trophic status is using a parameter that can quantitatively determine rate of growth and one that integrates a variety of environmental parameters (Wetzel 2001). Currently the best existing parameter available is measurement of rates of primary productivity.

In aquatic ecosystems, a vast diversity of phytoplankton species are concurrently observed in a waterbody ranging from small coccoidal cyanobacteria such as *Synechococcus* sp. to large chain-forming diatoms such as *Tabularia* sp. Aquatic ecosystems dominated by small cells generally support longer food chains compared to the shorter chains supported by larger-sized phytoplankton. The relative contribution of each species will directly impact the functioning of the food web and the study of the phytoplankton community provides insight into the ecosystem dynamics of the reservoir.

Our studies examined the size structure of the phytoplankton community in terms of chlorophyll and primary productivity, particularly the relative contribution of three commonly studied fractions; the picoplankton (0.2-2 μm), nanoplankton (2.0-20 μm) and microplankton (>20 μm). This report summarizes the primary productivity studies carried out on Kinbasket and Revelstoke Reservoirs in 2017 and 2018.

## Methods

### Field & Laboratory

The field sampling strategy and laboratory methodology were consistent with previous study years and can be found in Harris (2012). Appendix A provides field and incubation information for the study period. Values for primary productivity for all study years are provided in Appendix B.

## Results

Photosynthetically active radiation (PAR), defined as the radiation in the 400-700 nm waveband, varied from month to month and site to site during the 2017 and 2018 sampling season. For 2017, the month of peak PAR varied amongst the stations. In Kinbasket PAR peaked in July, whereas at Revelstoke Middle PAR was low throughout the sampling season but the peak occurred in September, while at Revelstoke Forebay PAR was highest in August (Figure 1). For 2018, in Kinbasket PAR was the generally high throughout the sampling season (> 1000 umol/m$^2$/s) and the peak was measured in July and in June at both Revelstoke Middle and Revelstoke Forebay (Figure 1). In 2017 the low PAR of less than < 500 μmol/m$^2$/s,at Revelstoke Middle throughout the sampling season was not optimal for production as solar radiation is the major energy source driving productivity. The field crew noted the prevalence of cloud cover throughout the 2017 sampling season at Revelstoke Middle therefore confirming the low light measurements in Figure 1. as (Appendix A)

The 1% depth was generally lower in Kinbasket compared to Revelstoke Middle and Revelstoke Forebay (Figure 1). In 2017, the mean euphotic zone depth was deepest at Kinbasket Forebay (16.5 m), followed by Revelstoke Forebay (13.3 m) and Revelstoke Middle (11.3 m) (Appendix A and Figure 1). In 2018, the mean euphotic zone depth was deepest at Kinbasket Forebay (17.5 m), followed by Revelstoke Forebay (15 m) and Revelstoke Middle (12.8 m) (Appendix A and Figure 1). Between the sampling months, June to September, the euphotic zone stayed the same or lowered each month with the exceptions of Revelstoke Middle in September 2017 and August 2018, Revelstoke Forebay in September 2017 and 2018 where the euphotic zone raised.

Secchi disk depths were generally deeper in Kinbasket than in Revelstoke (Figure 2). In 2017, the mean Secchi disk depth in Kinbasket was 5.4 m followed by Revelstoke Forebay at 4.3 m and then Revelstoke Middle at 4.0 m. The mean Secchi disk depth were deeper at all stations in 2018 relative to 2017. Secchi disk depth in Kinbasket was deeper at 6.9 m followed by Revelstoke Forebay at 6.5 m and then Revelstoke Middle at 5.3 m. In general, shallow Secchi disk depths were measured at all stations in June and the Secchi disk depth increased as the season progressed reaching maximum depths in August with one exception at Kinbasket in 2018 when the maximum Secchi depth was, observed in September (Figure 2).

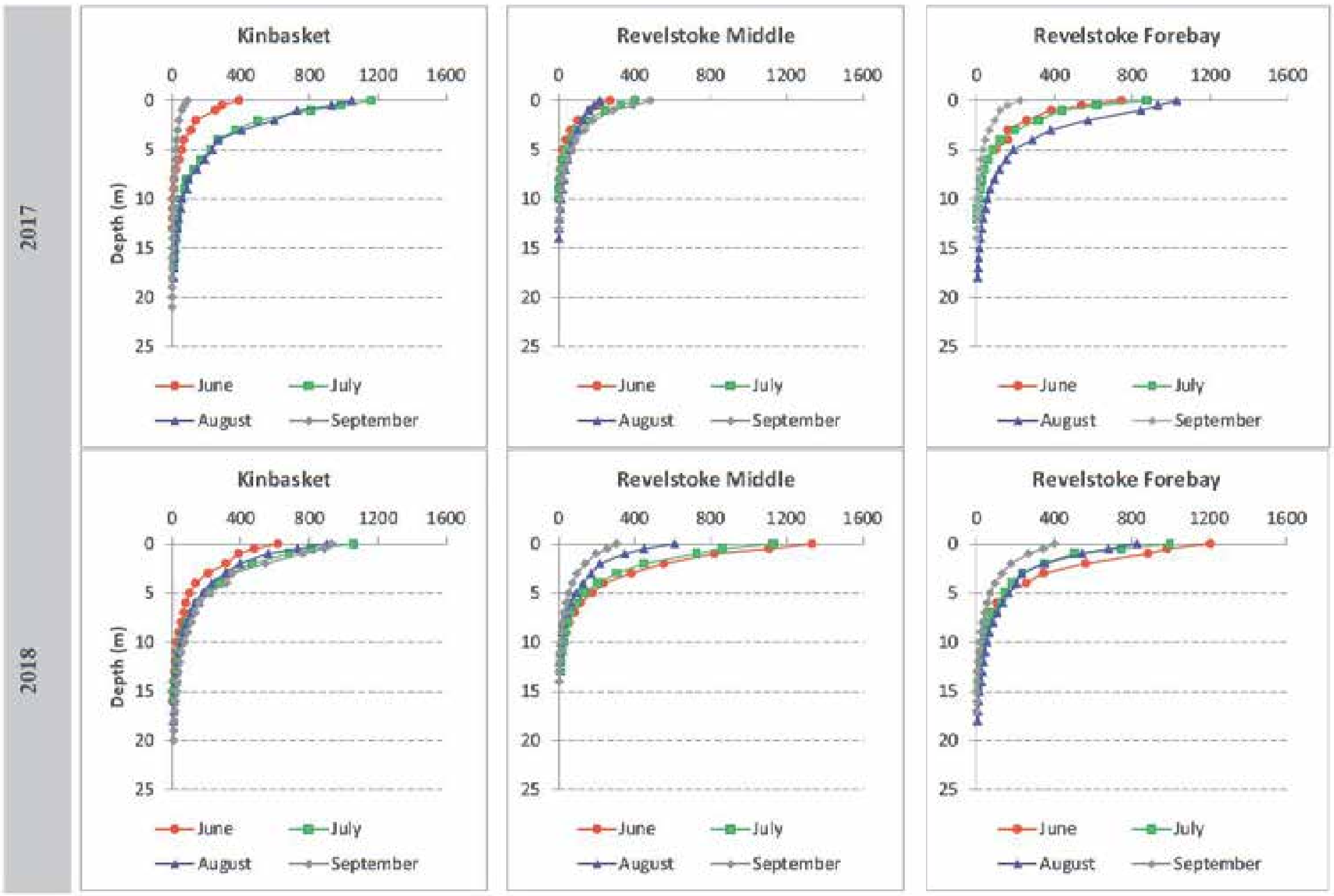



**Figure 1.** Photosynthetic active radiation (μmol/m$^2$/s) at Kinbasket Forebay, Revelstoke Middle and Revelstoke Forebay in 2017-2018. PAR measurements recorded to the depth of 1% of surface light.

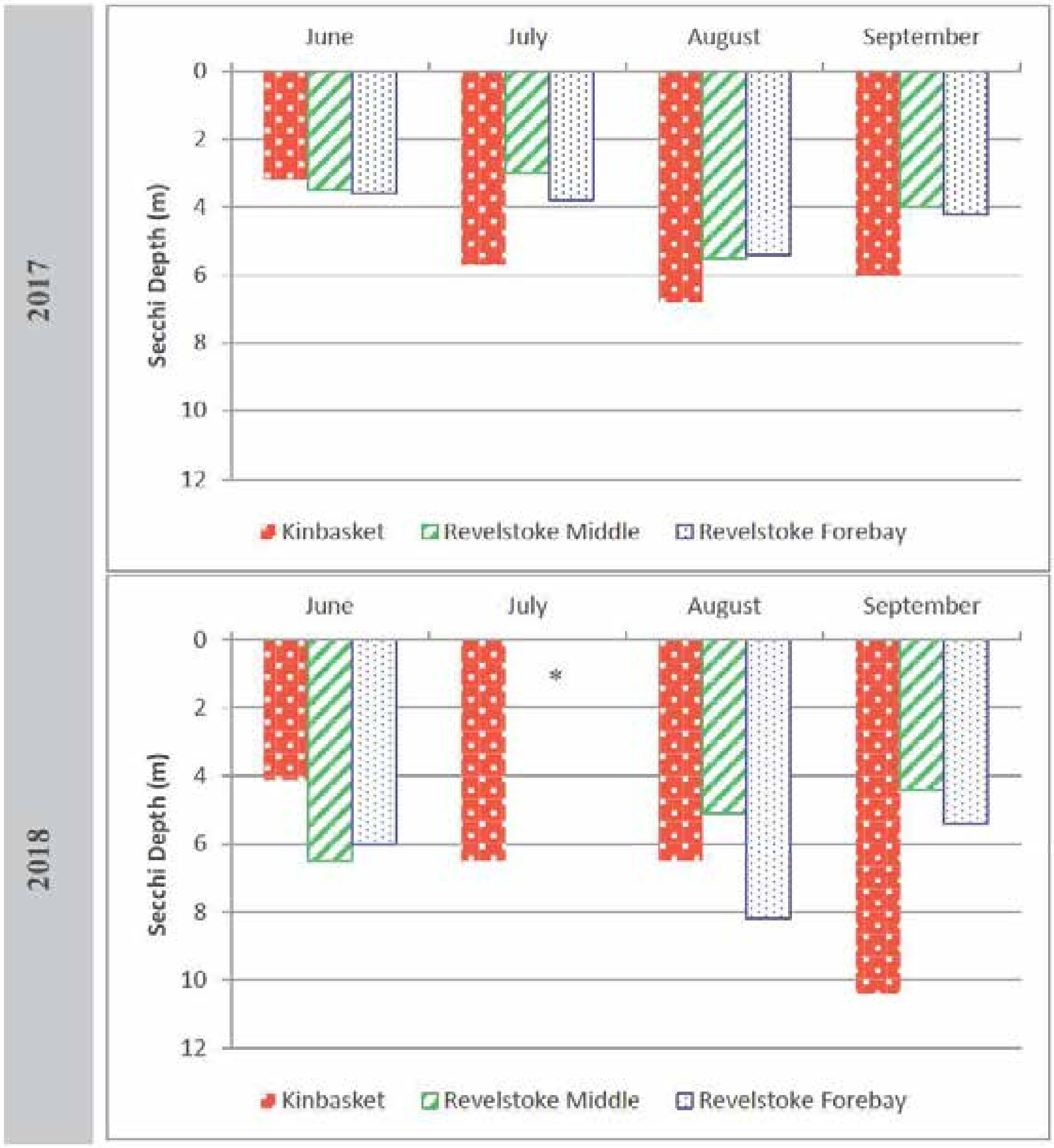



**Figure 2.** Secchi disk depths (m) in Kinbasket, Revelstoke Middle and Revelstoke Forebay in 2017-2018. *No secchi taken in July 2018 for Revelstoke Middle and Forebay.

The relative trends between stations in the attenuation coefficient, a measure of the transparency, have been consistent since 2009 (the first year attenuation coefficient was monitored) where the lowest mean attenuation coefficient was measured at Kinbasket Forebay at 0.27 $cm^{-1}$, (about 73% transmission $m^{-1}$) and the highest mean attenuation coefficient was measured at Revelstoke Middle at 0.37 $cm^{-1}$ (about 63% transmission $m^{-1}$). A high attenuation coefficient is indicative of low transparency/high turbidity and a low attenuation coefficient indicates high transparency/low turbidity. In 2017, the lowest attenuation coefficient was measured at Kinbasket Forebay at 0.25 $cm^{-1}$, (about 75% transmission $m^{-1}$) and the highest attenuation coefficient was measured at Revelstoke Middle at 0.48 $cm^{-1}$, (about 52% transmission $m^{-1}$). Overall, in August 2017 the attenuation coefficients were similar at all sites suggesting high transparency and low turbidity.

On average, the 2017 seasonal mean attenuation coefficient was 0.32 $cm^{-1}$ at Kinbasket Forebay, followed by 0.39 $cm^{-1}$ at Revelstoke Forebay and highest at Revelstoke Middle at 0.41 $cm^{-1}$ (Figure 3).. In 2018, the lowest attenuation coefficients was measured at Kinbasket Forebay at 0.26 $cm^{-1}$, (about 74% transmission $m^{-1}$) and the highest attenuation coefficient was measured at Revelstoke Middle at 0.41 $cm^{-1}$, (about 59% transmission $m^{-1}$). On average, the 2018 seasonal mean attenuation coefficient was 0.30 $cm^{-1}$ at Kinbasket Forebay, followed by 0.34 $cm^{-1}$ at Revelstoke Forebay and highest at Revelstoke Middle at 0.39 $cm^{-1}$ (Figure 3). Overall, 2018 attenuation coefficient were more similar between the sites (less variability).

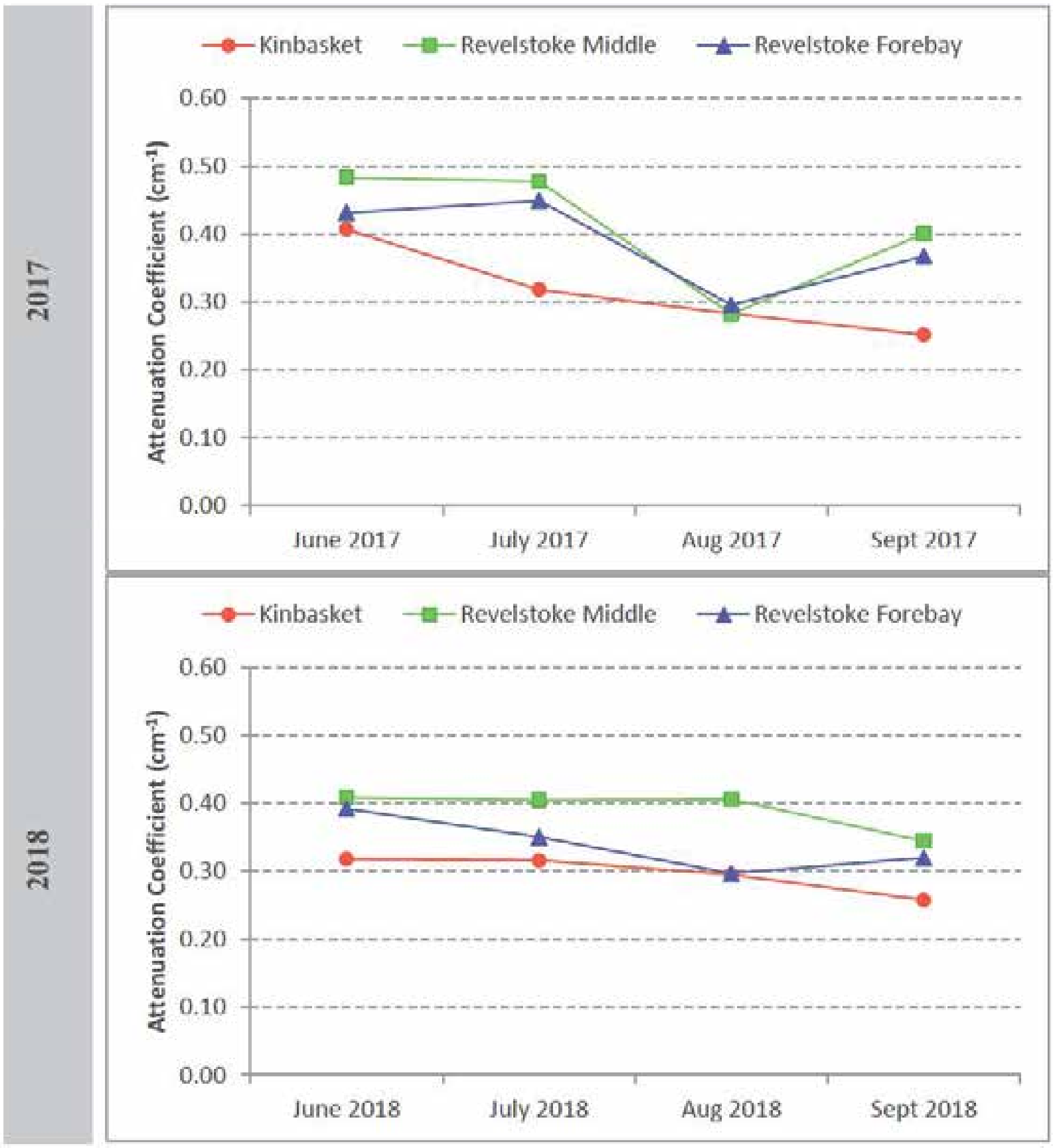



**Figure 3.** Attenuation coefficients for Kinbasket Forebay, Revelstoke Middle and Revelstoke Forebay in 2017-2018.

## Chlorophyll a

Chlorophyll a biomass in Kinbasket and Revelstoke reservoirs were low with results below 2.0 $mg/m^3$ (Figure 4), which is indicative of oligotrophic conditions (Wetzel 2001). In 2017, the discrete seasonal averages were 1.21 $mg/m^3$ in Kinbasket, 1.27 $mg/m^3$ in Revelstoke Middle and 1.13 $mg/m^3$ in Revelstoke Forebay. In most months very little heterogeneity throughout the water column was observed. In 2018, the discrete seasonal averages were 1.78 $mg/m^3$ in Kinbasket, 0.94 $mg/m^3$ in Revelstoke Middle and 0.84 $mg/m^3$ in Revelstoke Forebay. In most months very little heterogeneity throughout the water column was observed. As seen in previous study years (Harris 2012; 2013; 2015; 2017), the depth integrated biomass was higher in Kinbasket Forebay than in Revelstoke Middle or Revelstoke Forebay for most months with the exception of August 2017 where depth integrated biomass at Revelstoke Forebay was higher than Kinbasket (Figure 5). Biomass in Kinbasket Forebay generally exceeded 20 $mg/m^2$ (except June 2017 and August 2017) whereas at Revelstoke biomass was generally below 20 $mg/m^2$ and often around 10 $mg/m^2$ (except July 2017 at Rev-Mid and August 2017 Rev-FB)(Figure 5). The seasonal cycles at the three stations differed from 2017 to 2018. In 2017, the seasonal low were observed in September for Revelstoke Middle and Revelstoke Forebay whereas seasonal low were observed in Kinbasket in August. In 2018, the seasonal low were observed in September for Revelstoke Forebay and Kinbasket whereas seasonal low were observed in June for Revelstoke Middle. This may suggests different factors are controlling biomass values at the three sites. In 2017, the depth integrated seasonal averages were 22.6 $mg/m^2$ in Kinbasket, 16.5 $mg/m^2$ in Revelstoke Middle, and 15.5 $mg/m^2$ in Revelstoke Forebay (Table 2; Figure 5). In 2018, the depth integrated chlorophyll a seasonal averages were 30.8 $mg/m^2$ in Kinbasket, 10.7 $mg/m^2$ in Revelstoke Middle, and 11.5 $mg/m^2$ in Revelstoke Forebay (Table 2; Figure 5). Both Revelstoke Middle and Revelstoke Forebay in 2018 showed lack of seasonal variability with low chlorophyll a values and static.

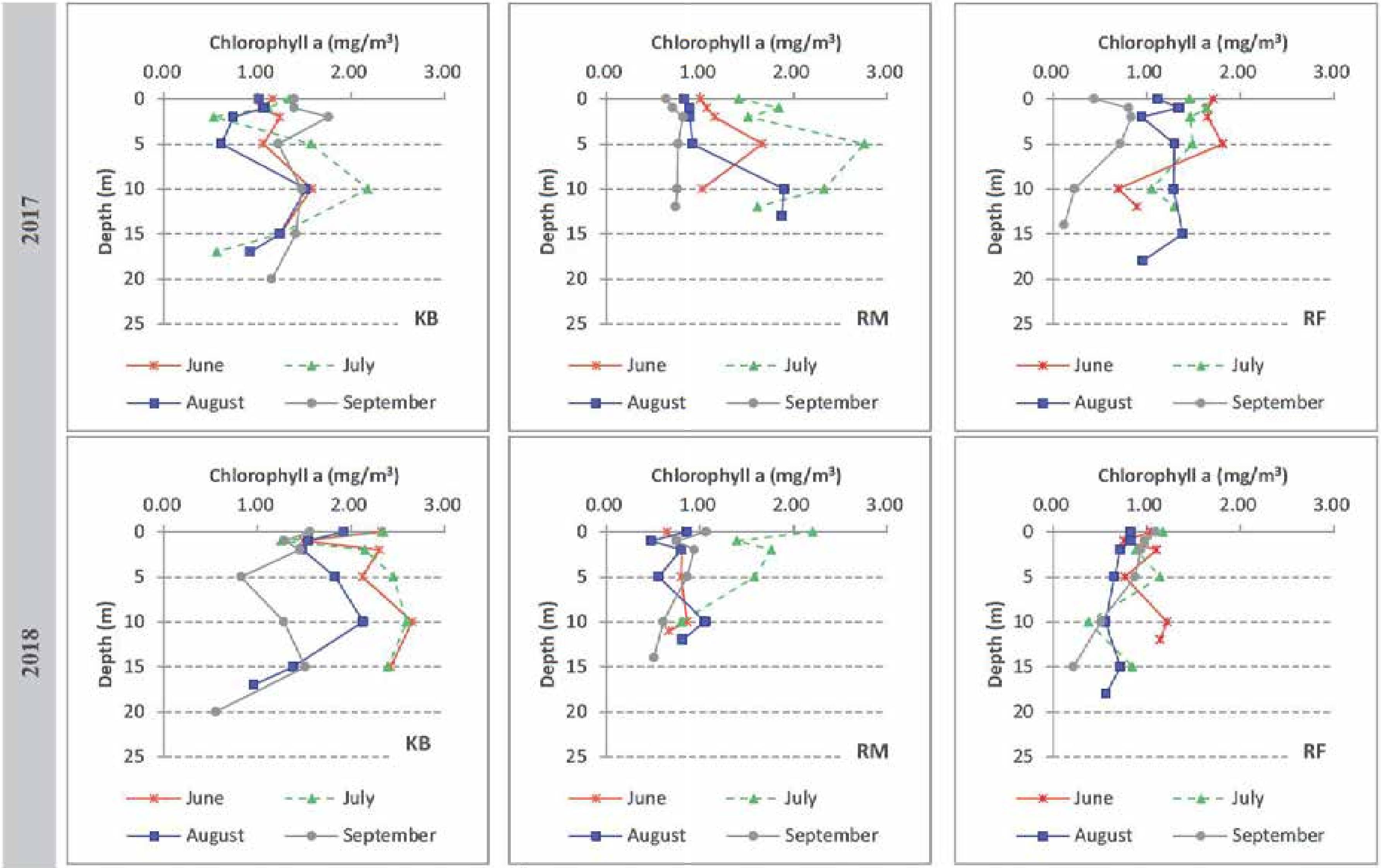



**Figure 4.** Vertical profiles of chlorophyll *a* (mg/m$^3$) for Kinbasket Forebay (KB), Revelstoke Middle (RM) and Revelstoke Forebay (RF) in 2017-2018.

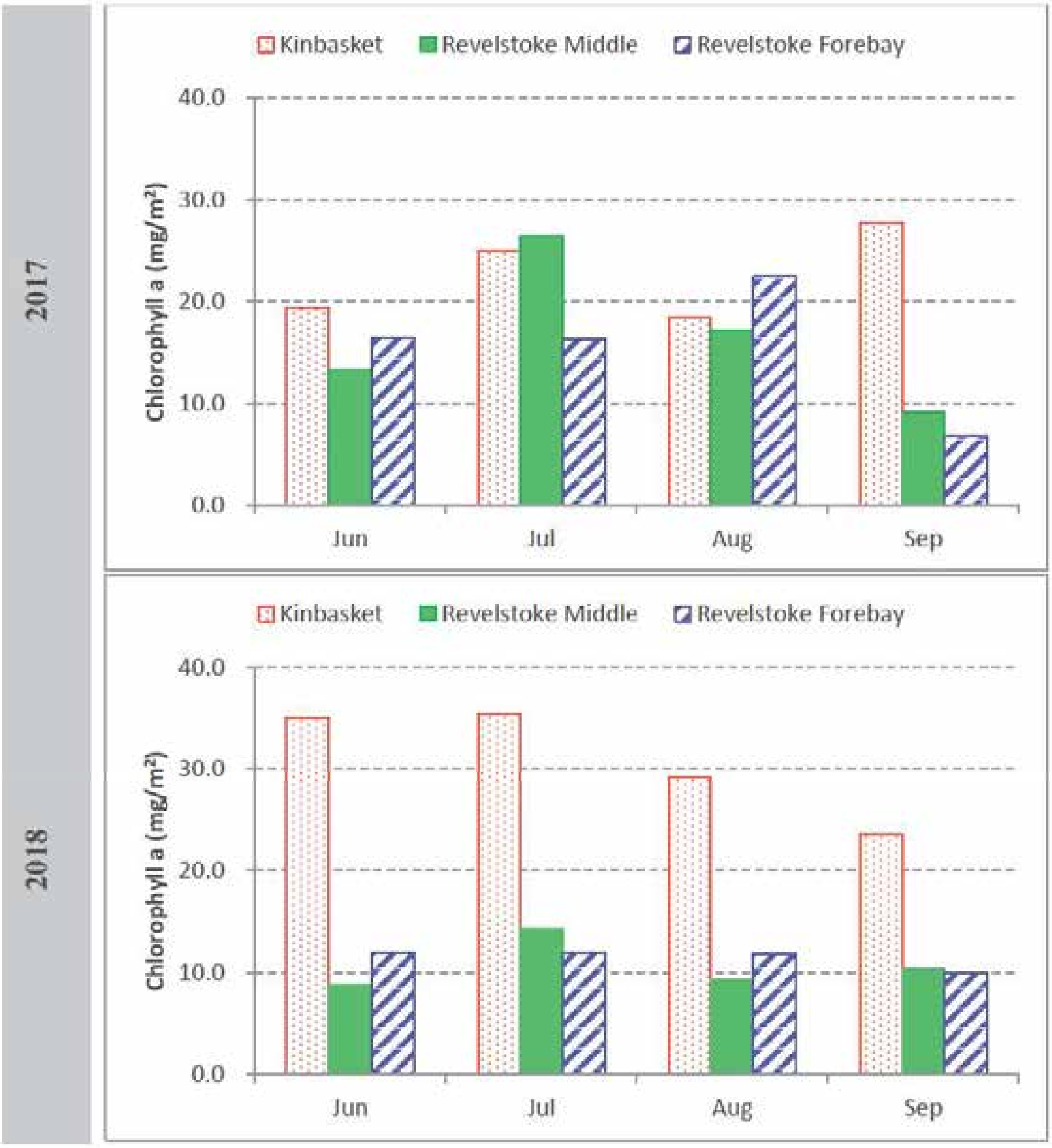



**Figure 5**. Integrated chlorophyll *a* (mg Chl $a/m^2$) in Kinbasket and Revelstoke in 2017-2018.

The size structure of the phytoplankton community plays an important role in food web structure and dynamics and provides some insight into the community structure and functional relationships in the ecosystem. On average, on Kinbasket Reservoir, in 2017 and 2018, picoplankton sized cells (0.2-2 μm) accounted for 52% of the total phytoplankton biomass followed closely by nanoplankton sized cells (2.0-20 μm) at 40% whereas the large sized microplankton (>20 μm) accounted for only 8% (Figure 6). On average, on Revelstoke Reservoir, in 2017 and 2018, picoplankton sized cells accounted for 53% of the total phytoplankton biomass followed closely by nanoplankton sized cells at 37% whereas the large sized microplankton accounted for only 9% (Figure 6). Picoplankton and nanoplankton sized cells (cells >20 μm) accounted for 91% of the biomass in Kinbasket and Revelstoke in 2017 and 2018. The relative contribution of the picoplankton, nanoplankton and microplankton varied in 2017 and 2018 (Figure 6). For instance in 2017, at Kinbasket Forebay and Revelstoke Middle picoplankton biomass was highest in June at 60% and 63% of the total biomass and the lowest in August and July at 49% and 31%, respectively. Compared to Revelstoke Forebay where picoplankton biomass was highest in August at 60% and 56% and lowest in July and September at 40%. In 2018, Kinbasket and Revelstoke Middle picoplankton accounted for 65% of biomass in June,compared to at Revelstoke Forebay picoplankton biomass was highest in September at 61%. The relatively high contribution of nanoplankton to the food web should support the growth of large sized zooplankton. The high proportion of picoplankton, owing to their small size, suggests relative scarcity of available nutrients and also suggests the importance of the microbial food web in Kinbasket and Revelstoke (Stockner and Porter 1988). In 2017, Revelstoke Middle and Revelstoke Forebay microplankton biomass was the highest in July with 32% and 24%, respectively (Figure 6). In 2018, Kinbasket microplankton biomass was highest in July with 20% (Figure 6). Typically, microplankton generally accounted for fewer than 15% of the community, again suggesting nutrient limitation, specifically limitation of nitrate (Dugdale and Wilkerson 1998).

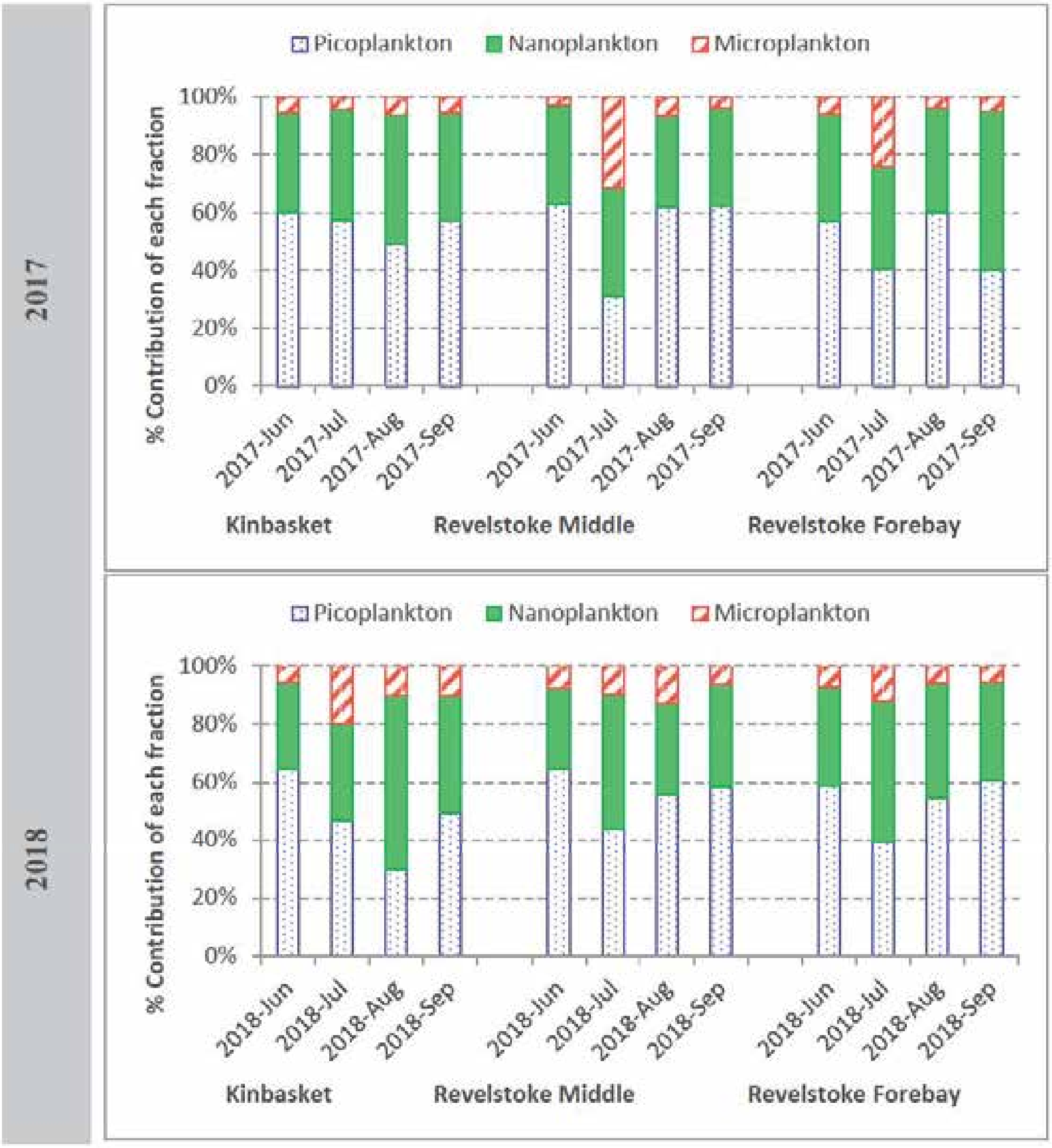
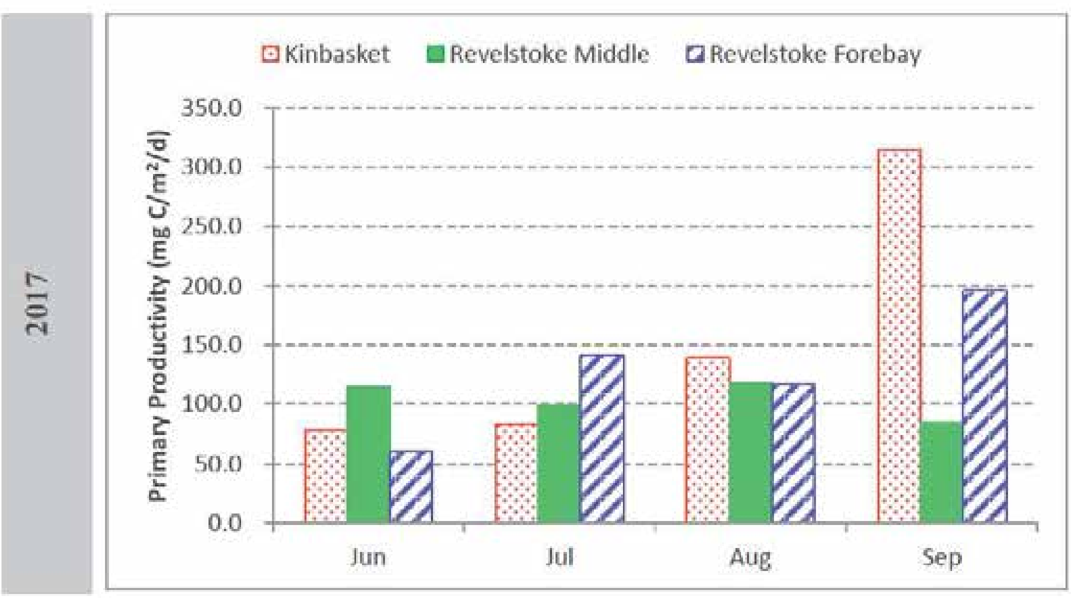



**Figure 6.** Relative contribution of picoplankton (0.2-2 µm), nanoplankton (2.0-20 µm) and microplankton (>20 µm) to chlorophyll in Kinbasket and Revelstoke in 2017-2018.

**Primary Productivity**

In 2017, total primary production of all algal size fractions, measured as the radioactive carbon retained on the 0.2 µm filter was 153 mg $C/m^2/d$ at Kinbasket Forebay and 129 mg $C/m^2/d$ at Revelstoke Forebay followed by Revelstoke Middle at 104 mg $C/m^2/d$ (Figure 7; Table 2). This general pattern of higher productivity on Kinbasket than Revelstoke and higher productivity at Revelstoke Forebay than at Revelstoke Middle has been observed in previous years (2008-2016). Productivity on Kinbasket Reservoir was generally less than 200 mg $C/m^2/d$ while on Revelstoke productivity rarely exceeded130 mg $C/m^2/d$. High rates of production were measured on Kinbasket on two occasions, once in September 2017 and again in June 2018 while Revelstoke Forebay exceeded 130 mg $C/m^2/d$ in September 2017. The monthly primary productivity was generally higher in Kinbasket than in Revelstoke, except on three occasions June 2017, July 2017, and September 2018 where primary productivity was higher at both Revelstoke Forebay and Revelstoke Middle (with the exception of June 2017 were only higher at Revelstoke Middle). In 2018, Kinbasket seasonal average of primary productivity was higher than in 2017 at 169 mg $C/m^2/d$ while at Revelstoke Forebay and Revelstoke Middle productivity lower at 95 mg $C/m^2/d$ at Revelstoke Forebay 101 mg $C/m^2/d$ respectively (Figure 7; Table 2). As expected, primary productivity varied seasonally in 2017 and 2018. In 2017, Kinbasket and Revelstoke Forebay were the highest in September whereas Revelstoke Middle was the highest in August. In 2018, Kinbasket was the highest in June, Revelstoke Forebay was the highest in August and Revelstoke Middle was the highest in September. Production rates in Kinbasket and Revelstoke Reservoirs are within Wetzel's oligotrophic trophic type (50-300 mg $C/m^2/d$) (Wetzel 2001).

This pattern of the highest production at Kinbasket Forebay and the lowest production at Revelstoke Middle was also observed in earlier years (Harris 2012; 2013; 2015; 2017). Throughout the study period, Kinbasket Forebay has consistently had the highest water transparency as reflected by low attenuation factors whereas Revelstoke had the least transparent water, suggesting that physical factors likely play an important role in the regulation of primary productivity in Kinbasket and Revelstoke reservoirs.



2018

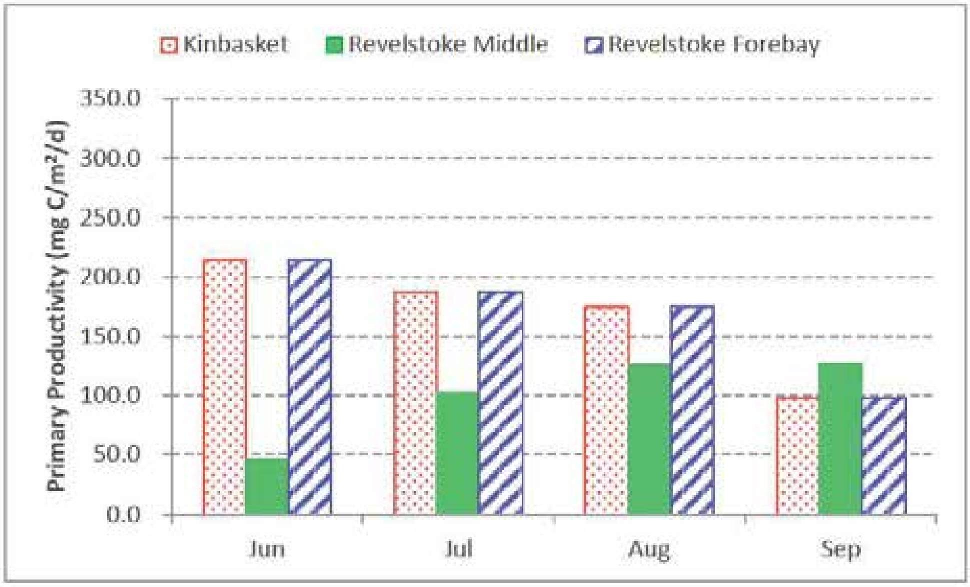



**Figure 7.** Primary productivity (mg C/m$^2$/d) in Kinbasket Forebay, Revelstoke Middle and Revelstoke Forebay in 2017-2018.

As was observed in early years, production in Kinbasket and Revelstoke in 2017 and 2018 was dominated by phytoplankton less than 20.0 μm in size. In 2017, picoplankton and nanoplankton, accounted for 92% of total production in Kinbasket and 88% of the total production in Revelstoke (Figure 8) and in 2018, a small reduction in picoplankton and nanoplankton production was measured (~5%) to 86% in Kinbasket and 83% of the total production in Revelstoke (Figure 8). This reduction was largely due to lower picoplankton and nanoplankton production in July 2018, bringing the averages down from previous years. Microplankton was the least productive fraction, accounting for on average at 9% and 13% in 2017 and at 15% and 17% in 2018 of total production for Kinbasket and Revelstoke, respectively (Figure 8). Microplankton was slightly higher in Revelstoke then Kinbasket.

In 2017, in all three locations, Kinbasket,Forebay, Revelstoke Middle and Revelstoke Forebay, nanoplankton was the most productive fraction followed closely by picoplankton and then microplankton (Figure 8). For Kinbasket, nancplankton production accounted for 50% of the total production, followed by picoplankton at 41% and microplankton at 9%. Both Revelstoke Forebay and Revelstoke Middle nanoplankton production accounted for 49% of the total production, followed by picoplankton at 42% and 36% respectively and microplankton at 10% and 15%, respectively. In 2018 forKinbasket, a shift to smaller sized picoplankton was observed where picoplankton production accounted for 46% of the total production, followed by nanoplankton at 39% and microplankton at 15% and for Revelstoke Forebay, picoplankton production accounted for 42% of the total production, followed closely by nanoplankton at 41% and microplankton at 17%. At Revelstoke Middle, nanoplankton was the most productive fraction at 45% followed closely by picoplankton at 38% and then microplankton at 17% (Figure 8). As expected the relative importance of the three size fractions varied seasonally in both Kinbasket and Revelstoke (Figure 8). Microplankton production was generally highest in July in both reservoirs.

From 2009-2011 the relative importance of picoplankton production was increasing (Harris 2013) along with a decrease in the relative importance of the larger fractions, nanoplankton and microplankton (Figure 9). This suggested the reservoir was still in a state of decreasing productivity or oligotrophication. In 2012 this trend was reversed where the relative contribution of production accounted for by phytoplankton cells less than 20.0 µm increased. From 2013 to 2017 a shift to higher nanoplankton production was measured but in 2018, a shift back to high picoplankton production was measured in both Kinbasket and Revelstoke Forebay (Figure 9).

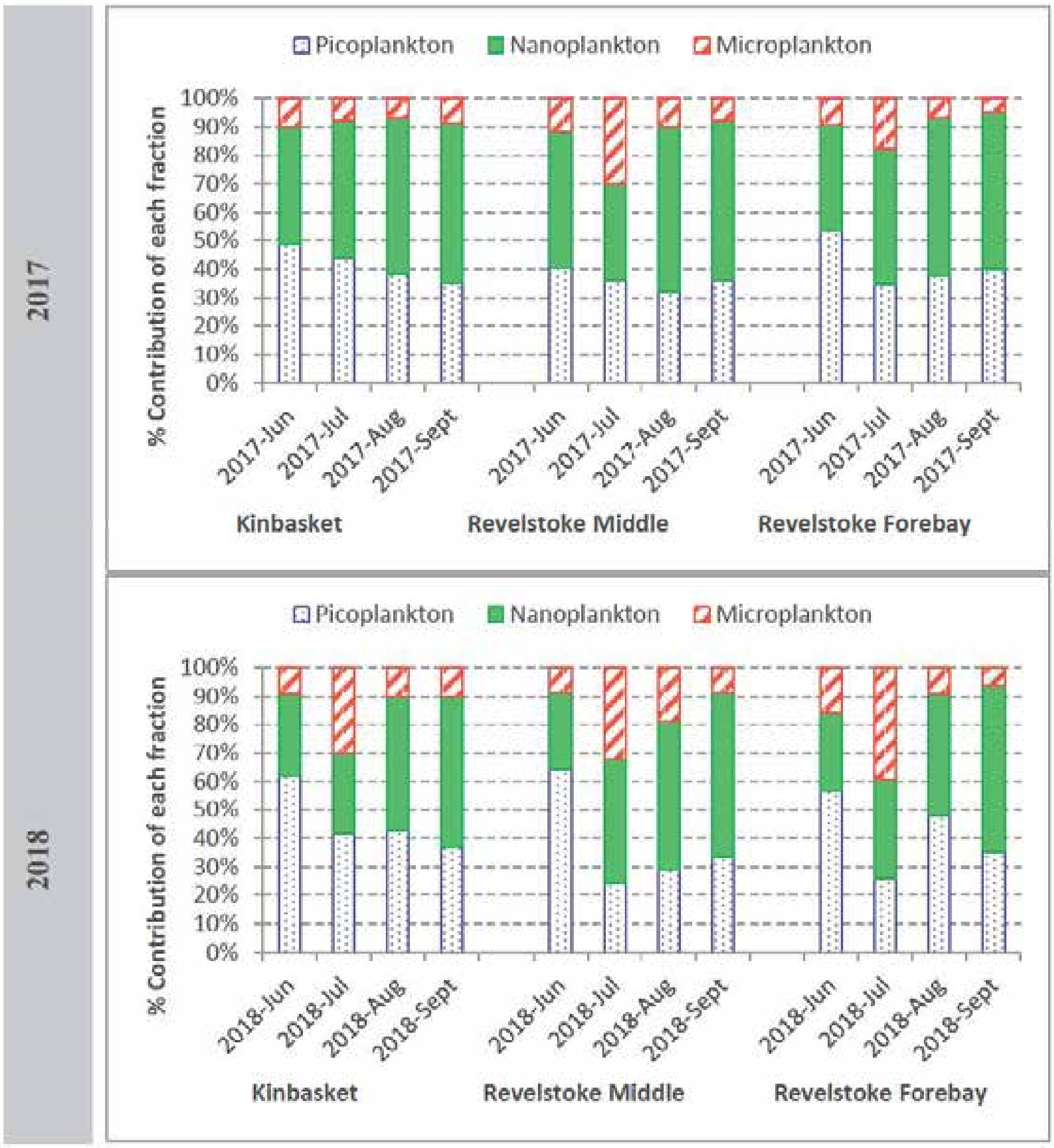



**Figure 8.** Relative contribution of picoplankton (0.2-2 µm), nanoplankton (2-20 µm), and microplankton (>20 µm) to primary productivity in Kinbasket and Revelstoke in 2017-2018.

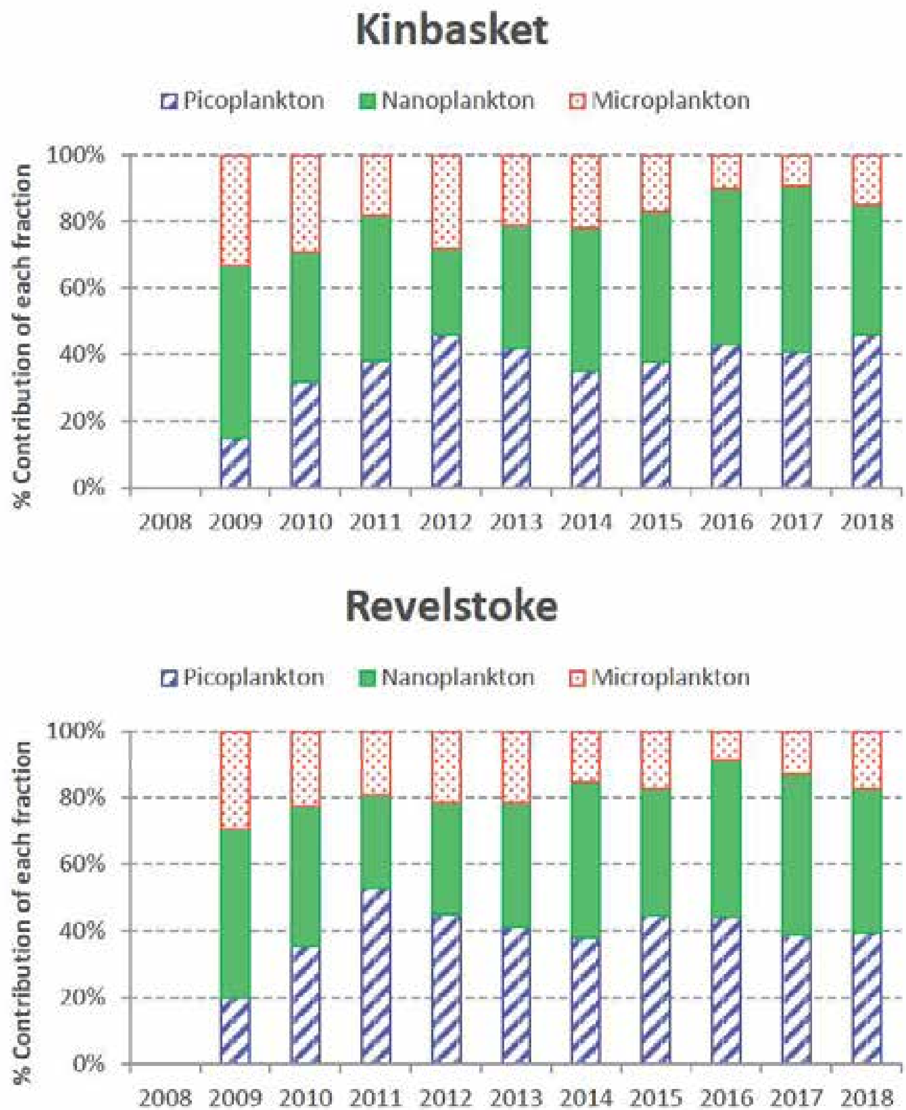



**Figure 9.** Mean annual size structure of primary productivity in Kinbasket and Revelstoke in 2008-2018. Note: 2008 was not completed using the same methods thus are not included in this table. Additionally, monthly means for Kinbasket and Revelstoke were averaged.

## Discussion

The food web in aquatic ecosystems is influenced by a number of complex factors including lake geomorphology, climatology based on location and a diverse range of physical and chemical parameters such as light, temperature, flow and nutrients. In addition, human interactions have influenced the functional relationships and productivity of aquatic ecosystems. It is important to characterize the current state of the aquatic ecosystem in order to gain an understanding of how the ecosystem dynamics are controlled and how the aquatic ecosystem responds to these diverse factors including hydroelectric reservoir operations. This increased understanding of the functional dynamics of the reservoir will advance our knowledge which in turn will allow water managers to predict ecosystem responses to future operational changes. This report summarizes data collected on the base of the food chain, the phytoplankton community, which is just one component of the much larger monitoring program that encompasses physical flow dynamics and chemical dynamics. Ultimately, the integration of the findings from each component of the monitoring program will lead to a comprehensive understanding of the limnology of Kinbasket and Revelstoke reservoirs.

Primary productivity sets the upper threshold for productivity for upper trophic levels. Although the 2017 and 2018 results show slightly higher phytoplankton biomass and primary productivity rates they still confirm earlier findings of low phytoplankton biomass of ~20-30 mg/m$^2$ in Kinbasket and ~10-15 mg/m$^2$ in Revelstoke and low rates of primary productivity of ~150 mg C/m$^2$/d in Kinbasket and near 100 mg C/m$^2$/d in Revelstoke. Both parameters in this study (chlorophyll and primary productivity) fall within the general ranges of the oligotrophic category as defined by Wetzel (2001).

In the last two years (2017 and 2018), wildfires have been becoming more and more frequent in BC. In 2017, it was hazy during the July and August sampling at the KIN-FB and smoky in July at REV-FB (Photograph 1). In 2018, it was hazy at REV-FB (Photograph 2) and KIN-FB (Photograph 3) where as it was smoky at REV-MID (Photograph 4) in August. The potential effects of the wildfires and smoke on light and primary productivity will be investigated further in the 2019 report.

**Photograph 1:** Smoke at REV-FB, July 19, 2017

**Photograph 2:** Smoke at REV-FB, August 21, 2018

**Photograph 3:** Smoke at KIN-FB, August 22, 2018

**Photograph 4:** Smoke at REV-MID, August 23, 2018

The percentage of energy transferred from one trophic level to the next is extremely low, between 5-15%, so the number of trophic levels in a food chain is an important determinant of productivity of upper trophic levels (Wetzel 2001). The size structure of the phytoplankton community can provide some insight into the structure of the food web. Nanoplankton (2.0-20.0 µm) are effectively consumed by many zooplankton species, which is important for the efficient transfer of organic matter up the food chain. The high contribution of nanoplankton suggests a strong linkage from this trophic level to the microzooplankton trophic level. While nanoplankton biomass and production are high in both Kinbasket and Revelstoke and often dominate the phytoplankton community, the strong prevalence of picoplankton-sized cells suggests that the microbial food web is also important in both Kinbasket and Revelstoke reservoirs. The microbial food web, or microbial loop, likely has an important function in providing a pathway for small cells to be incorporated into the food web, and plays an equally important role in efficient nutrient recycling (Stockner and Porter 1988).

The size structure also provides some clues as to the nutrient dynamics of Kinbasket and Revelstoke reservoirs. Small cells often dominate in oligotrophic waters as their large surface area to volume ratio supports efficient uptake and subsequently high growth rates. On the other hand, large cells often dominate in nutrient-rich eutrophic conditions due to the larger uptake kinetics and the large storage vacuoles of large microplankton sized cells. The prevalence of small cells and the low contribution of large cells in Kinbasket and Revelstoke suggests that nutrient availability is low and that the microbial loop likely plays an important role in nutrient recycling in these large oligotrophic reservoirs.

This study confirms the low productivity status of Kinbasket and Revelstoke reservoirs and provides a clearer understanding of the size structure of the phytoplankton communities which will aid in our understanding of trophic web dynamics and the sustainability of the fish communities.

**Table 2.** Depth integrated chlorophyll *a* and daily primary productivity for Kinbasket and Revelstoke reservoirs in BC in 2017-2018.

| Site | Study Year | Chlorophyll *a* ($mg\ m^{-2}$) | Primary Productivity ($mg\ C\ m^{-2}\ d^{-1}$) |
|---|---|---|---|
| Kinbasket Forebay | 2017 | 22.6 | 153 |
| Revelstoke Middle | 2017 | 16.5 | 104 |
| Revelstoke Forebay | 2017 | 15.5 | 129 |
| Kinbasket Forebay | 2018 | 30.6 | 169 |
| Revelstoke Middle | 2018 | 10.7 | 101 |
| Revelstoke Forebay | 2018 | 11.5 | 95 |

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## Appendix A Field Observations

**Appendix A** Field observations and incubation information for the 2017 and 2018 primary productivity study. Stations are: KB = Kinbasket-Forebay, RM = Revelstoke-Middle (also called Downie), RF = Revelstoke-Forebay.

| Date | Stn | Weather | Inc. Start | Inc. End | Total Inc Time (hr.min) |
|---|---|---|---|---|---|
| 20-Jun-17 | KB | Overcast; wind BF=2; CC=95-85% | 8:54 | 12:58 | 4.04 |
| 19-Jul-17 | KB | Sunny w/ scattered clouds + smoke; wind BF=0-3; CC=smoke but blue sky above | 8:52 | 12:57 | 4.05 |
| 23-Aug-17 | KB | Sunny w/ scattered clouds, slight haze; wind BF=2-1; CC=10% | 8:29 | 12:32 | 4.03 |
| 20-Sep-17 | KB | Overcast + light rain; wind BF=3; CC=100% | 8:48 | 12:42 | 3.54 |
| 21-Jun-18 | KB | Overcast + light rain on and off; wind BF=1-2; CC=90% | 8:54 | 12:54 | 4.00 |
| 25-Jul-18 | KB | Sunny, whitecaps | 9:28 | 13:35 | 4.07 |
| 22-Aug-18 | KB | Smoky, sunny; wind BF=1-2; got smoky and flat calm | 9:21 | 13:26 | 4.05 |
| 19-Sep-18 | KB | Sunny; wind BF=1; CC=80-5% (cloud cover decreased during soak time) | 9:33 | 13:30 | 3.57 |
| 21-Jun-17 | RM | Patchy sun; wind BF=1-0; light rain ~11am; CC=70-100% | 9:04 | 13:03 | 3.59 |
| 20-Jul-17 | RM | Unstable weather: Sun, dark cloud, rain; wind BF=2; CC=100-50% | 8:43 | 12:44 | 4.01 |
| 24-Aug-17 | RM | Overcast, light drizzle started ~1130; wind BF=1-3; CC=90%-variable | 8:44 | 12:46 | 4.02 |
| 21-Sep-17 | RM | Sunny w/ scattered clouds; wind BF=2-0; CC=40-90% | 8:45 | 12:40 | 3.55 |
| 20-Jun-18 | RM | Sunny, hot; wind BF=0-2; CC=1-5% | 9:38 | 13:34 | 3.56 |
| 26-Jul-18 | RM | Sunny, hot; CC=10% | 9:03 | 13:03 | 4.00 |
| 23-Aug-18 | RM | Smoky, sunny; wind BF=0; calm and got smokier | 9:28 | 13:29 | 4.01 |
| 20-Sep-18 | RM | Overcast + light rain on and off; wind BF=1; CC=100% | 9:13 | 13:14 | 4.01 |
| 22-Jun-17 | RF | Scattered clouds; wind BF=2-3; CC=50-80% | 8:52 | 12:52 | 4.00 |
| 18-Jul-17 | RF | Smoky; wind BF=3-4; CC=100% smoke | 9:07 | 13:04 | 3.57 |
| 22-Aug-17 | RF | Sunny, a bit hazy; wind BF=3-2; CC=0% (smoke down valley) | 9:18 | 13:20 | 4.02 |
| 19-Sep-17 | RF | Sunny w/ scattered clouds; wind BF=1-2; CC=40-65% | 9:05 | 13:05 | 4.00 |
| 19-Jun-18 | RF | Sunny, hot (heat wave); wind BF=1-2-0; CC=0% | 9:35 | 13:33 | 3.58 |
| 24-Jul-18 | RF | Overcast, sunny by 11; wind=10km; CC=90% | 9:45 | 13:50 | 4.05 |
| 21-Aug-18 | RF | Smoky, sunny; wind BF-2-3; CC=smoke | 9:50 | 13:51 | 4.01 |
| 18-Sep-18 | RF | Cloudy with sun; wind BF=2-3 CC=80-50% | 9:58 | 14:02 | 4.04 |

## Appendix B Raw Chlorophyll and Primary Productivity

**Table B1** Raw chlorophyll and primary productivity data for 2017-2018. Stations are: KIN = Kinbasket-Forebay, REV-Mid = Revelstoke-Middle (also called Downie), REV-FB = Revelstoke-Forebay.

| Station | Date | Depth (m) | Filter Size (µm) | Chl (mg/m$^3$) | PP (mg C/m$^3$/h) | PP (mg C/m$^3$/day) |
|---|---|---|---|---|---|---|
| KIN | 20-Jun-17 | 0 | I-0.2 | 1.16 | 0.34 | 4.74 |
| KIN | 20-Jun-17 | 1 | I-0.2 | 1.03 | 0.74 | 10.41 |

| Station | Date | Depth (m) | Filter Size (µm) | Chl (mg/m$^3$) | PP (mg C/m$^3$/h) | PP (mg C/m$^3$/day) |
|---|---|---|---|---|---|---|
| KIN | 20-Jun-17 | 2 | I-0.2 | 1.24 | 0.72 | 10.15 |
| KIN | 20-Jun-17 | 5 | I-0.2 | 1.06 | 0.61 | 8.62 |
| KIN | 20-Jun-17 | 10 | I-0.2 | 1.58 | 0.13 | 1.83 |
| KIN | 20-Jun-17 | 15 | I-0.2 | 1.24 | 0.03 | 0.41 |
| KIN | 20-Jun-17 | 0 | I-2.0 | 0.42 | 0.25 | 3.53 |
| KIN | 20-Jun-17 | 1 | I-2.0 | 0.46 | 0.36 | 5.11 |
| KIN | 20-Jun-17 | 2 | I-2.0 | 0.46 | 0.33 | 4.65 |
| KIN | 20-Jun-17 | 5 | I-2.0 | 0.45 | 0.29 | 4.13 |
| KIN | 20-Jun-17 | 10 | I-2.0 | 0.69 | 0.08 | 1.08 |
| KIN | 20-Jun-17 | 15 | I-2.0 | 0.45 | 0.01 | 0.12 |
| KIN | 20-Jun-17 | 0 | I-20.0 | 0.04 | 0.06 | 0.85 |
| KIN | 20-Jun-17 | 1 | I-20.0 | 0.08 | 0.07 | 1.01 |
| KIN | 20-Jun-17 | 2 | I-20.0 | 0.08 | 0.08 | 1.08 |
| KIN | 20-Jun-17 | 5 | I-20.0 | 0.08 | 0.06 | 0.78 |
| KIN | 20-Jun-17 | 10 | I-20.0 | 0.05 | 0.01 | 0.18 |
| KIN | 20-Jun-17 | 15 | I-20.0 | 0.05 | 0.00 | 0.05 |
| KIN | 19-Jul-17 | 0 | I-0.2 | 1.34 | 0.55 | 5.59 |
| KIN | 19-Jul-17 | 1 | I-0.2 | 1.11 | 0.51 | 5.15 |
| KIN | 19-Jul-17 | 2 | I-0.2 | 0.53 | 0.51 | 5.22 |
| KIN | 19-Jul-17 | 5 | I-0.2 | 1.57 | 0.72 | 7.28 |
| KIN | 19-Jul-17 | 10 | I-0.2 | 2.18 | 0.55 | 5.55 |
| KIN | 19-Jul-17 | 15 | I-0.2 | 1.24 | 0.20 | 2.02 |
| KIN | 19-Jul-17 | 17 | I-0.2 | 0.56 | 0.09 | 0.87 |
| KIN | 19-Jul-17 | 0 | I-2.0 | 0.43 | 0.29 | 2.95 |
| KIN | 19-Jul-17 | 1 | I-2.0 | 0.43 | 0.33 | 3.39 |
| KIN | 19-Jul-17 | 2 | I-2.0 | 0.28 | 0.33 | 3.34 |
| KIN | 19-Jul-17 | 5 | I-2.0 | 0.55 | 0.38 | 3.86 |
| KIN | 19-Jul-17 | 10 | I-2.0 | 0.55 | 0.30 | 3.09 |
| KIN | 19-Jul-17 | 15 | I-2.0 | 0.50 | 0.11 | 1.13 |
| KIN | 19-Jul-17 | 17 | I-2.0 | 0.42 | 0.06 | 0.64 |
| KIN | 19-Jul-17 | 0 | I-20.0 | 0.06 | 0.05 | 0.47 |
| KIN | 19-Jul-17 | 1 | I-20.0 | 0.05 | 0.06 | 0.60 |
| KIN | 19-Jul-17 | 2 | I-20.0 | 0.05 | 0.07 | 0.76 |
| KIN | 19-Jul-17 | 5 | I-20.0 | 0.06 | 0.06 | 0.62 |
| KIN | 19-Jul-17 | 10 | I-20.0 | 0.04 | 0.03 | 0.29 |
| KIN | 19-Jul-17 | 15 | I-20.0 | 0.03 | 0.02 | 0.18 |
| KIN | 19-Jul-17 | 17 | I-20.0 | 0.02 | 0.01 | 0.10 |
| KIN | 23-Aug-17 | 0 | I-0.2 | 1.01 | 0.64 | 7.73 |
| KIN | 23-Aug-17 | 1 | I-0.2 | 1.07 | 0.74 | 8.95 |
| KIN | 23-Aug-17 | 2 | I-0.2 | 0.74 | 0.88 | 10.63 |
| KIN | 23-Aug-17 | 5 | I-0.2 | 0.61 | 0.71 | 8.62 |
| KIN | 23-Aug-17 | 10 | I-0.2 | 1.52 | 0.74 | 8.93 |
| KIN | 23-Aug-17 | 15 | I-0.2 | 1.24 | 0.56 | 6.83 |
| KIN | 23-Aug-17 | 17 | I-0.2 | 0.92 | 0.14 | 1.75 |
| KIN | 23-Aug-17 | 0 | I-2.0 | 0.44 | 0.44 | 5.34 |
| KIN | 23-Aug-17 | 1 | I-2.0 | 0.45 | 0.54 | 6.56 |
| KIN | 23-Aug-17 | 2 | I-2.0 | 0.42 | 0.60 | 7.25 |
| KIN | 23-Aug-17 | 5 | I-2.0 | 0.37 | 0.56 | 6.80 |

| Station | Date | Depth (m) | Filter Size (µm) | Chl ($mg/m^3$) | PP (mg $C/m^3/h$) | PP (mg $C/m^3/day$) |
|---|---|---|---|---|---|---|
| KIN | 23-Aug-17 | 10 | I-2.0 | 0.65 | 0.50 | 6.02 |
| KIN | 23-Aug-17 | 15 | I-2.0 | 0.71 | 0.10 | 1.20 |
| KIN | 23-Aug-17 | 17 | I-2.0 | 0.48 | 0.09 | 1.10 |
| KIN | 23-Aug-17 | 0 | I-20.0 | 0.06 | 0.04 | 0.45 |
| KIN | 23-Aug-17 | 1 | I-20.0 | 0.05 | 0.06 | 0.75 |
| KIN | 23-Aug-17 | 2 | I-20.0 | 0.06 | 0.07 | 0.87 |
| KIN | 23-Aug-17 | 5 | I-20.0 | 0.05 | 0.07 | 0.83 |
| KIN | 23-Aug-17 | 10 | I-20.0 | 0.06 | 0.05 | 0.66 |
| KIN | 23-Aug-17 | 15 | I-20.0 | 0.06 | 0.02 | 0.22 |
| KIN | 23-Aug-17 | 17 | I-20.0 | 0.06 | 0.01 | 0.13 |
| KIN | 20-Sep-17 | 0 | I-0.2 | 1.39 | 1.55 | 39.76 |
| KIN | 20-Sep-17 | 1 | I-0.2 | 1.39 | 1.40 | 35.83 |
| KIN | 20-Sep-17 | 2 | I-0.2 | 1.76 | 1.67 | 42.68 |
| KIN | 20-Sep-17 | 5 | I-0.2 | 1.22 | 0.98 | 25.13 |
| KIN | 20-Sep-17 | 10 | I-0.2 | 1.47 | 0.42 | 10.63 |
| KIN | 20-Sep-17 | 15 | I-0.2 | 1.41 | 0.14 | 3.46 |
| KIN | 20-Sep-17 | 20 | I-0.2 | 1.15 | 0.02 | 0.60 |
| KIN | 20-Sep-17 | 0 | I-2.0 | 0.55 | 1.11 | 28.33 |
| KIN | 20-Sep-17 | 1 | I-2.0 | 0.57 | 1.02 | 26.09 |
| KIN | 20-Sep-17 | 2 | I-2.0 | 0.70 | 1.02 | 26.17 |
| KIN | 20-Sep-17 | 5 | I-2.0 | 0.53 | 0.67 | 17.08 |
| KIN | 20-Sep-17 | 10 | I-2.0 | 0.70 | 0.24 | 6.20 |
| KIN | 20-Sep-17 | 15 | I-2.0 | 0.65 | 0.08 | 2.05 |
| KIN | 20-Sep-17 | 20 | I-2.0 | 0.48 | 0.01 | 0.37 |
| KIN | 20-Sep-17 | 0 | I-20.0 | 0.08 | 0.14 | 3.48 |
| KIN | 20-Sep-17 | 1 | I-20.0 | 0.08 | 0.13 | 3.37 |
| KIN | 20-Sep-17 | 2 | I-20.0 | 0.08 | 0.15 | 3.73 |
| KIN | 20-Sep-17 | 5 | I-20.0 | 0.08 | 0.10 | 2.48 |
| KIN | 20-Sep-17 | 10 | I-20.0 | 0.07 | 0.03 | 0.89 |
| KIN | 20-Sep-17 | 15 | I-20.0 | 0.08 | 0.01 | 0.37 |
| KIN | 20-Sep-17 | 20 | I-20.0 | 0.07 | 0.00 | 0.00 |
| KIN | 21-Jun-18 | 0 | I-0.2 | 2.32 | 1.13 | 20.20 |
| KIN | 21-Jun-18 | 1 | I-0.2 | 1.49 | 1.79 | 31.89 |
| KIN | 21-Jun-18 | 2 | I-0.2 | 2.30 | 1.65 | 29.41 |
| KIN | 21-Jun-18 | 5 | I-0.2 | 2.12 | 1.06 | 18.87 |
| KIN | 21-Jun-18 | 10 | I-0.2 | 2.65 | 0.38 | 6.78 |
| KIN | 21-Jun-18 | 15 | I-0.2 | 2.42 | 0.10 | 1.82 |
| KIN | 21-Jun-18 | 0 | I-2.0 | 0.84 | 0.57 | 10.08 |
| KIN | 21-Jun-18 | 1 | I-2.0 | 0.71 | 0.62 | 11.12 |
| KIN | 21-Jun-18 | 2 | I-2.0 | 0.78 | 0.64 | 11.35 |
| KIN | 21-Jun-18 | 5 | I-2.0 | 0.70 | 0.39 | 7.03 |
| KIN | 21-Jun-18 | 10 | I-2.0 | 0.68 | 0.14 | 2.51 |
| KIN | 21-Jun-18 | 15 | I-2.0 | 0.86 | 0.04 | 0.69 |
| KIN | 21-Jun-18 | 0 | I-20.0 | 0.15 | 0.14 | 2.55 |
| KIN | 21-Jun-18 | 1 | I-20.0 | 0.13 | 0.16 | 2.89 |
| KIN | 21-Jun-18 | 2 | I-20.0 | 0.12 | 0.17 | 2.94 |
| KIN | 21-Jun-18 | 5 | I-20.0 | 0.11 | 0.08 | 1.51 |
| KIN | 21-Jun-18 | 10 | I-20.0 | 0.08 | 0.04 | 0.66 |

| Station | Date | Depth (m) | Filter Size (µm) | Chl (mg/m³) | PP (mg C/m³/h) | PP (mg C/m³/day) |
|---|---|---|---|---|---|---|
| KIN | 21-Jun-18 | 15 | I-20.0 | 0.06 | 0.01 | 0.15 |
| KIN | 25-Jul-18 | 0 | I-0.2 | 2.34 | 0.70 | 6.08 |
| KIN | 25-Jul-18 | 1 | I-0.2 | 1.25 | 1.77 | 15.38 |
| KIN | 25-Jul-18 | 2 | I-0.2 | 2.15 | 2.22 | 19.36 |
| KIN | 25-Jul-18 | 5 | I-0.2 | 2.45 | 2.09 | 18.17 |
| KIN | 25-Jul-18 | 10 | I-0.2 | 2.59 | 1.04 | 9.07 |
| KIN | 25-Jul-18 | 15 | I-0.2 | 2.39 | 0.58 | 5.02 |
| KIN | 25-Jul-18 | 0 | I-2.0 | 1.08 | 0.69 | 5.98 |
| KIN | 25-Jul-18 | 1 | I-2.0 | 0.98 | 1.02 | 8.90 |
| KIN | 25-Jul-18 | 2 | I-2.0 | 1.03 | 1.16 | 10.09 |
| KIN | 25-Jul-18 | 5 | I-2.0 | 1.08 | 1.18 | 10.30 |
| KIN | 25-Jul-18 | 10 | I-2.0 | 1.08 | 0.63 | 5.44 |
| KIN | 25-Jul-18 | 15 | I-2.0 | 1.47 | 0.38 | 3.34 |
| KIN | 25-Jul-18 | 0 | I-20.0 | 0.43 | 0.38 | 3.35 |
| KIN | 25-Jul-18 | 1 | I-20.0 | 0.45 | 0.58 | 5.06 |
| KIN | 25-Jul-18 | 2 | I-20.0 | 0.43 | 0.59 | 5.14 |
| KIN | 25-Jul-18 | 5 | I-20.0 | 0.26 | 0.60 | 5.23 |
| KIN | 25-Jul-18 | 10 | I-20.0 | 0.41 | 0.31 | 2.70 |
| KIN | 25-Jul-18 | 15 | I-20.0 | 0.40 | 0.24 | 2.07 |
| KIN | 22-Aug-18 | 0 | I-0.2 | 1.92 | 1.45 | 10.20 |
| KIN | 22-Aug-18 | 1 | I-0.2 | 1.54 | 1.66 | 11.69 |
| KIN | 22-Aug-18 | 2 | I-0.2 | 1.48 | 1.31 | 9.25 |
| KIN | 22-Aug-18 | 5 | I-0.2 | 1.83 | 1.73 | 12.23 |
| KIN | 22-Aug-18 | 10 | I-0.2 | 2.13 | 1.90 | 13.44 |
| KIN | 22-Aug-18 | 15 | I-0.2 | 1.38 | 0.74 | 5.25 |
| KIN | 22-Aug-18 | 17 | I-0.2 | 0.96 | 0.24 | 1.68 |
| KIN | 22-Aug-18 | 0 | I-2.0 | 1.15 | 0.76 | 5.37 |
| KIN | 22-Aug-18 | 1 | I-2.0 | 0.90 | 1.19 | 8.43 |
| KIN | 22-Aug-18 | 2 | I-2.0 | 0.90 | 1.15 | 8.08 |
| KIN | 22-Aug-18 | 5 | I-2.0 | 1.02 | 1.01 | 7.15 |
| KIN | 22-Aug-18 | 10 | I-2.0 | 1.59 | 0.87 | 6.16 |
| KIN | 22-Aug-18 | 15 | I-2.0 | 1.15 | 0.42 | 2.99 |
| KIN | 22-Aug-18 | 17 | I-2.0 | 0.94 | 0.16 | 1.13 |
| KIN | 22-Aug-18 | 0 | I-20.0 | 0.17 | 0.12 | 0.86 |
| KIN | 22-Aug-18 | 1 | I-20.0 | 0.15 | 0.16 | 1.16 |
| KIN | 22-Aug-18 | 2 | I-20.0 | 0.16 | 0.15 | 1.07 |
| KIN | 22-Aug-18 | 5 | I-20.0 | 0.18 | 0.19 | 1.34 |
| KIN | 22-Aug-18 | 10 | I-20.0 | 0.24 | 0.16 | 1.15 |
| KIN | 22-Aug-18 | 15 | I-20.0 | 0.15 | 0.06 | 0.46 |
| KIN | 22-Aug-18 | 17 | I-20.0 | 0.10 | 0.02 | 0.14 |
| KIN | 19-Sep-18 | 0 | I-0.2 | 1.56 | 0.61 | 2.67 |
| KIN | 19-Sep-18 | 1 | I-0.2 | 1.29 | 1.08 | 4.69 |
| KIN | 19-Sep-18 | 2 | I-0.2 | 1.45 | 1.50 | 6.55 |
| KIN | 19-Sep-18 | 5 | I-0.2 | 0.82 | 1.58 | 6.91 |
| KIN | 19-Sep-18 | 10 | I-0.2 | 1.28 | 1.33 | 5.78 |
| KIN | 19-Sep-18 | 15 | I-0.2 | 1.51 | 0.88 | 3.83 |
| KIN | 19-Sep-18 | 20 | I-0.2 | 0.55 | 0.27 | 1.17 |
| KIN | 19-Sep-18 | 0 | I-2.0 | 0.64 | 0.40 | 1.75 |

| Station | Date | Depth (m) | Filter Size (µm) | Chl (mg/m³) | PP (mg C/m³/h) | PP (mg C/m³/day) |
|---|---|---|---|---|---|---|
| KIN | 19-Sep-18 | 1 | I-2.0 | 0.48 | 0.73 | 3.19 |
| KIN | 19-Sep-18 | 2 | I-2.0 | 0.79 | 1.00 | 4.37 |
| KIN | 19-Sep-18 | 5 | I-2.0 | 0.47 | 1.07 | 4.68 |
| KIN | 19-Sep-18 | 10 | I-2.0 | 0.37 | 0.78 | 3.41 |
| KIN | 19-Sep-18 | 15 | I-2.0 | 0.53 | 0.54 | 2.35 |
| KIN | 19-Sep-18 | 20 | I-2.0 | 0.55 | 0.15 | 0.64 |
| KIN | 19-Sep-18 | 0 | I-20.0 | 0.10 | 0.07 | 0.30 |
| KIN | 19-Sep-18 | 1 | I-20.0 | 0.10 | 0.10 | 0.44 |
| KIN | 19-Sep-18 | 2 | I-20.0 | 0.11 | 0.14 | 0.60 |
| KIN | 19-Sep-18 | 5 | I-20.0 | 0.12 | 0.18 | 0.80 |
| KIN | 19-Sep-18 | 10 | I-20.0 | 0.13 | 0.14 | 0.59 |
| KIN | 19-Sep-18 | 15 | I-20.0 | 0.09 | 0.07 | 0.30 |
| KIN | 19-Sep-18 | 20 | I-20.0 | 0.10 | 0.02 | 0.10 |
| REV-Mid | 21-Jun-17 | 0 | I-0.2 | 1.01 | 0.77 | 20.52 |
| REV-Mid | 21-Jun-17 | 1 | I-0.2 | 1.08 | 1.16 | 30.70 |
| REV-Mid | 21-Jun-17 | 2 | I-0.2 | 1.16 | 0.50 | 13.31 |
| REV-Mid | 21-Jun-17 | 5 | I-0.2 | 1.67 | 0.43 | 11.51 |
| REV-Mid | 21-Jun-17 | 10 | I-0.2 | 1.03 | 0.02 | 0.47 |
| REV-Mid | 21-Jun-17 | 0 | I-2.0 | 0.25 | 0.47 | 12.50 |
| REV-Mid | 21-Jun-17 | 1 | I-2.0 | 0.35 | 0.47 | 12.59 |
| REV-Mid | 21-Jun-17 | 2 | I-2.0 | 0.43 | 0.43 | 11.35 |
| REV-Mid | 21-Jun-17 | 5 | I-2.0 | 0.57 | 0.24 | 6.47 |
| REV-Mid | 21-Jun-17 | 10 | I-2.0 | 0.57 | 0.01 | 0.29 |
| REV-Mid | 21-Jun-17 | 0 | I-20.0 | 0.05 | 0.10 | 2.61 |
| REV-Mid | 21-Jun-17 | 1 | I-20.0 | 0.10 | 0.13 | 3.37 |
| REV-Mid | 21-Jun-17 | 2 | I-20.0 | 0.01 | 0.09 | 2.33 |
| REV-Mid | 21-Jun-17 | 5 | I-20.0 | 0.00 | 0.03 | 0.90 |
| REV-Mid | 21-Jun-17 | 10 | I-20.0 | 0.00 | 0.01 | 0.22 |
| REV-Mid | 20-Jul-17 | 0 | I-0.2 | 1.42 | 0.65 | 7.82 |
| REV-Mid | 20-Jul-17 | 1 | I-0.2 | 1.85 | 1.26 | 15.03 |
| REV-Mid | 20-Jul-17 | 2 | I-0.2 | 1.52 | 1.16 | 13.92 |
| REV-Mid | 20-Jul-17 | 5 | I-0.2 | 2.76 | 1.05 | 12.52 |
| REV-Mid | 20-Jul-17 | 10 | I-0.2 | 2.33 | 0.06 | 0.66 |
| REV-Mid | 20-Jul-17 | 12 | I-0.2 | 1.62 | 0.02 | 0.21 |
| REV-Mid | 20-Jul-17 | 0 | I-2.0 | 1.05 | 0.49 | 5.82 |
| REV-Mid | 20-Jul-17 | 1 | I-2.0 | 1.07 | 0.73 | 8.78 |
| REV-Mid | 20-Jul-17 | 2 | I-2.0 | 1.16 | 0.84 | 10.07 |
| REV-Mid | 20-Jul-17 | 5 | I-2.0 | 2.27 | 0.62 | 7.46 |
| REV-Mid | 20-Jul-17 | 10 | I-2.0 | 1.34 | 0.05 | 0.60 |
| REV-Mid | 20-Jul-17 | 12 | I-2.0 | 1.07 | 0.01 | 0.11 |
| REV-Mid | 20-Jul-17 | 0 | I-20.0 | 0.47 | 0.16 | 1.94 |
| REV-Mid | 20-Jul-17 | 1 | I-20.0 | 0.48 | 0.25 | 2.96 |
| REV-Mid | 20-Jul-17 | 2 | I-20.0 | 0.58 | 0.22 | 2.67 |
| REV-Mid | 20-Jul-17 | 5 | I-20.0 | 1.30 | 0.41 | 4.85 |
| REV-Mid | 20-Jul-17 | 10 | I-20.0 | 0.57 | 0.02 | 0.26 |
| REV-Mid | 20-Jul-17 | 12 | I-20.0 | 0.34 | 0.01 | 0.08 |
| REV-Mid | 24-Aug-17 | 0 | I-0.2 | 0.83 | 0.49 | 12.71 |
| REV-Mid | 24-Aug-17 | 1 | I-0.2 | 0.89 | 0.58 | 15.11 |

| Station | Date | Depth (m) | Filter Size (µm) | Chl ($mg/m^3$) | PP (mg $C/m^3/h$) | PP (mg $C/m^3/day$) |
|---|---|---|---|---|---|---|
| REV-Mid | 24-Aug-17 | 2 | I-0.2 | 0.89 | 0.52 | 13.46 |
| REV-Mid | 24-Aug-17 | 5 | I-0.2 | 0.92 | 0.52 | 13.34 |
| REV-Mid | 24-Aug-17 | 10 | I-0.2 | 1.90 | 0.12 | 3.18 |
| REV-Mid | 24-Aug-17 | 13 | I-0.2 | 1.88 | 0.09 | 2.31 |
| REV-Mid | 24-Aug-17 | 0 | I-2.0 | 0.29 | 0.37 | 9.55 |
| REV-Mid | 24-Aug-17 | 1 | I-2.0 | 0.38 | 0.41 | 10.71 |
| REV-Mid | 24-Aug-17 | 2 | I-2.0 | 0.27 | 0.38 | 9.93 |
| REV-Mid | 24-Aug-17 | 5 | I-2.0 | 0.36 | 0.28 | 7.35 |
| REV-Mid | 24-Aug-17 | 10 | I-2.0 | 0.80 | 0.16 | 4.17 |
| REV-Mid | 24-Aug-17 | 13 | I-2.0 | 0.76 | 0.04 | 1.11 |
| REV-Mid | 24-Aug-17 | 0 | I-20.0 | 0.05 | 0.06 | 1.47 |
| REV-Mid | 24-Aug-17 | 1 | I-20.0 | 0.05 | 0.04 | 1.14 |
| REV-Mid | 24-Aug-17 | 2 | I-20.0 | 0.05 | 0.06 | 1.67 |
| REV-Mid | 24-Aug-17 | 5 | I-20.0 | 0.07 | 0.04 | 1.12 |
| REV-Mid | 24-Aug-17 | 10 | I-20.0 | 0.14 | 0.03 | 0.68 |
| REV-Mid | 24-Aug-17 | 13 | I-20.0 | 0.09 | 0.00 | 0.07 |
| REV-Mid | 21-Sep-17 | 0 | I-0.2 | 0.64 | 0.61 | 8.27 |
| REV-Mid | 21-Sep-17 | 1 | I-0.2 | 0.71 | 0.76 | 10.30 |
| REV-Mid | 21-Sep-17 | 2 | I-0.2 | 0.82 | 0.96 | 13.02 |
| REV-Mid | 21-Sep-17 | 5 | I-0.2 | 0.77 | 0.63 | 8.58 |
| REV-Mid | 21-Sep-17 | 10 | I-0.2 | 0.76 | 0.18 | 2.45 |
| REV-Mid | 21-Sep-17 | 12 | I-0.2 | 0.74 | 0.10 | 1.35 |
| REV-Mid | 21-Sep-17 | 0 | I-2.0 | 0.23 | 0.38 | 5.08 |
| REV-Mid | 21-Sep-17 | 1 | I-2.0 | 0.33 | 0.49 | 6.59 |
| REV-Mid | 21-Sep-17 | 2 | I-2.0 | 0.26 | 0.58 | 7.89 |
| REV-Mid | 21-Sep-17 | 5 | I-2.0 | 0.29 | 0.44 | 5.91 |
| REV-Mid | 21-Sep-17 | 10 | I-2.0 | 0.24 | 0.10 | 1.33 |
| REV-Mid | 21-Sep-17 | 12 | I-2.0 | 0.31 | 0.05 | 0.70 |
| REV-Mid | 21-Sep-17 | 0 | I-20.0 | 0.03 | 0.04 | 0.51 |
| REV-Mid | 21-Sep-17 | 1 | I-20.0 | 0.03 | 0.06 | 0.76 |
| REV-Mid | 21-Sep-17 | 2 | I-20.0 | 0.03 | 0.08 | 1.01 |
| REV-Mid | 21-Sep-17 | 5 | I-20.0 | 0.03 | 0.05 | 0.73 |
| REV-Mid | 21-Sep-17 | 10 | I-20.0 | 0.03 | 0.01 | 0.13 |
| REV-Mid | 21-Sep-17 | 12 | I-20.0 | 0.03 | 0.01 | 0.10 |
| REV-Mid | 20-Jun-18 | 0 | I-0.2 | 0.65 | 0.37 | 2.74 |
| REV-Mid | 20-Jun-18 | 1 | I-0.2 | 0.75 | 1.02 | 7.56 |
| REV-Mid | 20-Jun-18 | 2 | I-0.2 | 0.81 | 0.84 | 6.22 |
| REV-Mid | 20-Jun-18 | 5 | I-0.2 | 0.80 | 0.66 | 4.85 |
| REV-Mid | 20-Jun-18 | 10 | I-0.2 | 0.86 | 0.22 | 1.66 |
| REV-Mid | 20-Jun-18 | 11 | I-0.2 | 0.67 | 0.14 | 1.02 |
| REV-Mid | 20-Jun-18 | 0 | I-2.0 | 0.10 | 0.24 | 1.75 |
| REV-Mid | 20-Jun-18 | 1 | I-2.0 | 0.25 | 0.31 | 2.26 |
| REV-Mid | 20-Jun-18 | 2 | I-2.0 | 0.24 | 0.26 | 1.91 |
| REV-Mid | 20-Jun-18 | 5 | I-2.0 | 0.19 | 0.25 | 1.82 |
| REV-Mid | 20-Jun-18 | 10 | I-2.0 | 0.26 | 0.09 | 0.64 |
| REV-Mid | 20-Jun-18 | 11 | I-2.0 | 0.22 | 0.06 | 0.43 |
| REV-Mid | 20-Jun-18 | 0 | I-20.0 | 0.10 | 0.03 | 0.22 |
| REV-Mid | 20-Jun-18 | 1 | I-20.0 | 0.04 | 0.05 | 0.37 |

| Station | Date | Depth (m) | Filter Size (µm) | Chl (mg/m³) | PP (mg C/m³/h) | PP (mg C/m³/day) |
|---|---|---|---|---|---|---|
| REV-Mid | 20-Jun-18 | 2 | I-20.0 | 0.08 | 0.04 | 0.32 |
| REV-Mid | 20-Jun-18 | 5 | I-20.0 | 0.06 | 0.08 | 0.56 |
| REV-Mid | 20-Jun-18 | 10 | I-20.0 | 0.02 | 0.02 | 0.18 |
| REV-Mid | 20-Jun-18 | 11 | I-20.0 | 0.04 | 0.02 | 0.12 |
| REV-Mid | 26-Jul-18 | 0 | I-0.2 | 2.21 | 1.62 | 17.54 |
| REV-Mid | 26-Jul-18 | 1 | I-0.2 | 1.40 | 2.34 | 25.31 |
| REV-Mid | 26-Jul-18 | 2 | I-0.2 | 1.77 | 1.47 | 15.85 |
| REV-Mid | 26-Jul-18 | 5 | I-0.2 | 1.59 | 0.58 | 6.23 |
| REV-Mid | 26-Jul-18 | 10 | I-0.2 | 0.80 | 0.44 | 4.75 |
| REV-Mid | 26-Jul-18 | 0 | I-2.0 | 0.86 | 0.96 | 10.38 |
| REV-Mid | 26-Jul-18 | 1 | I-2.0 | 0.94 | 1.19 | 12.91 |
| REV-Mid | 26-Jul-18 | 2 | I-2.0 | 0.91 | 1.15 | 12.43 |
| REV-Mid | 26-Jul-18 | 5 | I-2.0 | 0.77 | 0.74 | 7.95 |
| REV-Mid | 26-Jul-18 | 10 | I-2.0 | 0.61 | 0.33 | 3.52 |
| REV-Mid | 26-Jul-18 | 0 | I-20.0 | 0.10 | 0.39 | 4.22 |
| REV-Mid | 26-Jul-18 | 1 | I-20.0 | 0.09 | 0.54 | 5.89 |
| REV-Mid | 26-Jul-18 | 2 | I-20.0 | 0.11 | 0.55 | 5.93 |
| REV-Mid | 26-Jul-18 | 5 | I-20.0 | 0.13 | 0.29 | 3.09 |
| REV-Mid | 26-Jul-18 | 10 | I-20.0 | 0.19 | 0.12 | 1.33 |
| REV-Mid | 23-Aug-18 | 0 | I-0.2 | 0.86 | 0.56 | 5.91 |
| REV-Mid | 23-Aug-18 | 1 | I-0.2 | 0.48 | 1.43 | 15.17 |
| REV-Mid | 23-Aug-18 | 2 | I-0.2 | 0.80 | 1.00 | 10.68 |
| REV-Mid | 23-Aug-18 | 5 | I-0.2 | 0.56 | 1.69 | 17.95 |
| REV-Mid | 23-Aug-18 | 10 | I-0.2 | 1.06 | 0.36 | 3.81 |
| REV-Mid | 23-Aug-18 | 12 | I-0.2 | 0.81 | 0.12 | 1.31 |
| REV-Mid | 23-Aug-18 | 0 | I-2.0 | 0.25 | 0.34 | 3.58 |
| REV-Mid | 23-Aug-18 | 1 | I-2.0 | 0.21 | 0.88 | 9.33 |
| REV-Mid | 23-Aug-18 | 2 | I-2.0 | 0.27 | 0.82 | 8.76 |
| REV-Mid | 23-Aug-18 | 5 | I-2.0 | 0.44 | 1.27 | 13.50 |
| REV-Mid | 23-Aug-18 | 10 | I-2.0 | 0.28 | 0.17 | 1.76 |
| REV-Mid | 23-Aug-18 | 12 | I-2.0 | 0.42 | 0.06 | 0.67 |
| REV-Mid | 23-Aug-18 | 0 | I-20.0 | 0.04 | 0.04 | 0.48 |
| REV-Mid | 23-Aug-18 | 1 | I-20.0 | 0.04 | 0.10 | 1.08 |
| REV-Mid | 23-Aug-18 | 2 | I-20.0 | 0.05 | 0.09 | 0.91 |
| REV-Mid | 23-Aug-18 | 5 | I-20.0 | 0.24 | 0.46 | 4.91 |
| REV-Mid | 23-Aug-18 | 10 | I-20.0 | 0.07 | 0.04 | 0.37 |
| REV-Mid | 23-Aug-18 | 12 | I-20.0 | 0.08 | 0.01 | 0.11 |
| REV-Mid | 20-Sep-18 | 0 | I-0.2 | 1.07 | 1.12 | 12.18 |
| REV-Mid | 20-Sep-18 | 1 | I-0.2 | 0.75 | 1.88 | 20.49 |
| REV-Mid | 20-Sep-18 | 2 | I-0.2 | 0.94 | 1.22 | 13.26 |
| REV-Mid | 20-Sep-18 | 5 | I-0.2 | 0.86 | 1.32 | 14.41 |
| REV-Mid | 20-Sep-18 | 10 | I-0.2 | 0.61 | 0.33 | 3.56 |
| REV-Mid | 20-Sep-18 | 14 | I-0.2 | 0.51 | 0.02 | 0.20 |
| REV-Mid | 20-Sep-18 | 0 | I-2.0 | 0.35 | 0.72 | 7.88 |
| REV-Mid | 20-Sep-18 | 1 | I-2.0 | 0.30 | 1.11 | 12.15 |
| REV-Mid | 20-Sep-18 | 2 | I-2.0 | 0.36 | 1.13 | 12.29 |
| REV-Mid | 20-Sep-18 | 5 | I-2.0 | 0.31 | 0.74 | 8.11 |
| REV-Mid | 20-Sep-18 | 10 | I-2.0 | 0.32 | 0.22 | 2.40 |

| Station | Date | Depth (m) | Filter Size (µm) | Chl (mg/m$^3$) | PP (mg C/m$^3$/h) | PP (mg C/m$^3$/day) |
|---|---|---|---|---|---|---|
| REV-Mid | 20-Sep-18 | 14 | I-2.0 | 0.26 | 0.05 | 0.51 |
| REV-Mid | 20-Sep-18 | 0 | I-20.0 | 0.06 | 0.10 | 1.11 |
| REV-Mid | 20-Sep-18 | 1 | I-20.0 | 0.05 | 0.13 | 1.46 |
| REV-Mid | 20-Sep-18 | 2 | I-20.0 | 0.04 | 0.15 | 1.61 |
| REV-Mid | 20-Sep-18 | 5 | I-20.0 | 0.05 | 0.11 | 1.21 |
| REV-Mid | 20-Sep-18 | 10 | I-20.0 | 0.05 | 0.02 | 0.23 |
| REV-Mid | 20-Sep-18 | 14 | I-20.0 | 0.03 | 0.00 | 0.04 |
| REV-FB | 22-Jun-17 | 0 | I-0.2 | 1.71 | 0.53 | 5.14 |
| REV-FB | 22-Jun-17 | 1 | I-0.2 | 1.65 | 0.70 | 6.88 |
| REV-FB | 22-Jun-17 | 2 | I-0.2 | 1.65 | 0.84 | 8.20 |
| REV-FB | 22-Jun-17 | 5 | I-0.2 | 1.81 | 0.73 | 7.15 |
| REV-FB | 22-Jun-17 | 10 | I-0.2 | 0.70 | 0.16 | 1.54 |
| REV-FB | 22-Jun-17 | 12 | I-0.2 | 0.90 | 0.07 | 0.66 |
| REV-FB | 22-Jun-17 | 0 | I-2.0 | 0.62 | 0.23 | 2.23 |
| REV-FB | 22-Jun-17 | 1 | I-2.0 | 0.53 | 0.33 | 3.18 |
| REV-FB | 22-Jun-17 | 2 | I-2.0 | 0.50 | 0.40 | 3.94 |
| REV-FB | 22-Jun-17 | 5 | I-2.0 | 0.57 | 0.34 | 3.30 |
| REV-FB | 22-Jun-17 | 10 | I-2.0 | 0.51 | 0.07 | 0.69 |
| REV-FB | 22-Jun-17 | 12 | I-2.0 | 0.49 | 0.03 | 0.28 |
| REV-FB | 22-Jun-17 | 0 | I-20.0 | 0.08 | 0.05 | 0.52 |
| REV-FB | 22-Jun-17 | 1 | I-20.0 | 0.10 | 0.06 | 0.60 |
| REV-FB | 22-Jun-17 | 2 | I-20.0 | 0.10 | 0.09 | 0.83 |
| REV-FB | 22-Jun-17 | 5 | I-20.0 | 0.10 | 0.08 | 0.75 |
| REV-FB | 22-Jun-17 | 10 | I-20.0 | 0.05 | 0.01 | 0.07 |
| REV-FB | 22-Jun-17 | 12 | I-20.0 | 0.06 | 0.00 | 0.03 |
| REV-FB | 18-Jul-17 | 0 | I-0.2 | 1.46 | 1.08 | 17.13 |
| REV-FB | 18-Jul-17 | 1 | I-0.2 | 1.64 | 1.27 | 20.22 |
| REV-FB | 18-Jul-17 | 2 | I-0.2 | 1.47 | 1.30 | 20.74 |
| REV-FB | 18-Jul-17 | 5 | I-0.2 | 1.49 | 0.92 | 14.70 |
| REV-FB | 18-Jul-17 | 10 | I-0.2 | 1.06 | 0.19 | 2.98 |
| REV-FB | 18-Jul-17 | 12 | I-0.2 | 1.30 | 0.09 | 1.51 |
| REV-FB | 18-Jul-17 | 0 | I-2.0 | 0.89 | 0.77 | 12.29 |
| REV-FB | 18-Jul-17 | 1 | I-2.0 | 0.92 | 0.81 | 12.87 |
| REV-FB | 18-Jul-17 | 2 | I-2.0 | 0.85 | 0.89 | 14.17 |
| REV-FB | 18-Jul-17 | 5 | I-2.0 | 0.82 | 0.58 | 9.26 |
| REV-FB | 18-Jul-17 | 10 | I-2.0 | 0.86 | 0.12 | 1.91 |
| REV-FB | 18-Jul-17 | 12 | I-2.0 | 0.60 | 0.06 | 0.90 |
| REV-FB | 18-Jul-17 | 0 | I-20.0 | 0.35 | 0.31 | 4.91 |
| REV-FB | 18-Jul-17 | 1 | I-20.0 | 0.32 | 0.28 | 4.38 |
| REV-FB | 18-Jul-17 | 2 | I-20.0 | 0.36 | 0.22 | 3.46 |
| REV-FB | 18-Jul-17 | 5 | I-20.0 | 0.37 | 0.14 | 2.28 |
| REV-FB | 18-Jul-17 | 10 | I-20.0 | 0.39 | 0.03 | 0.51 |
| REV-FB | 18-Jul-17 | 12 | I-20.0 | 0.21 | 0.02 | 0.26 |
| REV-FB | 22-Aug-17 | 0 | I-0.2 | 1.12 | 0.60 | 5.00 |
| REV-FB | 22-Aug-17 | 1 | I-0.2 | 1.35 | 0.69 | 5.76 |
| REV-FB | 22-Aug-17 | 2 | I-0.2 | 0.95 | 1.12 | 9.29 |
| REV-FB | 22-Aug-17 | 5 | I-0.2 | 1.30 | 1.12 | 9.29 |
| REV-FB | 22-Aug-17 | 10 | I-0.2 | 1.29 | 0.83 | 6.93 |

| Station | Date | Depth (m) | Filter Size (µm) | Chl (mg/m$^3$) | PP (mg C/m$^3$/h) | PP (mg C/m$^3$/day) |
|---|---|---|---|---|---|---|
| REV-FB | 22-Aug-17 | 15 | I-0.2 | 1.39 | 0.46 | 3.84 |
| REV-FB | 22-Aug-17 | 18 | I-0.2 | 0.96 | 0.17 | 1.45 |
| REV-FB | 22-Aug-17 | 0 | I-2.0 | 0.51 | 0.34 | 2.86 |
| REV-FB | 22-Aug-17 | 1 | I-2.0 | 0.42 | 0.58 | 4.82 |
| REV-FB | 22-Aug-17 | 2 | I-2.0 | 0.46 | 0.67 | 5.56 |
| REV-FB | 22-Aug-17 | 5 | I-2.0 | 0.51 | 0.71 | 5.93 |
| REV-FB | 22-Aug-17 | 10 | I-2.0 | 0.48 | 0.56 | 4.64 |
| REV-FB | 22-Aug-17 | 15 | I-2.0 | 0.59 | 0.22 | 1.80 |
| REV-FB | 22-Aug-17 | 18 | I-2.0 | 0.34 | 0.08 | 0.63 |
| REV-FB | 22-Aug-17 | 0 | I-20.0 | 0.04 | 0.04 | 0.32 |
| REV-FB | 22-Aug-17 | 1 | I-20.0 | 0.05 | 0.07 | 0.58 |
| REV-FB | 22-Aug-17 | 2 | I-20.0 | 0.05 | 0.09 | 0.73 |
| REV-FB | 22-Aug-17 | 5 | I-20.0 | 0.06 | 0.07 | 0.60 |
| REV-FB | 22-Aug-17 | 10 | I-20.0 | 0.04 | 0.06 | 0.46 |
| REV-FB | 22-Aug-17 | 15 | I-20.0 | 0.05 | 0.03 | 0.23 |
| REV-FB | 22-Aug-17 | 18 | I-20.0 | 0.04 | 0.01 | 0.07 |
| REV-FB | 19-Sep-17 | 0 | I-0.2 | 0.44 | 0.75 | 11.22 |
| REV-FB | 19-Sep-17 | 1 | I-0.2 | 0.81 | 1.53 | 22.94 |
| REV-FB | 19-Sep-17 | 2 | I-0.2 | 0.84 | 1.83 | 27.49 |
| REV-FB | 19-Sep-17 | 5 | I-0.2 | 0.72 | 1.66 | 24.89 |
| REV-FB | 19-Sep-17 | 10 | I-0.2 | 0.23 | 0.17 | 2.53 |
| REV-FB | 19-Sep-17 | 14 | I-0.2 | 0.12 | 0.06 | 0.85 |
| REV-FB | 19-Sep-17 | 0 | I-2.0 | 0.33 | 0.58 | 8.68 |
| REV-FB | 19-Sep-17 | 1 | I-2.0 | 0.31 | 0.94 | 14.17 |
| REV-FB | 19-Sep-17 | 2 | I-2.0 | 0.36 | 1.22 | 18.30 |
| REV-FB | 19-Sep-17 | 5 | I-2.0 | 0.20 | 0.90 | 13.50 |
| REV-FB | 19-Sep-17 | 10 | I-2.0 | 0.17 | 0.11 | 1.61 |
| REV-FB | 19-Sep-17 | 14 | I-2.0 | 0.15 | 0.02 | 0.24 |
| REV-FB | 19-Sep-17 | 0 | I-20.0 | 0.02 | 0.03 | 0.52 |
| REV-FB | 19-Sep-17 | 1 | I-20.0 | 0.03 | 0.10 | 1.47 |
| REV-FB | 19-Sep-17 | 2 | I-20.0 | 0.03 | 0.08 | 1.14 |
| REV-FB | 19-Sep-17 | 5 | I-20.0 | 0.03 | 0.08 | 1.24 |
| REV-FB | 19-Sep-17 | 10 | I-20.0 | 0.02 | 0.01 | 0.11 |
| REV-FB | 19-Sep-17 | 14 | I-20.0 | 0.01 | 0.00 | 0.01 |
| REV-FB | 19-Jun-18 | 0 | I-0.2 | 1.05 | 0.45 | 3.02 |
| REV-FB | 19-Jun-18 | 1 | I-0.2 | 0.76 | 0.68 | 4.56 |
| REV-FB | 19-Jun-18 | 2 | I-0.2 | 1.11 | 0.66 | 4.48 |
| REV-FB | 19-Jun-18 | 5 | I-0.2 | 0.77 | 0.68 | 4.60 |
| REV-FB | 19-Jun-18 | 10 | I-0.2 | 1.22 | 0.28 | 1.91 |
| REV-FB | 19-Jun-18 | 12 | I-0.2 | 1.15 | 0.14 | 0.93 |
| REV-FB | 19-Jun-18 | 0 | I-2.0 | 0.33 | 0.20 | 1.35 |
| REV-FB | 19-Jun-18 | 1 | I-2.0 | 0.37 | 0.30 | 1.99 |
| REV-FB | 19-Jun-18 | 2 | I-2.0 | 0.44 | 0.29 | 1.95 |
| REV-FB | 19-Jun-18 | 5 | I-2.0 | 0.43 | 0.28 | 1.91 |
| REV-FB | 19-Jun-18 | 10 | I-2.0 | 0.41 | 0.12 | 0.82 |
| REV-FB | 19-Jun-18 | 12 | I-2.0 | 0.42 | 0.06 | 0.38 |
| REV-FB | 19-Jun-18 | 0 | I-20.0 | 0.08 | 0.07 | 0.46 |
| REV-FB | 19-Jun-18 | 1 | I-20.0 | 0.07 | 0.10 | 0.65 |

| Station | Date | Depth (m) | Filter Size (µm) | Chl (mg/m$^3$) | PP (mg C/m$^3$/h) | PP (mg C/m$^3$/day) |
|---|---|---|---|---|---|---|
| REV-FB | 19-Jun-18 | 2 | I-20.0 | 0.07 | 0.10 | 0.65 |
| REV-FB | 19-Jun-18 | 5 | I-20.0 | 0.06 | 0.11 | 0.73 |
| REV-FB | 19-Jun-18 | 10 | I-20.0 | 0.07 | 0.05 | 0.34 |
| REV-FB | 19-Jun-18 | 12 | I-20.0 | 0.07 | 0.02 | 0.11 |
| REV-FB | 24-Jul-18 | 0 | I-0.2 | 1.18 | 0.68 | 5.90 |
| REV-FB | 24-Jul-18 | 1 | I-0.2 | 0.98 | 1.01 | 8.77 |
| REV-FB | 24-Jul-18 | 2 | I-0.2 | 0.89 | 1.32 | 11.50 |
| REV-FB | 24-Jul-18 | 5 | I-0.2 | 1.15 | 0.90 | 7.83 |
| REV-FB | 24-Jul-18 | 10 | I-0.2 | 0.38 | 0.66 | 5.74 |
| REV-FB | 24-Jul-18 | 15 | I-0.2 | 0.85 | 0.25 | 2.20 |
| REV-FB | 24-Jul-18 | 0 | I-2.0 | 0.69 | 0.49 | 4.23 |
| REV-FB | 24-Jul-18 | 1 | I-2.0 | 0.65 | 0.66 | 5.72 |
| REV-FB | 24-Jul-18 | 2 | I-2.0 | 0.57 | 0.82 | 7.13 |
| REV-FB | 24-Jul-18 | 5 | I-2.0 | 0.53 | 0.82 | 7.13 |
| REV-FB | 24-Jul-18 | 10 | I-2.0 | 0.39 | 0.46 | 4.03 |
| REV-FB | 24-Jul-18 | 15 | I-2.0 | 0.26 | 0.16 | 1.36 |
| REV-FB | 24-Jul-18 | 0 | I-20.0 | 0.09 | 0.26 | 2.26 |
| REV-FB | 24-Jul-18 | 1 | I-20.0 | 0.05 | 0.37 | 3.20 |
| REV-FB | 24-Jul-18 | 2 | I-20.0 | 0.09 | 0.45 | 3.90 |
| REV-FB | 24-Jul-18 | 5 | I-20.0 | 0.12 | 0.49 | 4.30 |
| REV-FB | 24-Jul-18 | 10 | I-20.0 | 0.10 | 0.19 | 1.69 |
| REV-FB | 24-Jul-18 | 15 | I-20.0 | 0.11 | 0.07 | 0.58 |
| REV-FB | 21-Aug-18 | 0 | I-0.2 | 0.83 | 0.88 | 6.47 |
| REV-FB | 21-Aug-18 | 1 | I-0.2 | 0.83 | 1.07 | 7.87 |
| REV-FB | 21-Aug-18 | 2 | I-0.2 | 0.72 | 1.50 | 11.04 |
| REV-FB | 21-Aug-18 | 5 | I-0.2 | 0.66 | 1.37 | 10.10 |
| REV-FB | 21-Aug-18 | 10 | I-0.2 | 0.56 | 0.96 | 7.09 |
| REV-FB | 21-Aug-18 | 15 | I-0.2 | 0.72 | 0.41 | 3.05 |
| REV-FB | 21-Aug-18 | 18 | I-0.2 | 0.57 | 0.11 | 0.84 |
| REV-FB | 21-Aug-18 | 0 | I-2.0 | 0.26 | 0.47 | 3.49 |
| REV-FB | 21-Aug-18 | 1 | I-2.0 | 0.32 | 0.61 | 4.47 |
| REV-FB | 21-Aug-18 | 2 | I-2.0 | 0.34 | 0.84 | 6.20 |
| REV-FB | 21-Aug-18 | 5 | I-2.0 | 0.26 | 0.67 | 4.93 |
| REV-FB | 21-Aug-18 | 10 | I-2.0 | 0.28 | 0.49 | 3.62 |
| REV-FB | 21-Aug-18 | 15 | I-2.0 | 0.33 | 0.22 | 1.61 |
| REV-FB | 21-Aug-18 | 18 | I-2.0 | 0.37 | 0.05 | 0.36 |
| REV-FB | 21-Aug-18 | 0 | I-20.0 | 0.04 | 0.08 | 0.60 |
| REV-FB | 21-Aug-18 | 1 | I-20.0 | 0.05 | 0.12 | 0.86 |
| REV-FB | 21-Aug-18 | 2 | I-20.0 | 0.04 | 0.14 | 1.00 |
| REV-FB | 21-Aug-18 | 5 | I-20.0 | 0.04 | 0.13 | 0.95 |
| REV-FB | 21-Aug-18 | 10 | I-20.0 | 0.04 | 0.08 | 0.56 |
| REV-FB | 21-Aug-18 | 15 | I-20.0 | 0.03 | 0.03 | 0.21 |
| REV-FB | 21-Aug-18 | 18 | I-20.0 | 0.04 | 0.01 | 0.09 |
| REV-FB | 18-Sep-18 | 0 | I-0.2 | 1.10 | 1.23 | 9.01 |
| REV-FB | 18-Sep-18 | 1 | I-0.2 | 0.98 | 1.62 | 11.87 |
| REV-FB | 18-Sep-18 | 2 | I-0.2 | 0.94 | 2.03 | 14.87 |
| REV-FB | 18-Sep-18 | 5 | I-0.2 | 0.88 | 1.62 | 11.86 |
| REV-FB | 18-Sep-18 | 10 | I-0.2 | 0.51 | 0.52 | 3.79 |

| Station | Date | Depth (m) | Filter Size (µm) | Chl (mg/m³) | PP (mg C/m³/h) | PP (mg C/m³/day) |
|---|---|---|---|---|---|---|
| REV-FB | 18-Sep-18 | 15 | I-0.2 | 0.22 | 0.10 | 0.72 |
| REV-FB | 18-Sep-18 | 0 | I-2.0 | 0.36 | 0.71 | 5.19 |
| REV-FB | 18-Sep-18 | 1 | I-2.0 | 0.35 | 1.01 | 7.43 |
| REV-FB | 18-Sep-18 | 2 | I-2.0 | 0.28 | 1.33 | 9.72 |
| REV-FB | 18-Sep-18 | 5 | I-2.0 | 0.29 | 1.08 | 7.93 |
| REV-FB | 18-Sep-18 | 10 | I-2.0 | 0.22 | 0.33 | 2.41 |
| REV-FB | 18-Sep-18 | 15 | I-2.0 | 0.14 | 0.03 | 0.25 |
| REV-FB | 18-Sep-18 | 0 | I-20.0 | 0.04 | 0.06 | 0.42 |
| REV-FB | 18-Sep-18 | 1 | I-20.0 | 0.04 | 0.08 | 0.58 |
| REV-FB | 18-Sep-18 | 2 | I-20.0 | 0.04 | 0.14 | 1.05 |
| REV-FB | 18-Sep-18 | 5 | I-20.0 | 0.02 | 0.10 | 0.77 |
| REV-FB | 18-Sep-18 | 10 | I-20.0 | 0.03 | 0.03 | 0.20 |
| REV-FB | 18-Sep-18 | 15 | I-20.0 | 0.03 | 0.01 | 0.05 |

# Appendix C Integrated Chlorophyll and Primary Productivity

**Table C1** Integrated chlorophyll *a* (mg Chl *a*/m²) for Kinbasket and Revelstoke Reservoir in 2017-2018. Stations are KB = Kinbasket-Forebay, RM = Revelstoke-Middle (also called Downie), RF = Revelstoke-Forebay.

| Year | Month | Chlorophyll a (mg Chl *a*/m²) | | |
|---|---|---|---|---|
| | | KB | RM | RF |
| 2017 | Jun | 19.4 | 13.2 | 16.4 |
| 2017 | Jul | 24.9 | 26.4 | 16.3 |
| 2017 | Aug | 18.3 | 17.2 | 22.4 |
| 2017 | Sep | 27.8 | 9.2 | 6.9 |
| **2017** | **Mean** | 22.6 | 16.5 | 15.5 |
| 2018 | Jun | 35.0 | 8.8 | 12.0 |
| 2018 | Jul | 35.4 | 14.4 | 12.0 |
| 2018 | Aug | 29.2 | 9.3 | 11.9 |
| 2018 | Sep | 23.6 | 10.4 | 10.0 |
| **2018** | **Mean** | 30.8 | 10.7 | 11.5 |

**Table C2** Total daily primary productivity (mg C/m²/d) in Kinbasket and Revelstoke in 2002 and 2008-2018.

| Year | Month | Primary Productivity (mg C/m²/d) | | |
|---|---|---|---|---|
| | | KB | RM | RF |
| 2002 | Aug | 77.6 | - | - |
| 2008 | Jul | 84.4 | 33.6 | 51.8 |
| 2008 | Aug | 42.2 | 9.6 | 13.4 |
| 2008 | Sep | 25.3 | 11.0 | 18.8 |
| 2009 | Jun | 61.9 | 18.4 | 30.6 |
| 2009 | Jul | 22.6 | 19.8 | 54.9 |
| 2009 | Aug | 34.1 | 18.5 | 25.3 |
| 2009 | Sep | 26.7 | 15.1 | 1.4 |
| 2010 | Jun | 30.2 | 28.4 | 66.4 |
| 2010 | Jul | 72.3 | 41.2 | 20.4 |
| 2010 | Aug | 106.2 | 38.3 | 35.1 |

| Year | Month | Primary Productivity (mg C/m²/d) | | |
|---|---|---|---|---|
| | | KB | RM | RF |
| 2010 | Sept | 149.7 | 45.0 | 71.8 |
| 2011 | Jun | 46.2 | 54.1 | 57.9 |
| 2011 | Jul | 75.3 | 74.1 | 80.5 |
| 2011 | Aug | - | 61.2 | 69.2 |
| 2011 | Sep | - | 91.3 | 77.6 |
| 2012 | Jun | 26.4 | 11.6 | 23.0 |
| 2012 | Jul | 77 | 26.5 | 114.2 |
| 2012 | Aug | 52.7 | 58.5 | 78.7 |
| 2012 | Sep | 98.7 | 51.4 | 99.3 |
| 2013 | Jun | 179.1 | 78.2 | 59.8 |
| 2013 | Jul | 122 | 63.5 | 75.2 |
| 2013 | Aug | 89.5 | 59.6 | 76.8 |
| 2013 | Sept | 161 | 182.5 | 95.5 |
| 2014 | Jun | 156.5 | 143.0 | 55.0 |
| 2014 | Jul | 87.8 | 97.6 | 186.6 |
| 2014 | Aug | 97.3 | 99.8 | 125.9 |
| 2014 | Sep | 262.1 | 131.6 | 132.4 |
| 2015 | Jun | 50.5 | 33.2 | 21.2 |
| 2015 | Jul | 190.4 | 75.8 | 126.5 |
| 2015 | Aug | 191.4 | 64.8 | 135.2 |
| 2015 | Sep | 177.7 | 150.3 | 361.7 |
| 2016 | Jun | 217.9 | 44.8 | 47.8 |
| 2016 | Jul | 51.6 | 61.3 | 117.8 |
| 2016 | Aug | 126.8 | 58.2 | 111.8 |
| 2016 | Sep | 34.7 | 48.5 | 70.1 |
| 2017 | Jun | 77.7 | 114.8 | 60.5 |
| 2017 | Jul | 83.2 | 99.4 | 141.0 |
| 2017 | Aug | 138.9 | 117.9 | 116.2 |
| 2017 | Sep | 313.5 | 84.7 | 196.1 |
| 2018 | Jun | 214.7 | 46.3 | 41.1 |
| 2018 | Jul | 187.7 | 102.6 | 100.3 |
| 2018 | Aug | 171.5 | 125.9 | 122.5 |
| 2018 | Sep | 97.7 | 127.1 | 114.3 |
| 2008 | Mean | 50.6 | 6.0 | 9.3 |
| 2009 | Mean | 36.4 | 17.9 | 28.1 |
| 2010 | Mean | 90.0 | 38.0 | 48.0 |
| 2011 | Mean | 60.8 | 70.2 | 71.3 |
| 2012 | Mean | 63.7 | 37.0 | 78.8 |
| 2013 | Mean | 137.9 | 96.0 | 76.8 |
| 2014 | Mean | 150.9 | 118.0 | 125.0 |
| 2015 | Mean | 152.5 | 81.0 | 161.2 |
| 2016 | Mean | 107.8 | 53.2 | 86.9 |
| 2017 | Mean | 153.3 | 104.2 | 128.5 |
| 2018 | Mean | 167.9 | 100.5 | 94.5 |

*Appendix 6*

*Phytoplankton*
*Kinbasket and Revelstoke Reservoirs, 2017*

*Darren Brandt*
*Advanced Eco-Solutions*

# PHYTOPLANKTON POPULATIONS IN KINBASKET AND REVELSTOKE RESERVOIRS, UPPER COLUMBIA BASIN, BRITISH COLUMBIA – 2017

PREPARED FOR:

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V0E 2S0

By

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**August 2019**

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# SECTION 1.0 INTRODUCTION

## *1.1 Background & Study Purpose*

Kinbasket is the first of 3 large reservoirs on the upper reaches of the Columbia River Basin in Canada. It was created upon completion of the Mica Dam over 30 years ago and its discharge flows directly to the upper reaches of Revelstoke Reservoir, the second in the series. Revelstoke Reservoir discharges to the Columbia River and Upper Arrow Lakes Reservoir, the third in the series at the city of Revelstoke, BC. Both Kinbasket and Revelstoke Reservoirs are assumed to be oligotrophic, with low concentrations of total dissolved phosphorus (TDP), low phytoplankton and zooplankton biomass, and low fish production, as is the case in the Arrow Lakes Reservoir which is immediately downstream of Kinbasket and Revelstoke Reservoirs (Pieters et al., 1998). It is hypothesized that one of the factors leading to the low production status of both ecosystems is 'oligotrophication,' or 'nutrient depletion', caused by reservoir aging; i.e. increased water retention increases rates of nutrient utilization within the reservoir as well as increased rates of sedimentation of organic and inorganic particulate carbon (C), i.e. nutrient trapping (Stockner et al. 2000, Pieters et al. 1998, 1999).

This study is part of CLBMON-3 Kinbasket and Revelstoke Reservoirs Ecological Productivity Monitoring under BC Hydro's Columbia River Water Use Plan. Results from 2008 through 2017. In addition to the data from previous studies will permit further commentary on observed changes in phytoplankton density and biomass among depths, stations (sectors) and between years.

# SECTION 2.0 METHODS

## *2.1 Sampling Protocol and Station Locations*

Samples were collected from discrete depths at four stations in Kinbasket Reservoir (Canoe, Columbia, Wood, and Forebay) in 2017. Samples were collected monthly from April through October for 3 stations 9Forebay, Canoe, and Columbia) and April through September for one station (Wood). Samples from three stations in Revelstoke Reservoir (Revelstoke-Forebay, Revelstoke-Mid and Revelstoke-Upper) were taken monthly from April to October in 2017. Phytoplankton communities and density change with depth. Due to this characteristic, discrete samples were taken at depths of 2, 5, 10, 15, and 25 meters. An aliquot of each of these samples was preserved with Lugol's for identification and enumeration.

Two depth strata: the epilimnion and hypolimnion were assessed by creating composites of discrete samples. The mean of the densities of taxa from samples collected at 2, 5, and 10 meters were used to determine epilimnetic density and biovolume while samples from 15 and, 25 meters were used to determine the hypolimnetic density and biovolumes. In 2009 and 2008, samples taken at various depths were composited in the field and then identified and enumerated in the laboratory. The change in methodology in 2010 through 2017 is compatible with the previous sampling methodology; however, the taxa richness could be higher in the composited samples from 2010 through 2017 since counting multiple samples and then compositing them after identification and enumeration will result in an increase in the fraction of the sample counted than counting a single field composited sample.

At each station an aliquot of composited water from the epilimnion (0-10 meters) and hypolimnion (15-25 meters) was taken for bacterial and pico-cyanobacterial enumeration. Bacteria samples were preserved with three drops of 25% glutaraldehyde and placed in a small, brown polyethylene bottle.

## *2.2 Enumeration Protocol*

### *2.2.1 Phytoplankton*

Phytoplankton samples were preserved in the field in acid Lugol's iodine preservative and shipped to Advanced Eco-Solutions Inc. in Newman Lake, WA for enumeration. The samples were gently shaken for 60 seconds and poured into 25 mL settling chambers and allowed to settle for a minimum of 3 hrs prior to quantitative enumeration using the Utermohl Method (Utermohl 1958). Counts were done using a plankton microscope. All cells within a random transect of 3.5 mm in length were counted at high power (900X magnification) that permitted a semi-quantitative enumeration of minute (<2 µ) autotrophic pico-cyanobacteria cells (1.0-2.0 µ) [Class Cyanophyceae], and of small, delicate auto-, mixo- and heterotrophic nano-flagellates (2.0-20.0 µ) [Classes Chrysophyceae and Cryptophyceae]. Comments on the relative density of ciliates in each sample were also noted on count sheets. Where feasible, from 250-300 cells were enumerated in each sample to assure counting consistency and statistical accuracy (Lund et al. 1958). The compendium of Canter-Lund and Lund (1995) was used as a taxonomic reference. The primary taxonomist was Nichole Manley of Advanced Eco-Solutions Inc.

### *2.2.2 Bacteria and Pico-cyanobacteria*

Fifteen milliliters of sample water was filtered for pico-cyano bacteria density determination. A second aliquot of 5 mL was inoculated with a fluorescent dye (DAPI) for autotrophic picoplankton (heterotrophic bacteria) determination. Both of these sub-samples were filtered through black 0.2 polycarbonate Nucleopore filters. The bacteria become trapped on the surface of the filters. The number of cells in a given filter area was then used to determine bacteria densities. Pico-cyano bacteria densities were determined using direct count epiflourescence method described by MacIsaac et al. (1993 and heterotrophic bacteria was enumerated using the epiflourescence method described by MacIsaac and Stockner (1993). Eight to 32 random fields on each of the filters were counted at 1000x magnification using either blue-band excitation filter (450-490nm) for pico-cyano bacteria or a UV wide-band excitation filter (397-560nm) for heterotrophic bacteria density determination. Heterotrophic bacteria and pico-cyanobacterial densities are reported as cells/mL. Pico-plankton enumeration is an emerging plankton technique and is not yet commonly used in other lake systems. To facilitate comparison of phytoplankton densities in Revelstoke and Kinbasket to other systems and to previous data from the reservoirs the densities of picoplankton were not added to the total phytoplankton counts. The total density of autotrophs can be calculated by summing the phytoplankton and picoplankton if so desired.

# SECTION 3.0 RESULTS

## 3.1 Study Limitations

As a caveat, it should be noted that the number of stations sampled (four in Kinbasket and three in Revelstoke), and sampling frequency (monthly) provide only an approximation of phytoplankton population density, biomass, diversity, and spatiotemporal variability in two of the largest Upper Columbia Basin's reservoirs. Interpretations in this report are made on observed patterns of only two variables, *Density* (cells/mL) of groups and their respective taxonomic Classes, and *Biovolume* ($mm^3/L$) or biomass of groups and Classes. Thus, this report should essentially be considered more as an 'overview' of the current status of phytoplankton populations in Kinbasket and Revelstoke rather than a comprehensive 'synthesis' of phytoplankton community dynamics.

## 3.2 Phytoplankton Density and Biovolume by Class – 2017

A complete list of the taxa identified in Kinbasket and Revelstoke Reservoirs in 2017 can be found in Appendix A. The taxa are organized into major taxonomic groups that are used throughout the report.

### 3.2.1 Epilimnion

**Kinbasket**

In Kinbasket Reservoir blue-greens (cyanophytes)were the most abundant group in the epilimnion, followed by flagellates (chryso/cryptophytes), with greens (chlorophytes), diatoms (bacillariophytes), and dinoflagellates (dinophytes) considerably less abundant (Table 1 and Figure 1). In terms of density, the major taxa contributing to the high density of the flagellates were microflagellates. The cyanophytes were dominated by Synechococcus (coccoids). Both of these taxa account for the biggest increase in density in the reservoir in 2017. Peak phytoplankton density occurred at the Wood Station in June (12,838 cells/mL) (Figure 3).The Canoe Station had the lowest phytoplankton density at 2,130 cells/mL in October. On a seasonal average the Canoe and Columbia stations had similar mean phytoplankton densities, both higher than the Forebay and Wood stations.

In terms of biovolume, the major contributors throughout the season were greens, flagellates and blue-greens, followed by diatoms, and dinoflagellates (Figure 2). The Columbia station had the highest seasonal mean biomass of the stations (Table 2 and Figure 4).

**Table 1 Kinbasket Reservoir mean phytoplankton density (Cells/mL) by group and month from the 2, 5 and 10 meter laboratory composites in 2017**

| Station | Group | April | May | June | July | Aug | Sept | Oct | Seasonal Average |
|---|---|---|---|---|---|---|---|---|---|
| Kin-Canoe | Blue-greens | 3,642 | 6,204 | 5,846 | 4,065 | 4,984 | 2,984 | 976 | 4,100 |
| | Coccoid Greens, Desmids, etc. | 317 | 642 | 1,114 | 862 | 1,016 | 520 | 179 | 664 |
| | Diatoms | 24 | 73 | 228 | 634 | 561 | 455 | 163 | 305 |
| | Dinoflagellates | 24 | 81 | 171 | 203 | 65 | 24 | 8 | 82 |
| | Flagellates | 3,081 | 3,366 | 5,049 | 3,594 | 3,634 | 2,309 | 805 | 3,120 |
| | **Sum of All Groups** | 7,090 | 10,366 | 12,407 | 9,358 | 10,261 | 6,293 | 2,130 | 8,272 |
| Kin-Columbia | Blue-greens | 1,439 | 3,114 | 3,854 | 3,675 | 4,260 | 3,797 | 968 | 3,015 |
| | Coccoid Greens, Desmids, etc. | 317 | 829 | 902 | 1,016 | 1,081 | 2,163 | 73 | 912 |
| | Diatoms | 33 | 57 | 268 | 878 | 691 | 455 | 163 | 364 |
| | Dinoflagellates | 16 | 138 | 154 | 187 | 81 | 81 | 73 | 105 |
| | Flagellates | 1,740 | 2,984 | 4,016 | 3,862 | 3,520 | 3,618 | 1,008 | 2,964 |
| | **Sum of All Groups** | 3,545 | 7,122 | 9,196 | 9,618 | 9,635 | 10,114 | 2,285 | 7,359 |
| Kin-Forebay | Blue-greens | 3,480 | 2,252 | 2,976 | 3,163 | 4,187 | 3,756 | 2,886 | 3,243 |
| | Coccoid Greens, Desmids, etc. | 382 | 748 | 968 | 935 | 724 | 715 | 577 | 721 |
| | Diatoms | 16 | 8 | 285 | 748 | 854 | 585 | 211 | 387 |
| | Dinoflagellates | 16 | 114 | 146 | 244 | 89 | 89 | 65 | 109 |
| | Flagellates | 2,569 | 2,651 | 2,886 | 2,618 | 2,228 | 2,520 | 2,821 | 2,613 |
| | **Sum of All Groups** | 6,464 | 5,773 | 7,260 | 7,708 | 8,082 | 7,667 | 6,561 | 7,073 |
| Kin-Wood | Blue-greens | 1,659 | 2,285 | 5,716 | 4,008 | 3,886 | 2,756 | | 3,385 |
| | Coccoid Greens, Desmids, etc. | 382 | 959 | 1,106 | 659 | 545 | 959 | | 768 |
| | Diatoms | 24 | 16 | 154 | 732 | 846 | 585 | | 393 |
| | Dinoflagellates | 16 | 211 | 203 | 138 | 81 | 106 | | 126 |
| | Flagellates | 2,512 | 4,350 | 5,659 | 3,090 | 2,073 | 2,024 | | 3,285 |
| | **Sum of All Groups** | 4,594 | 7,821 | 12,838 | 8,626 | 7,431 | 6,431 | | 7,957 |

**Table 2 Kinbasket Reservoir mean phytoplankton biovolume ($mm^3/L$) by group and month from the 2, 5 and 10 meter laboratory composites in 2017**

| Station | Group | April | May | June | July | Aug | Sept | Oct | Seasonal Average |
|---|---|---|---|---|---|---|---|---|---|
| Kin-Canoe | Blue-greens | 0.0143 | 0.0424 | 0.0365 | 0.0368 | 0.0328 | 0.0252 | 0.0098 | 0.0283 |
| | Coccoid Greens, Desmids, etc. | 0.0161 | 0.0568 | 0.1006 | 0.2020 | 0.2217 | 0.1062 | 0.0097 | 0.1019 |
| | Diatoms | 0.0031 | 0.0085 | 0.0531 | 0.0694 | 0.0725 | 0.0392 | 0.0215 | 0.0382 |
| | Dinoflagellates | 0.0049 | 0.0089 | 0.0240 | 0.0427 | 0.0114 | 0.0069 | 0.0033 | 0.0146 |
| | Flagellates | 0.0311 | 0.0574 | 0.1870 | 0.0859 | 0.0793 | 0.0554 | 0.0201 | 0.0737 |
| | **Sum of All Groups** | 0.0695 | 0.1741 | 0.4012 | 0.4368 | 0.4177 | 0.2329 | 0.0644 | 0.2567 |
| Kin-Columbia | Blue-greens | | | | | | | | |
| | Coccoid Greens, Desmids, etc. | 0.0057 | 0.0206 | 0.0333 | 0.0293 | 0.0358 | 0.0252 | 0.0039 | 0.0220 |
| | Diatoms | 0.0194 | 0.1426 | 0.1407 | 0.2726 | 0.1332 | 0.3002 | 0.0462 | 0.1507 |
| | Dinoflagellates | 0.0028 | 0.0067 | 0.0439 | 0.1155 | 0.0514 | 0.0435 | 0.0512 | 0.0450 |
| | Flagellates | 0.0033 | 0.0191 | 0.0268 | 0.0325 | 0.0069 | 0.0138 | 0.0154 | 0.0168 |
| | **Sum of All Groups** | 0.0442 | 0.0703 | 0.0932 | 0.0910 | 0.1052 | 0.0850 | 0.0329 | 0.0745 |
| Kin-Forebay | Blue-greens | 0.0753 | 0.2593 | 0.3379 | 0.5408 | 0.3324 | 0.4677 | 0.1497 | 0.3090 |
| | Coccoid Greens, Desmids, etc. | | | | | | | | |
| | Diatoms | 0.0157 | 0.0155 | 0.0328 | 0.0246 | 0.0403 | 0.0270 | 0.0155 | 0.0245 |
| | Dinoflagellates | 0.0828 | 0.1258 | 0.1872 | 0.1769 | 0.0954 | 0.1063 | 0.0764 | 0.1216 |
| | Flagellates | 0.0020 | 0.0012 | 0.0508 | 0.0942 | 0.0598 | 0.0427 | 0.0130 | 0.0377 |
| | **Sum of All Groups** | 0.0033 | 0.0256 | 0.0240 | 0.0455 | 0.0630 | 0.0199 | 0.0073 | 0.0269 |
| Kin-Wood | Blue-greens | 0.0275 | 0.0737 | 0.0839 | 0.0718 | 0.0568 | 0.0679 | 0.0478 | 0.0613 |
| | Coccoid Greens, Desmids, etc. | 0.1313 | 0.2419 | 0.3786 | 0.4129 | 0.3153 | 0.2639 | 0.1601 | 0.2720 |
| | Diatoms | | | | | | | | |
| | Dinoflagellates | 0.0066 | 0.0160 | 0.0359 | 0.0260 | 0.0234 | 0.0289 | | 0.0228 |
| | Flagellates | 0.0424 | 0.1565 | 0.2264 | 0.1352 | 0.0829 | 0.1080 | | 0.1252 |
| | **Sum of All Groups** | 0.0022 | 0.0012 | 0.0280 | 0.0706 | 0.0778 | 0.0528 | | 0.0388 |

**Figure 1 Average phytoplankton density (Cells/mL) in Kinbasket Reservoir in 2017 derived from the 2, 5, 10 meter laboratory composites**

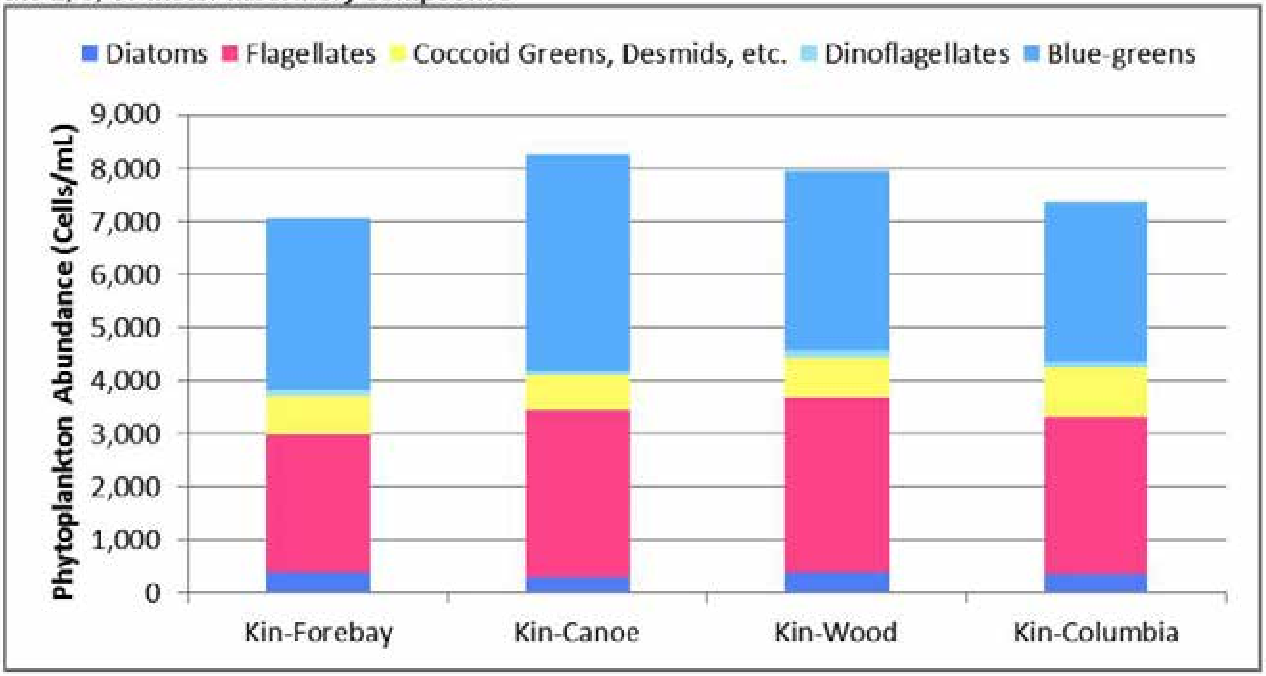



**Figure 2 Average phytoplankton biovolume (mm$^3$/L) in Kinbasket Reservoir in 2017 derived from the 2, 5, and 10 meter laboratory composites**

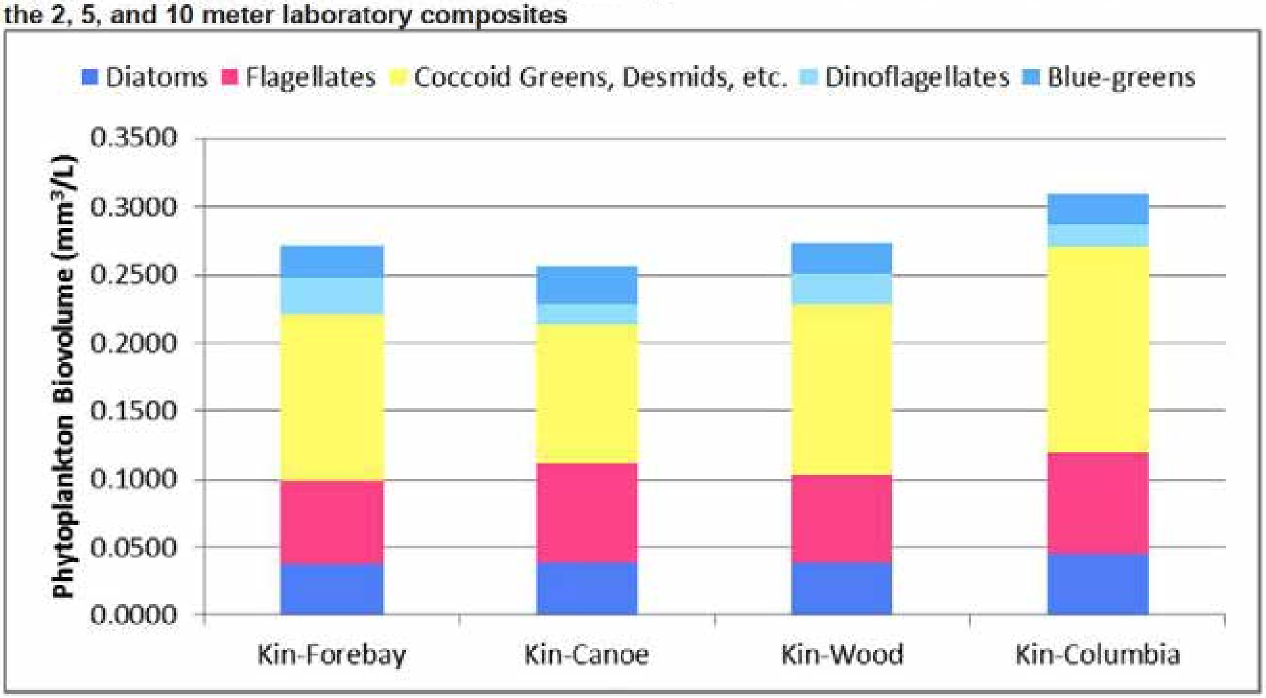


**Figure 3 Kinbasket mean epilimnetic phytoplankton density by month for 2017**

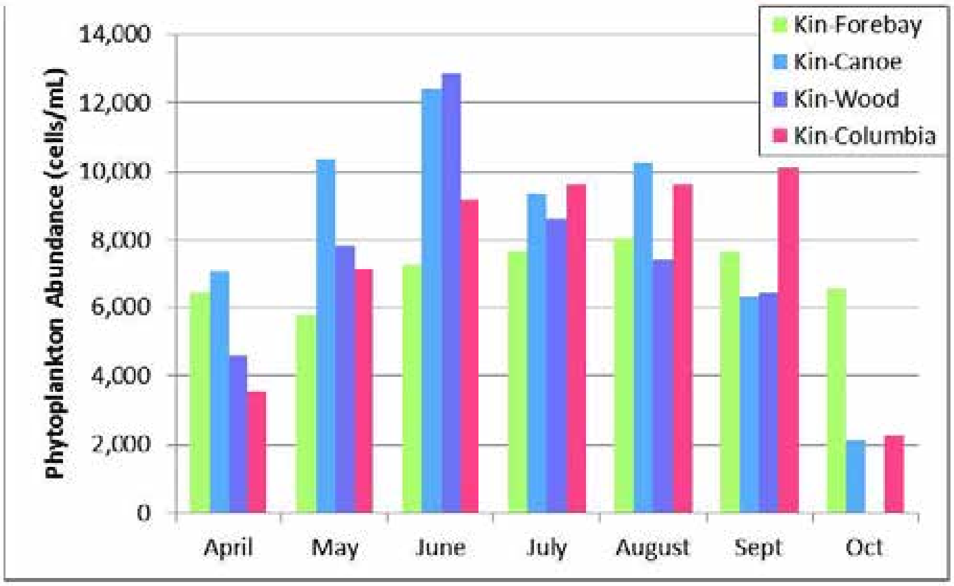
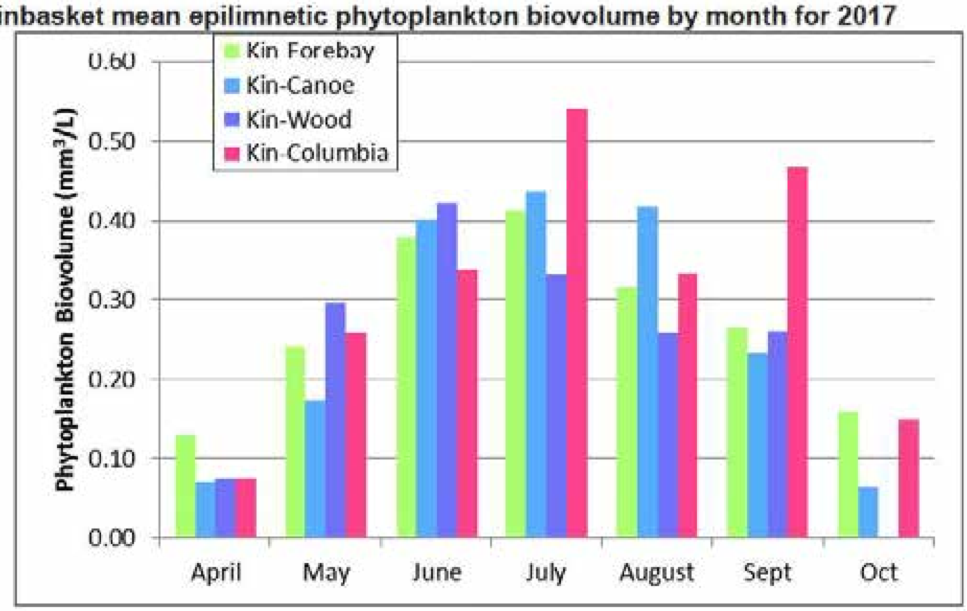



**Figure 4 Kinbasket mean epilimnetic phytoplankton biovolume by month for 2017**




## Revelstoke

The dominant taxonomic groups in Revelstoke are the blue-greens and flagellates (Table 3 and Figure 5). The mean overall cell density is slightly higher than those observed in Kinbasket (7,665 cells/mL) compared to Revelstoke's 9,623 cells/mL. Based on biovolume, the taxonomic groups in order of largest to smallest percentage of the phytoplankton community are greens, flagellates, and blue-greens, followed by diatoms and dinoflagellates (Table 4 and Figure 6).

Peak epilimnetic phytoplankton density occurred at the Forebay station in August and in terms of biovolume the peak occurred in June at the upper station (12,846 cells/mL and 0.3694 $mm^3/L$) (Figure 7 and Figure 8). The Middle station also had the lowest phytoplankton density (5,171 cells/mL), and biovolume (0.13 $mm^3/L$) in April.

**Table 3 Revelstoke Reservoir mean phytoplankton density (Cells/mL) by group and month from the 2, 5 and 10 meter laboratory composites 2017**

| Station | Group | April | May | June | July | Aug | Sept | Oct | Seasonal Average |
|---|---|---|---|---|---|---|---|---|---|
| Rev-Forebay | Blue-greens | 2610 | 3268 | 2488 | 7561 | 7870 | 6846 | 6447 | 5299 |
| | Coccoid Greens, Desmids, etc. | 602 | 1122 | 837 | 553 | 862 | 585 | 537 | 728 |
| | Diatoms | 130 | 138 | 138 | 301 | 179 | 154 | 33 | 153 |
| | Dinoflagellates | 65 | 154 | 57 | 81 | 138 | 122 | 106 | 103 |
| | Flagellates | 2106 | 2781 | 2228 | 2512 | 3797 | 2951 | 4829 | 3029 |
| | **Sum of All Groups** | 5512 | 7464 | 5748 | 11009 | 12846 | 10659 | 11952 | 9313 |
| Rev-Mid | Blue-greens | 2195 | 5049 | 4862 | 7529 | 4667 | 4854 | 5675 | 4976 |
| | Coccoid Greens, Desmids, etc. | 423 | 935 | 1195 | 642 | 911 | 618 | 683 | 772 |
| | Diatoms | 49 | 187 | 138 | 398 | 81 | 114 | 146 | 159 |
| | Dinoflagellates | 81 | 171 | 195 | 138 | 146 | 114 | 187 | 148 |
| | Flagellates | 2423 | 4545 | 4342 | 4016 | 3309 | 3073 | 5147 | 3836 |
| | **Sum of All Groups** | 5171 | 10887 | 10732 | 12724 | 9114 | 8773 | 11838 | 9891 |
| Rev-Upper | Blue-greens | 2301 | 6090 | 4203 | 5577 | 5716 | 6301 | 3610 | 4828 |
| | Coccoid Greens, Desmids, etc. | 431 | 715 | 821 | 748 | 959 | 374 | 772 | 689 |
| | Diatoms | 73 | 260 | 228 | 106 | 114 | 146 | 114 | 149 |
| | Dinoflagellates | 16 | 122 | 187 | 106 | 138 | 65 | 138 | 110 |
| | Flagellates | 2455 | 4854 | 3992 | 4309 | 4431 | 4529 | 2642 | 3888 |
| | **Sum of All Groups** | 5277 | 12041 | 9431 | 10846 | 11358 | 11415 | 7277 | 9664 |

**Table 4 Revelstoke Reservoir mean phytoplankton biovolume ($mm^3/L$) by group and month from the 2, 5 and 10 meter laboratory composites in 2017**

| Station | Group | April | May | June | July | Aug | Sept | Oct | Seasonal Average |
|---|---|---|---|---|---|---|---|---|---|
| Rev-Forebay | Blue-greens | 0.0341 | 0.0396 | 0.0348 | 0.0394 | 0.0587 | 0.0417 | 0.0357 | 0.0406 |
| | Coccoid Greens, Desmids, etc. | 0.0437 | 0.3355 | 0.1227 | 0.0928 | 0.1261 | 0.0973 | 0.1304 | 0.1355 |
| | Diatoms | 0.0100 | 0.0227 | 0.0134 | 0.0308 | 0.0376 | 0.0183 | 0.0028 | 0.0194 |
| | Dinoflagellates | 0.0187 | 0.0199 | 0.0110 | 0.0183 | 0.0138 | 0.0183 | 0.0191 | 0.0170 |
| | Flagellates | 0.0297 | 0.0722 | 0.0675 | 0.0433 | 0.1035 | 0.0891 | 0.0623 | 0.0668 |
| | **Sum of All Groups** | 0.1362 | 0.4898 | 0.2494 | 0.2246 | 0.3397 | 0.2647 | 0.2503 | 0.2792 |
| Rev-Mid | Blue-greens | 0.0253 | 0.0526 | 0.0527 | 0.0528 | 0.0542 | 0.0347 | 0.0416 | 0.0449 |
| | Coccoid Greens, Desmids, etc. | 0.0346 | 0.1021 | 0.1807 | 0.0735 | 0.0925 | 0.1747 | 0.1779 | 0.1194 |
| | Diatoms | 0.0078 | 0.0294 | 0.0134 | 0.0742 | 0.0187 | 0.0154 | 0.0142 | 0.0247 |
| | Dinoflagellates | 0.0146 | 0.0220 | 0.0215 | 0.0268 | 0.0211 | 0.0199 | 0.0244 | 0.0215 |
| | Flagellates | 0.0468 | 0.1219 | 0.0752 | 0.0730 | 0.0748 | 0.0592 | 0.0908 | 0.0774 |
| | **Sum of All Groups** | 0.1291 | 0.3278 | 0.3436 | 0.3003 | 0.2613 | 0.3040 | 0.3489 | 0.2879 |
| Rev-Upper | Blue-greens | 0.0249 | 0.0531 | 0.0541 | 0.0745 | 0.0529 | 0.0496 | 0.0175 | 0.0467 |
| | Coccoid Greens, Desmids, etc. | 0.0345 | 0.1329 | 0.1649 | 0.1723 | 0.1419 | 0.0934 | 0.1216 | 0.1231 |
| | Diatoms | 0.0131 | 0.0394 | 0.0299 | 0.0122 | 0.0065 | 0.0176 | 0.0051 | 0.0177 |
| | Dinoflagellates | 0.0098 | 0.0297 | 0.0366 | 0.0093 | 0.0207 | 0.0085 | 0.0081 | 0.0175 |
| | Flagellates | 0.0523 | 0.1059 | 0.0839 | 0.0648 | 0.0923 | 0.0815 | 0.0511 | 0.0760 |
| | **Sum of All Groups** | 0.1346 | 0.3610 | 0.3694 | 0.3331 | 0.3144 | 0.2507 | 0.2035 | 0.2809 |

**Figure 5 Average phytoplankton density (Cells/mL) in Revelstoke Reservoir between April - September 2017 derived from the 2, 5, and 10 meter laboratory composites**

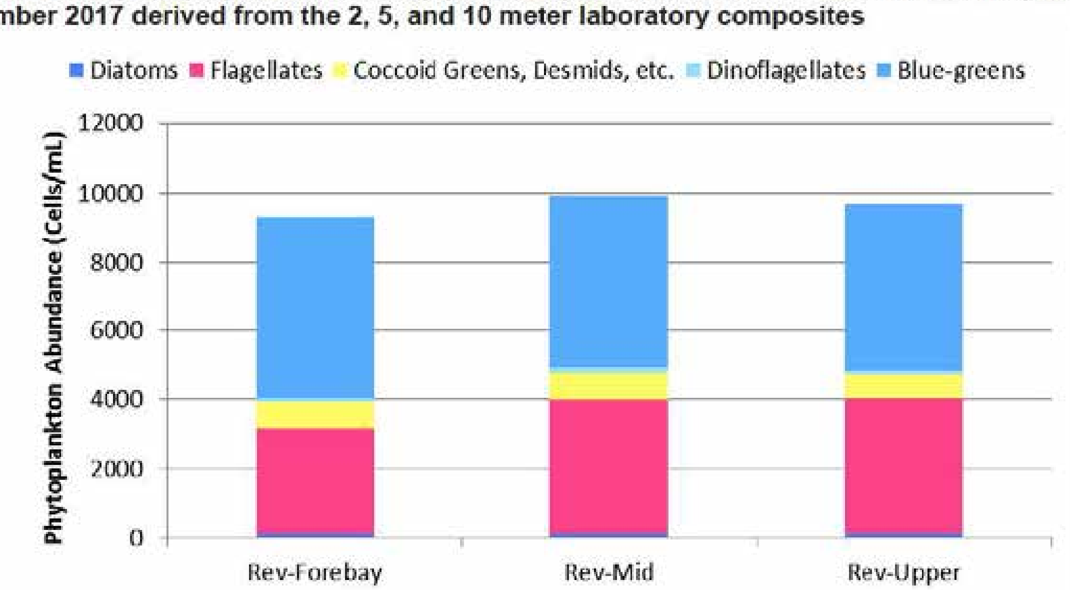


**Figure 6 Average phytoplankton biovolume (mm³/L) in Revelstoke Reservoir between May - October 2017 derived from the 2, 5, and 10 meter laboratory composites**

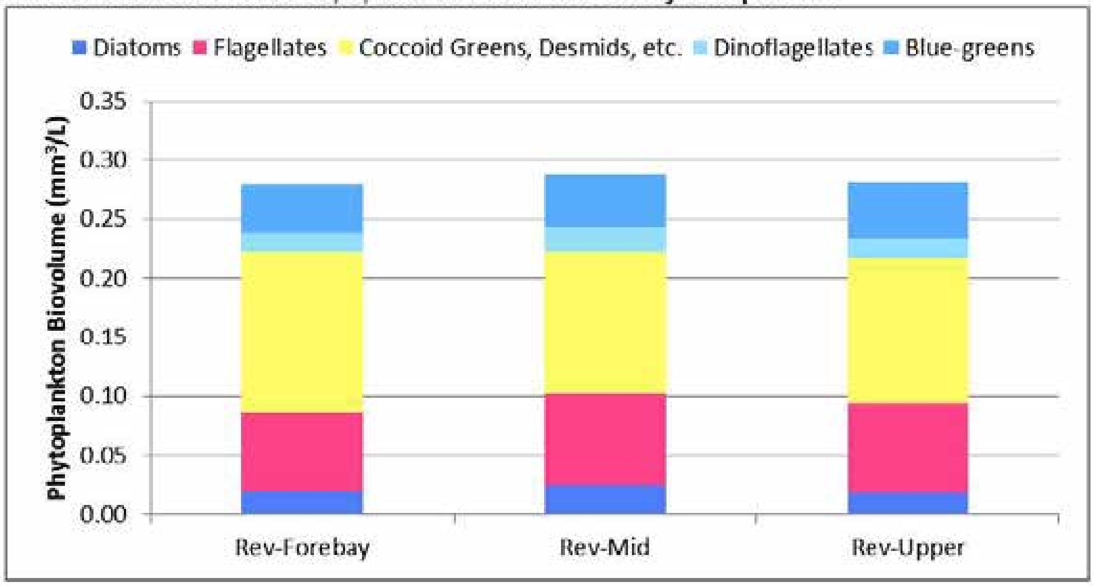



**Figure 7 Revelstoke mean epilimnetic phytoplankton density by month**

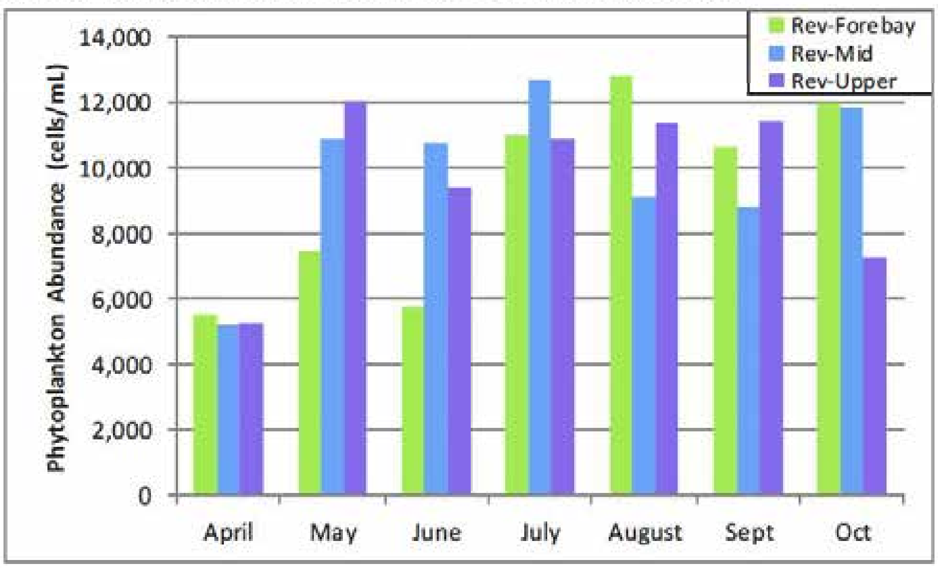
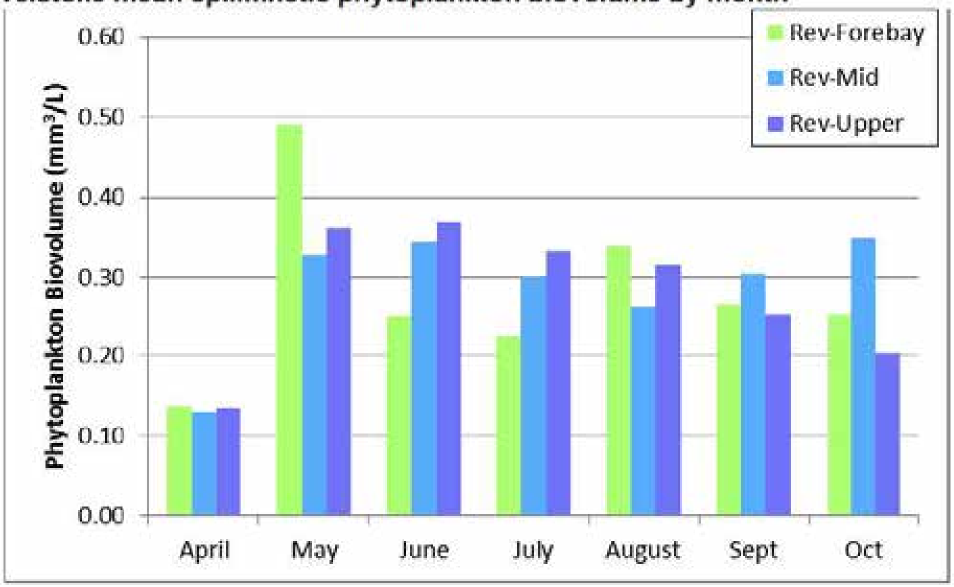


Figure 8 Revelstoke mean epilimnetic phytoplankton biovolume by month




### *3.2.2 Hypolimnion*

**Kinbasket**

Hypolimnetic phytoplankton densities in Kinbasket Reservoir were similar to epilimnetic densities. Blue-Greens were the most abundant group, followed by flagellates. Diatoms, greens and dinoflagellates were minor contributors to hypolimnetic phytoplankton density (Table 5 and Figure 9). In terms of biovolume, greens, blue-greens and flagellates were the largest contributors followed by diatoms and dinoflagellates (Table 6 and Figure 10). The Wood station had the highest seasonal average phytoplankton density (9,068 cells/mL) and the Columbia and Wood stations had the highest seasonal average of biovolume (0.27 $mm^3/L$). The Columbia station had the highest hypolimnetic phytoplankton cell densities of the year in July (Figure 11). As expected the hypolimnetic biovolume were higher in the summer months than the spring and fall (Figure 12).

**Table 5 Kinbasket Reservoir hypolimnion phytoplankton density (Cells/mL) by group and month from the 15, and 25 meter laboratory composites in 2017**

| Station | Group | April | May | June | July | Aug | Sept | Oct | Seasonal Average |
|---|---|---|---|---|---|---|---|---|---|
| Kin-Canoe | Blue-greens | 3964 | 4817 | 4573 | 4147 | 5012 | 3744 | 939 | 3885 |
| | Coccoid Greens, Desmids, etc. | 329 | 488 | 988 | 744 | 1659 | 976 | 341 | 789 |
| | Diatoms | 37 | 85 | 134 | 134 | 390 | 549 | 146 | 211 |
| | Dinoflagellates | 0 | 61 | 134 | 232 | 134 | 12 | 0 | 115 |
| | Flagellates | 2817 | 2915 | 3720 | 4207 | 4049 | 2695 | 695 | 3014 |
| | **Sum of All Groups** | 7147 | 8366 | 9549 | 9464 | 11244 | 7976 | 2122 | 7981 |
| Kin-Columbia | Blue-greens | 1671 | 2281 | 5573 | 6854 | 4866 | 4293 | 793 | 3761 |
| | Coccoid Greens, Desmids, etc. | 366 | 598 | 756 | 1463 | 988 | 768 | 37 | 711 |
| | Diatoms | 24 | 49 | 171 | 159 | 451 | 293 | 171 | 188 |
| | Dinoflagellates | 0 | 85 | 146 | 244 | 134 | 24 | 49 | 114 |
| | Flagellates | 1878 | 2720 | 5012 | 5878 | 4829 | 3098 | 1146 | 3509 |
| | **Sum of All Groups** | 3939 | 5732 | 11659 | 14598 | 11269 | 8476 | 2195 | 8267 |
| Kin-Forebay | Blue-greens | 1842 | 2561 | 2964 | 2488 | 5561 | 2866 | 3220 | 3072 |
| | Coccoid Greens, Desmids, etc. | 220 | 768 | 805 | 854 | 720 | 1244 | 524 | 733 |
| | Diatoms | 37 | 0 | 195 | 232 | 415 | 390 | 256 | 254 |
| | Dinoflagellates | 24 | 122 | 183 | 98 | 134 | 49 | 49 | 94 |
| | Flagellates | 2085 | 2915 | 2720 | 2634 | 2842 | 2500 | 3122 | 2688 |
| | **Sum of All Groups** | 4207 | 6366 | 6866 | 6305 | 9671 | 7049 | 7171 | 6805 |
| Kin-Wood | Blue-greens | 2110 | 1915 | 5098 | 8540 | 5415 | 4988 | | 5037 |
| | Coccoid Greens, Desmids, etc. | 366 | 744 | 854 | 1317 | 683 | 927 | | 815 |
| | Diatoms | 12 | 24 | 122 | 305 | 683 | 207 | | 226 |
| | Dinoflagellates | 12 | 110 | 183 | 171 | 24 | 134 | | 106 |
| | Flagellates | 2195 | 3183 | 5025 | 6504 | 4098 | 3890 | | 4397 |
| | **Sum of All Groups** | 4695 | 5976 | 11281 | 16837 | 10903 | 10147 | | 9068 |

Table 6 Kinbasket Reservoir phytoplankton biovolume (mm3/L) by group and month from the 15, and 25 meter laboratory composites in 2017

| Station | Group | April | May | June | July | Aug | Sept | Oct | Seasonal Average |
|---|---|---|---|---|---|---|---|---|---|
| Kin-Canoe | Blue-greens | 0.0187 | 0.0232 | 0.0304 | 0.0301 | 0.0347 | 0.0253 | 0.0156 | 0.0254 |
| | Coccoid Greens, Desmids, etc. | 0.0263 | 0.0374 | 0.1300 | 0.2425 | 0.2625 | 0.1565 | 0.0196 | 0.1250 |
| | Diatoms | 0.0043 | 0.0089 | 0.0249 | 0.0137 | 0.0262 | 0.0409 | 0.0159 | 0.0192 |
| | Dinoflagellates | 0.0000 | 0.0110 | 0.0183 | 0.0421 | 0.0171 | 0.0024 | 0.0000 | 0.0130 |
| | Flagellates | 0.0278 | 0.0449 | 0.0727 | 0.0843 | 0.0734 | 0.0747 | 0.0193 | 0.0567 |
| | **Sum of All Groups** | 0.0770 | 0.1254 | 0.2763 | 0.4126 | 0.4140 | 0.2997 | 0.0703 | 0.2393 |
| Kin-Columbia | Blue-greens | 0.0065 | 0.0122 | 0.0438 | 0.0368 | 0.0281 | 0.0349 | 0.0032 | 0.0237 |
| | Coccoid Greens, Desmids, etc. | 0.0210 | 0.0385 | 0.1127 | 0.4259 | 0.1537 | 0.1861 | 0.0915 | 0.1471 |
| | Diatoms | 0.0085 | 0.0110 | 0.0166 | 0.0348 | 0.0313 | 0.0421 | 0.0329 | 0.0253 |
| | Dinoflagellates | 0.0000 | 0.0098 | 0.0250 | 0.0494 | 0.0085 | 0.0055 | 0.0146 | 0.0161 |
| | Flagellates | 0.0445 | 0.0466 | 0.0733 | 0.1023 | 0.1025 | 0.0605 | 0.0237 | 0.0648 |
| | **Sum of All Groups** | 0.0806 | 0.1181 | 0.2715 | 0.6491 | 0.3242 | 0.3291 | 0.1659 | 0.2769 |
| Kin-Forebay | Blue-greens | 0.0075 | 0.0136 | 0.0258 | 0.0262 | 0.0441 | 0.0236 | 0.0161 | 0.0224 |
| | Coccoid Greens, Desmids, etc. | 0.0145 | 0.1446 | 0.1212 | 0.1136 | 0.1286 | 0.1978 | 0.1615 | 0.1260 |
| | Diatoms | 0.0029 | 0.0000 | 0.0349 | 0.0310 | 0.0509 | 0.0444 | 0.0146 | 0.0255 |
| | Dinoflagellates | 0.0073 | 0.0146 | 0.0390 | 0.0152 | 0.0274 | 0.0067 | 0.0067 | 0.0167 |
| | Flagellates | 0.0257 | 0.0974 | 0.0744 | 0.0618 | 0.0799 | 0.0740 | 0.0493 | 0.0661 |
| | **Sum of All Groups** | 0.0580 | 0.2703 | 0.2953 | 0.2478 | 0.3309 | 0.3465 | 0.2482 | 0.2567 |
| Kin-Wood | Blue-greens | 0.0114 | 0.0082 | 0.0470 | 0.0495 | 0.0348 | 0.0392 | | 0.0350 |
| | Coccoid Greens, Desmids, etc. | 0.0234 | 0.0894 | 0.1803 | 0.2376 | 0.0994 | 0.0728 | | 0.1172 |
| | Diatoms | 0.0012 | 0.0030 | 0.0235 | 0.0345 | 0.0500 | 0.0189 | | 0.0219 |
| | Dinoflagellates | 0.0098 | 0.0201 | 0.0250 | 0.0518 | 0.0012 | 0.0226 | | 0.0217 |
| | Flagellates | 0.0188 | 0.0824 | 0.0895 | 0.0701 | 0.0637 | 0.0812 | | 0.0710 |
| | **Sum of All Groups** | 0.0646 | 0.2032 | 0.3653 | 0.4436 | 0.2492 | 0.2347 | | 0.2668 |

**Figure 9 Average phytoplankton density (Cells/mL) in Kinbasket Reservoir between April - August 2017 derived from the 15, and 25 meter laboratory composites**

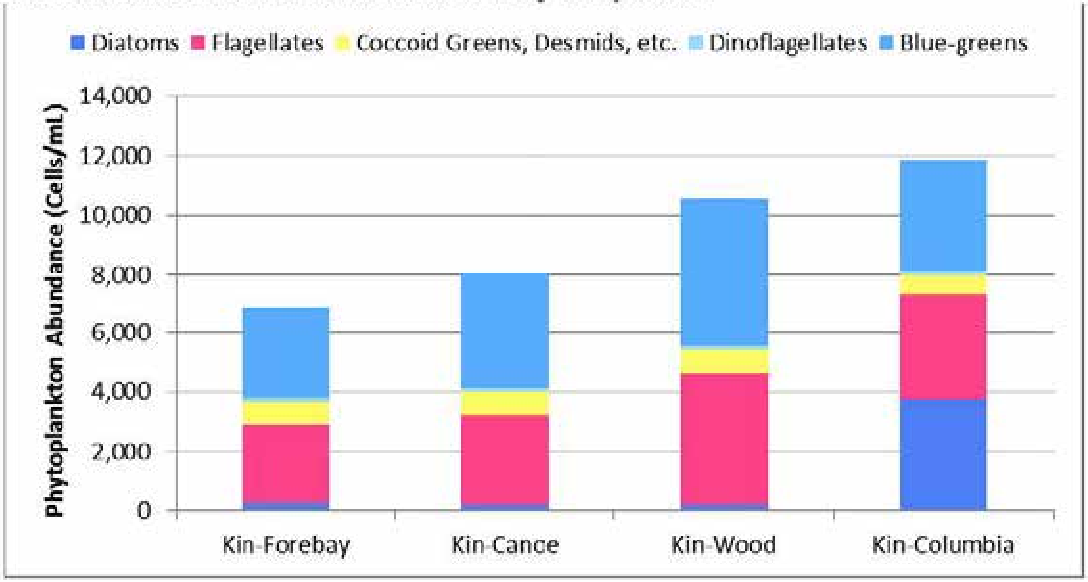



**Figure 10 Average phytoplankton biovolume ($mm^3/L$) in Kinbasket Reservoir between April - August 2017 derived from the 15, and 25 meter laboratory composites**

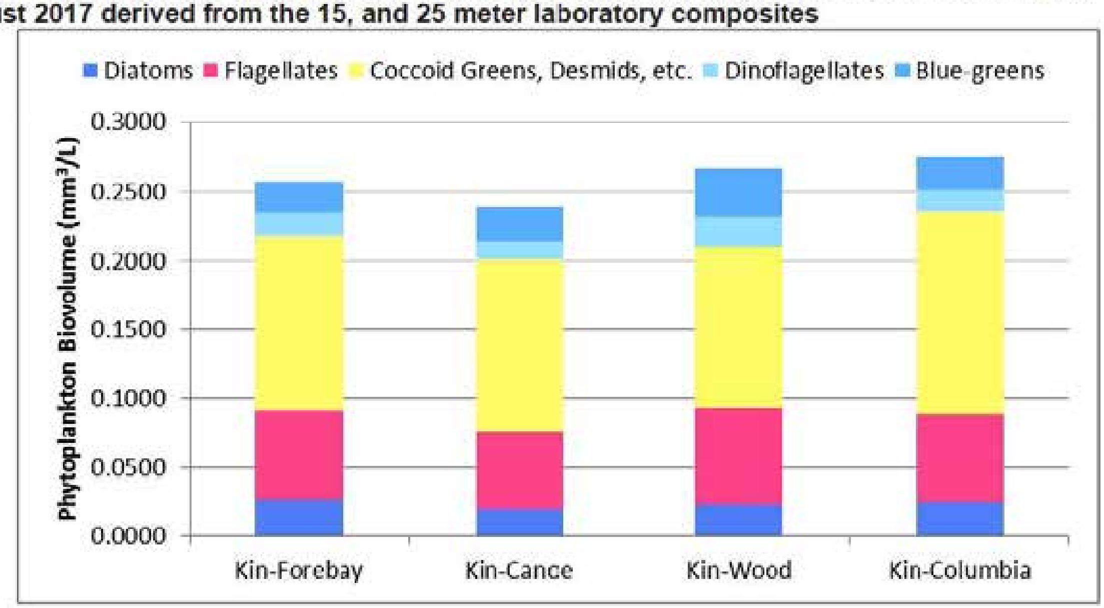


**Figure 11 Kinbasket mean hypolimnetic phytoplankton density by month**

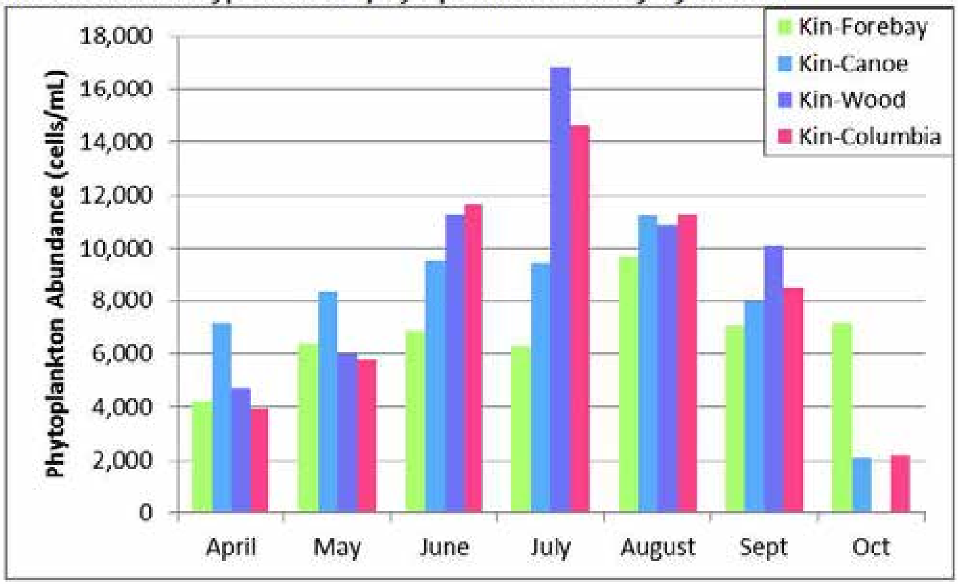
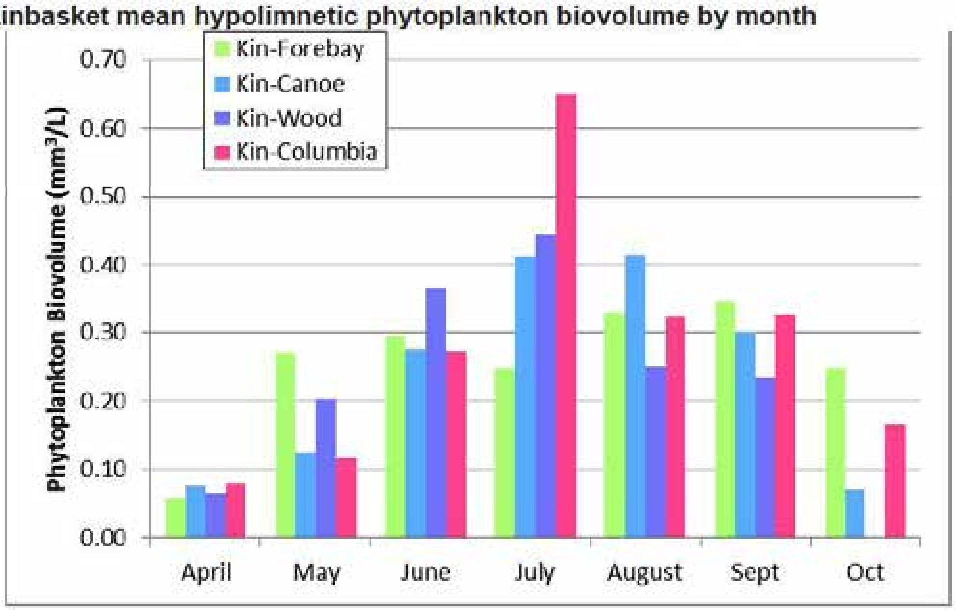



**Figure 12 Kinbasket mean hypolimnetic phytoplankton biovolume by month**




## Revelstoke

The most abundant groups in the hypolimnion of Revelstoke Reservoir in 2017 were blue-greens and flagellates. The least abundant groups present were dinoflagellates and diatoms (Table 7 and Figure 13). The greatest contributors to biovolume at all stations were flagellates and the greens. Diatoms and dinoflagellates contributed the least to biovolume (Table 8 and Figure 14). The Middle station had the highest mean cell density and biovolumes of the three Revelstoke stations, followed by the Upper and Forebay stations.

August had the highest phytoplankton density in the hypolimnion at 15,842 cells/mL with the majority of those being the small cyano-bacteria taxa (Figure 15 and Figure 16).

**Table 7 Revelstoke Reservoir phytoplankton density (Cells/mL) by group and month from the 15, and 25 meter laboratory composites in 2017**

| Station | Group | April | May | June | July | Aug | Sept | Oct | Seasonal Average |
|---|---|---|---|---|---|---|---|---|---|
| Rev-Forebay | Blue-greens | 2,732 | 2,903 | 2,671 | 4,512 | 6,683 | 5,061 | 6,220 | 4,397 |
| | Coccoid Greens, Desmids, etc. | 659 | 951 | 829 | 744 | 768 | 622 | 585 | 737 |
| | Diatoms | 12 | 232 | 171 | 73 | 73 | 24 | 49 | 91 |
| | Dinoflagellates | 61 | 73 | 159 | 24 | 73 | 171 | 171 | 105 |
| | Flagellates | 2,000 | 2,366 | 2,439 | 3,561 | 4,049 | 3,512 | 4,573 | 3,214 |
| | **Sum of All Groups** | 5,464 | 6,525 | 6,269 | 8,915 | 11,647 | 9,391 | 11,598 | 8,544 |
| Rev-Mid | Blue-greens | 2,317 | 4,537 | 4,110 | 7,281 | 8,927 | 4,049 | 9,183 | 5,772 |
| | Coccoid Greens, Desmids, etc. | 1,488 | 610 | 890 | 781 | 573 | 634 | 732 | 815 |
| | Diatoms | 49 | 134 | 159 | 85 | 73 | 61 | 61 | 89 |
| | Dinoflagellates | 61 | 171 | 110 | 98 | 146 | 73 | 171 | 118 |
| | Flagellates | 2,390 | 3,415 | 4,049 | 5,671 | 6,122 | 3,427 | 6,354 | 4,490 |
| | **Sum of All Groups** | 6,305 | 8,866 | 9,317 | 13,915 | 15,842 | 8,244 | 16,501 | 11,284 |
| Rev-Upper | Blue-greens | 2,573 | 5,525 | 4,342 | 4,854 | 6,195 | 4,220 | 4,207 | 4,559 |
| | Coccoid Greens, Desmids, etc. | 488 | 598 | 695 | 1,220 | 573 | 293 | 732 | 657 |
| | Diatoms | 37 | 293 | 122 | 134 | 134 | 98 | 61 | 125 |
| | Dinoflagellates | 24 | 122 | 110 | 122 | 110 | 134 | 61 | 98 |
| | Flagellates | 2,378 | 5,061 | 3,354 | 4,220 | 4,890 | 3,939 | 3,134 | 3,854 |
| | **Sum of All Groups** | 5,500 | 11,598 | 8,622 | 10,549 | 11,903 | 8,683 | 8,195 | 9,293 |

**Table 8 Revelstoke Reservoir phytoplankton biovolume ($mm^3/L$) by group and month from the 15, and 25 meter laboratory composites in 2017**

| Station | Group | May | June | July | August | Sept. | Oct. | Seasonal Average |
|---|---|---|---|---|---|---|---|---|
| Rev-Forebay | Blue-greens | 0.0195 | 0.0455 | 0.0359 | 0.0492 | 0.0536 | 0.0440 | 0.0296 |
| | Coccoid Greens, Desmids, etc. | 0.0401 | 0.0857 | 0.1676 | 0.1683 | 0.2357 | 0.0770 | 0.0725 |
| | Diatoms | 0.0012 | 0.0174 | 0.0345 | 0.0155 | 0.0095 | 0.0012 | 0.0046 |
| | Dinoflagellates | 0.0268 | 0.0207 | 0.0280 | 0.0012 | 0.0140 | 0.0317 | 0.0104 |
| | Flagellates | 0.0259 | 0.0555 | 0.0474 | 0.0623 | 0.0812 | 0.0783 | 0.0743 |
| | **Sum of All Groups** | 0.1135 | 0.2249 | 0.3135 | 0.2965 | 0.3940 | 0.2322 | 0.1914 |
| Rev-Mid | Blue-greens | 0.0283 | 0.0564 | 0.0330 | 0.0594 | 0.0748 | 0.0457 | 0.0588 |
| | Coccoid Greens, Desmids, etc. | 0.0949 | 0.0822 | 0.3143 | 0.3182 | 0.1104 | 0.2019 | 0.0886 |
| | Diatoms | 0.0095 | 0.0255 | 0.0216 | 0.0198 | 0.0073 | 0.0070 | 0.0110 |
| | Dinoflagellates | 0.0159 | 0.0329 | 0.0140 | 0.0110 | 0.0116 | 0.0140 | 0.0146 |
| | Flagellates | 0.0289 | 0.0595 | 0.0507 | 0.0787 | 0.0927 | 0.0557 | 0.0849 |
| | **Sum of All Groups** | 0.1775 | 0.2565 | 0.4337 | 0.4871 | 0.2969 | 0.3243 | 0.2580 |
| Rev-Upper | Blue-greens | 0.0651 | 0.0447 | 0.0465 | 0.0420 | 0.0648 | 0.0494 | 0.0375 |
| | Coccoid Greens, Desmids, etc. | 0.0673 | 0.0746 | 0.1733 | 0.2468 | 0.1339 | 0.1132 | 0.1130 |
| | Diatoms | 0.0032 | 0.0365 | 0.0244 | 0.0549 | 0.0099 | 0.0128 | 0.0044 |
| | Dinoflagellates | 0.0030 | 0.0293 | 0.0140 | 0.0079 | 0.0159 | 0.0171 | 0.0049 |
| | Flagellates | 0.0294 | 0.0820 | 0.0604 | 0.0650 | 0.0688 | 0.0684 | 0.0546 |
| | **Sum of All Groups** | 0.1680 | 0.2670 | 0.3187 | 0.4166 | 0.2933 | 0.2609 | 0.2143 |

**Figure 13 Average phytoplankton density (Cells/mL) in Revelstoke Reservoir between May - October 2017 derived from the 15, and 25 meter laboratory composites**

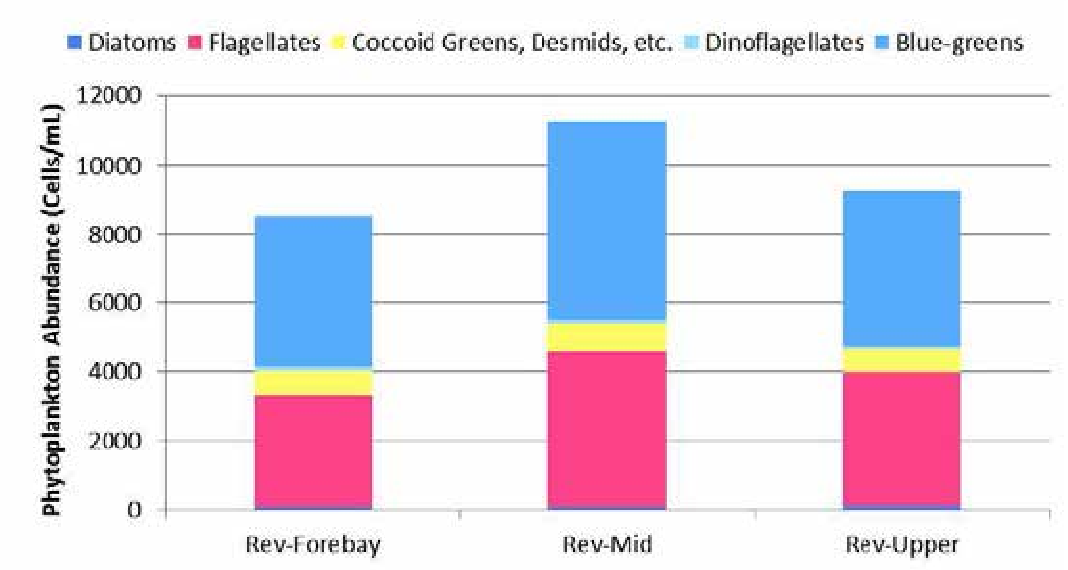



**Figure 14 Average phytoplankton biovolume ($mm^3/L$) in Revelstoke Reservoir between May - October 2017 derived from the 15, and 25 meter laboratory composites**

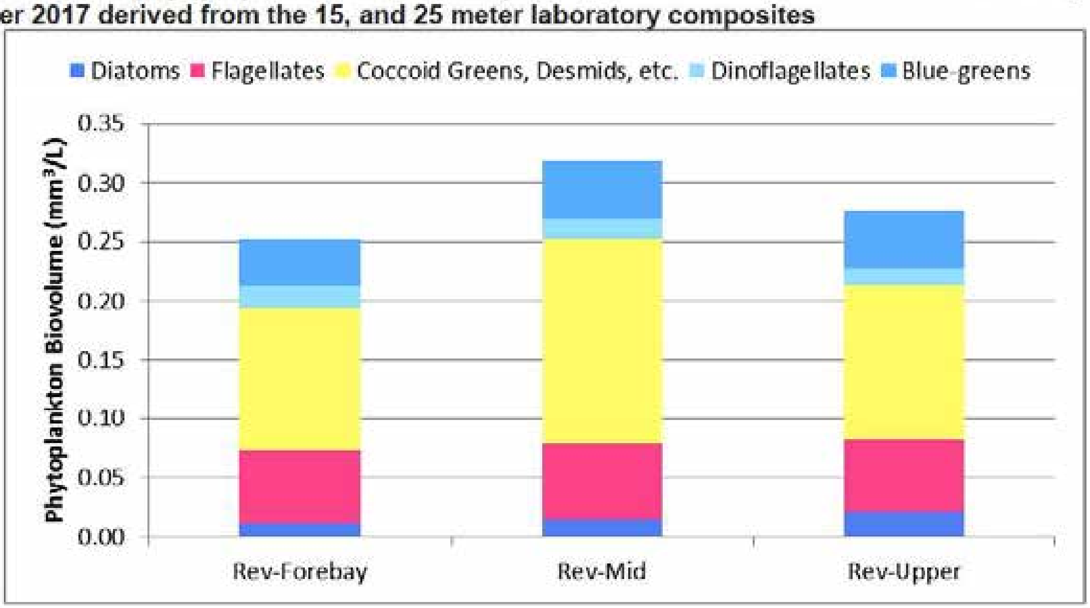


**Figure 15 Revelstoke mean hypolimnetic phytoplankton density by month**

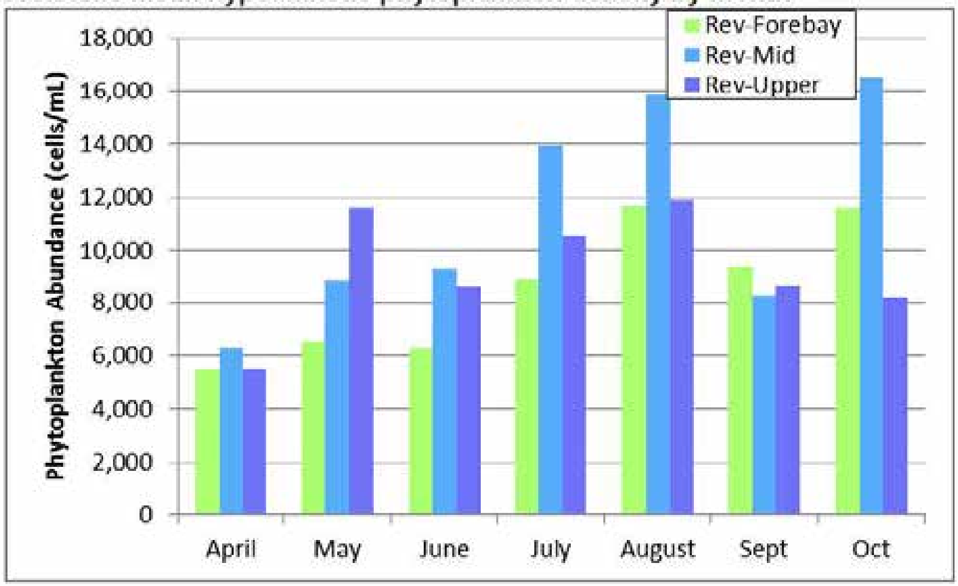
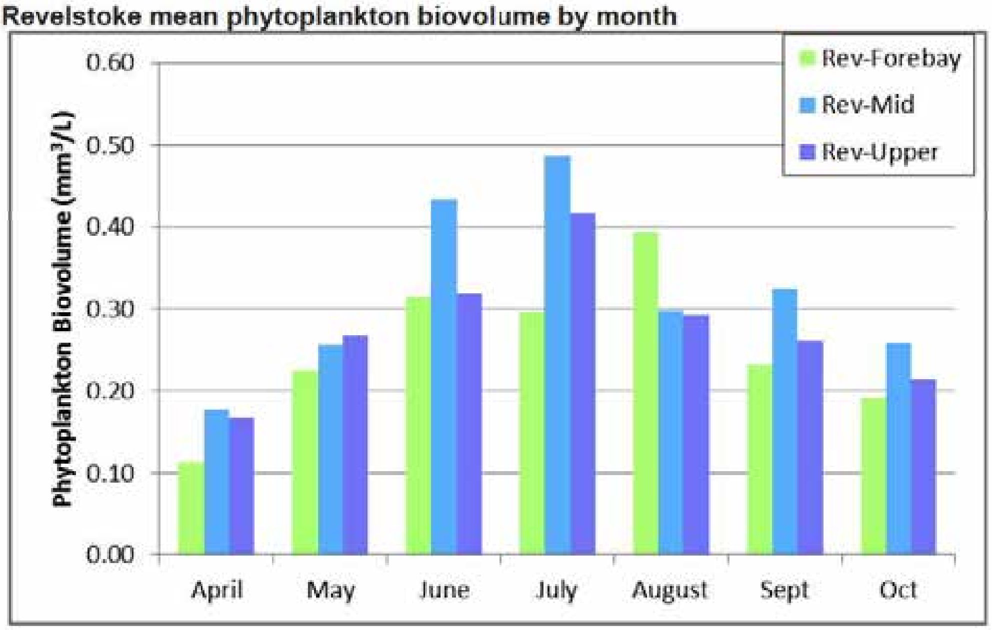



**Figure 16 Revelstoke mean phytoplankton biovolume by month**



## *3.3 Vertical Distribution- Phytoplankton Density and Biovolume – 2017*

Average density (cells/mL) and average biovolume ($mm^3/L$) of phytoplankton groups were calculated for individual depth strata for both Kinbasket and Revelstoke Reservoirs. The averages were based on every sample collected at each station within the respective reservoirs during the 2017 sampling season.

### Kinbasket

Blue-Greens and flagellates dominated the community at all depths (Figure 17). The average density was the highest at 25 meters. The 2017 biovolume of the phytoplankton community exhibits a slight but not significant difference with depth with the greatest biovolume occurring at 25metere of depth (Figure 18).

**Figure 17 Average phytoplankton density (Cells/mL), by depth and group, in Kinbasket Reservoir in 2017**

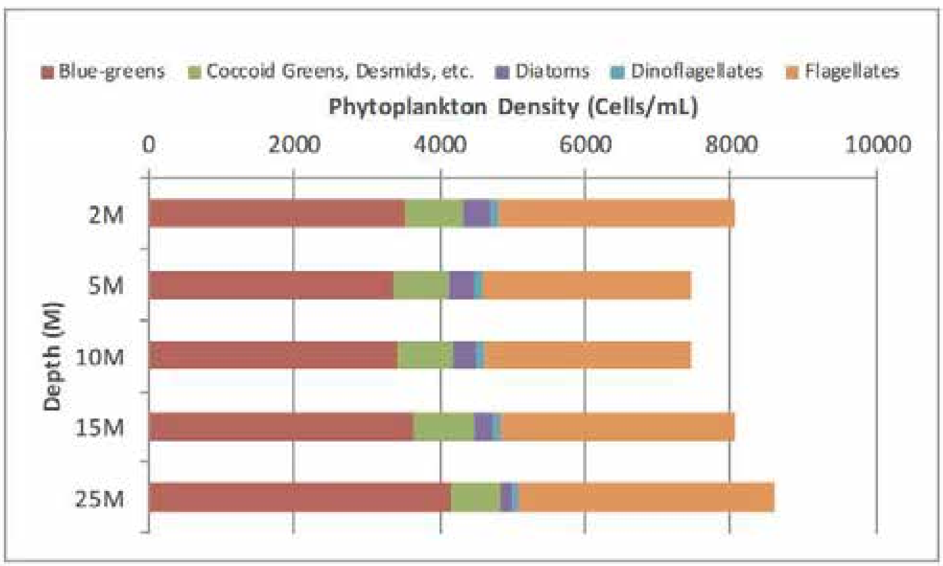
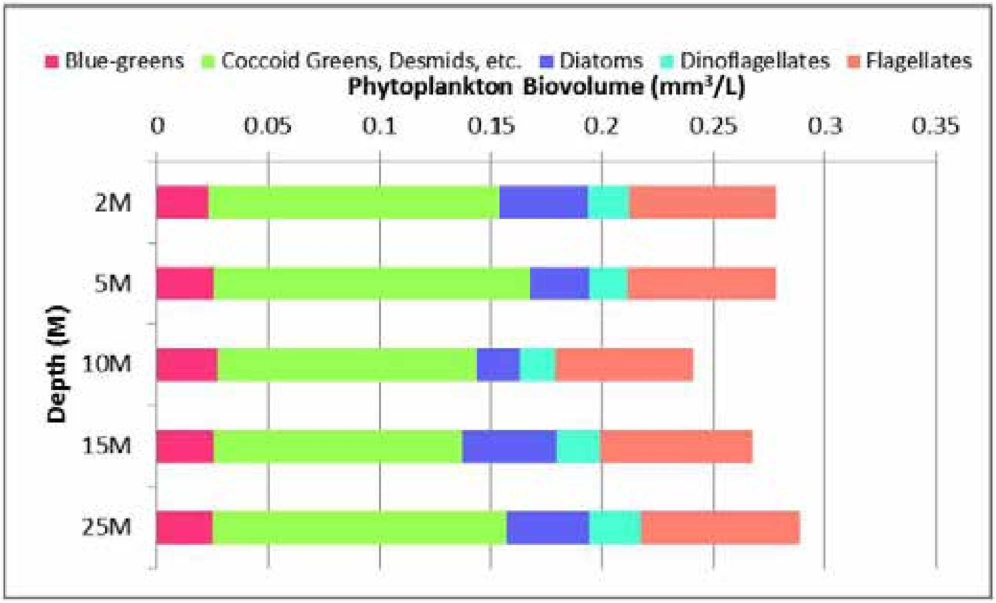


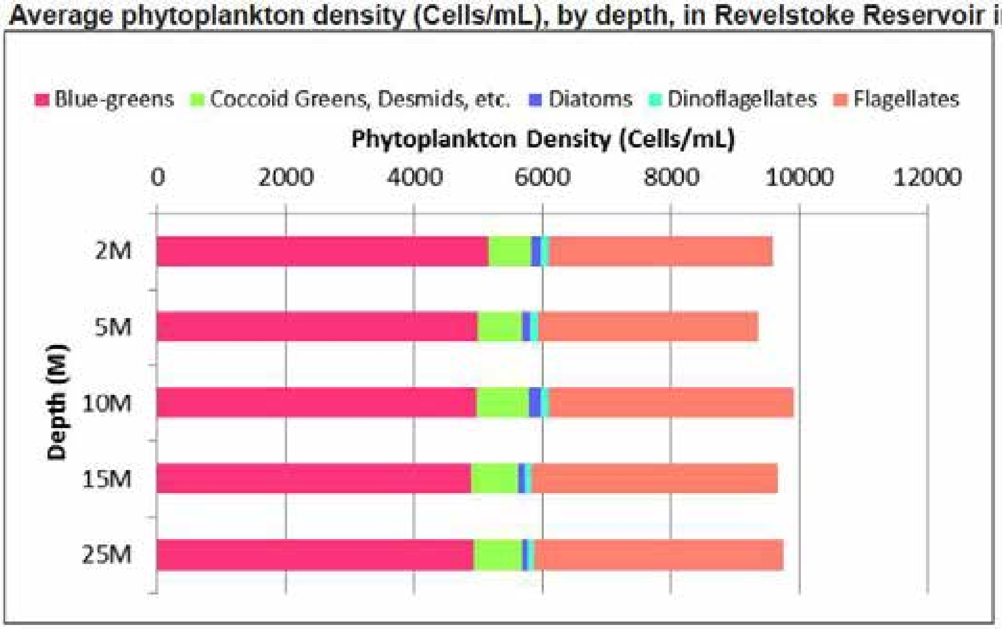
**Figure 18 Average phytoplankton biovolume (mm$^3$/L), by depth and group, in Kinbasket Reservoir in 2017**




## Revelstoke

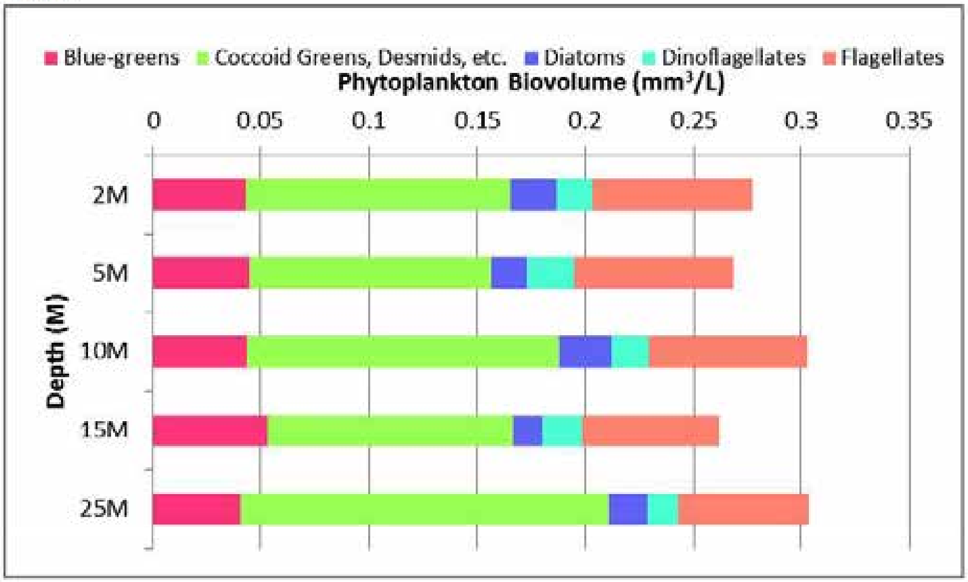
In Revelstoke there is little change in cell density with depth. The most abundant group at all depths were the blue-greens and flagellates. Dinoflagellate and diatoms were the least abundant groups (Figure 19).

**Figure 19 Average phytoplankton density (Cells/mL), by depth, in Revelstoke Reservoir in 2017**



The greatest average biovolume in Revelstoke Reservoir was at 10 and 25 meters. Flagellates, greens and blue-greens were the greatest contributors to the phytoplankton biovolume within in the system. Dinoflagellates and diatoms were the groups had the lowest average biovolumes (Figure 20).

**Figure 20 Average phytoplankton biovolume ($mm^3/L$), by depth and group, in Revelstoke Reservoir in 2017**




## 3.4 Phytoplankton in 2008-2017

To compare the 2008 through 2017 sampling seasons, phytoplankton cell counts and biovolume data from every sampling event at each station for the epilimnion samples were compiled.

### Kinbasket

Inter-annual comparison of the average total density and total biovolume of phytoplankton suggests that there was an increase in phytoplankton density between 2008 and 2015; however, 2017 has a distinct reduction in both cell density and biovolume (Table 10). 2017 was most comparable to phytoplankton levels see in 2010 and 2011 (Figure 21 and Figure 22).

Table 9 Average seasonal phytoplankton density and biomass in Kinbasket Reservoir

| Kinbasket | Year | Kin-Forebay | Canoe | Wood | Columbia | Reservoir Average |
|---|---|---|---|---|---|---|
| Average Density (Cells/mL) | 2008 | 1,672 | 1,284 | 1,276 | 1,238 | 1,368 |
| | 2009 | 2,215 | 2,066 | 2,208 | 2,110 | 2,150 |
| | 2010 | 2,797 | 3,133 | 3,075 | 2,569 | 2,893 |
| | 2011[1] | 2,476 | 2,717 | 5,558 | 3,586 | 3,584 |
| | 2012 | 3,823 | 4,541 | 5,522 | 4,490 | 4,594 |
| | 2013 | 5,995 | 7,838 | 7,864 | 8,885 | 7,645 |
| | 2014 | 5,999 | 7,083 | 6,953 | 7,507 | 6,886 |
| | 2015 | 7,055 | 9,227 | 7,695 | 8,958 | 7,734 |
| | 2017 | 2,893 | 4,397 | 3,077 | 4,080 | 3,612 |
| | 2017 | 6,805 | 7,981 | 9,068 | 8,267 | 8,030 |
| Biovolume ($mm^3/L$) | 2008 | 0.19 | 0.13 | 0.16 | 0.16 | 0.16 |
| | 2009 | 0.26 | 0.22 | 0.23 | 0.18 | 0.22 |
| | 2010 | 0.14 | 0.14 | 0.16 | 0.12 | 0.14 |
| | 2011 | 0.09 | 0.07 | 0.1 | 0.07 | 0.08 |
| | 2012 | 0.09 | 0.08 | 0.13 | 0.12 | 0.11 |
| | 2013 | 0.17 | 0.18 | 0.25 | 0.19 | 0.2 |
| | 2014 | 0.18 | 0.19 | 0.17 | 0.21 | 0.19 |
| | 2015 | 0.28 | 0.27 | 0.26 | 0.37 | 0.3 |
| | 2017 | 0.09 | 0.09 | 0.08 | 0.07 | 0.09 |
| | 2017 | 0.26 | 0.24 | 0.27 | 0.28 | 0.26 |

**Figure 21 Mean epilimnetic phytoplankton density by year for Kinbasket**

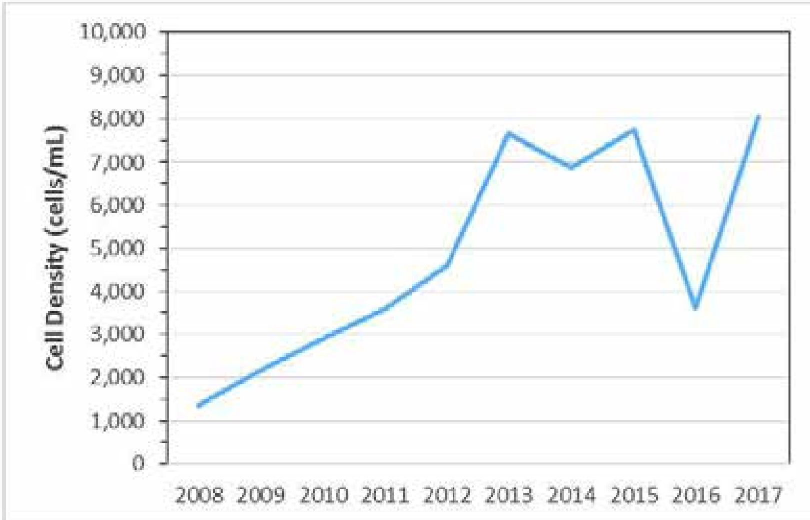
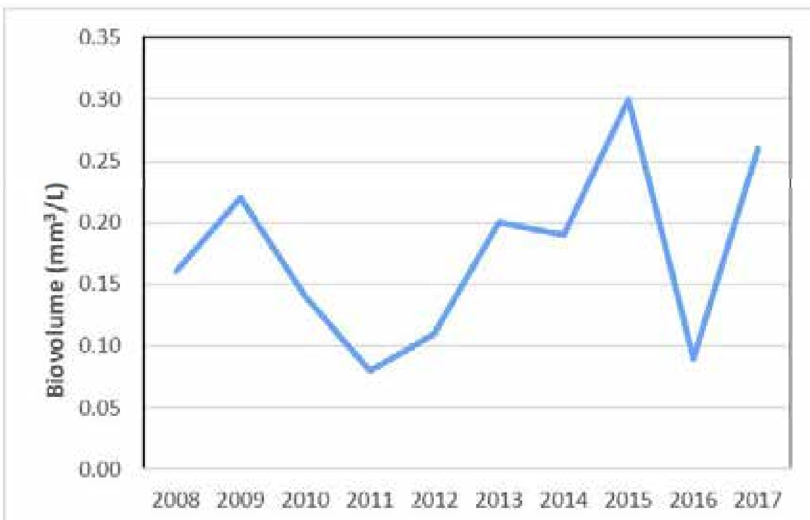



**Figure 22 Mean epilimnetic phytoplankton biovolume by year for Kinbasket**




## Revelstoke

As observed in Kinbasket there is considerable intra and inter-annual variation in phytoplankton density and to a lesser extent in biovolumes within Revelstoke (Figure 23 and Figure 24). From 2008 through 2013 the means cell densities increased consistently (Table 10). The densities observed in 2014 and 2015 are slightly lower than 2013 but still considerably higher than 2008-2011 densities. The increasing mean densities are driven by high densities or Synechococcus and small micro-flagellate densities that occur in one or two months of the year.

Table 10 Average seasonal phytoplankton density and biomass in Revelstoke Reservoir

| Revelstoke | Year | Forebay | Mid | Upper | Reservoir Average |
|---|---|---|---|---|---|
| Average Density (Cells/mL) | 2008 | 2,604 | 1,829 | 1,544 | 1,992 |
| | 2009 | 2,416 | 1,901 | 1,683 | 2,000 |
| | 2010 | 1,940 | 2,502 | 1,684 | 2,375 |
| | 2011 | 3,823 | 5,143 | 4,395 | 4,154 |
| | 2012 | 5,708 | 6,425 | 7,561 | 6,565 |
| | 2013 | 7,839 | 8,328 | 12,400 | 9,523 |
| | 2014 | 6,736 | 6,949 | 6,865 | 6,850 |
| | 2015 | 7,307 | 10,194 | 7,843 | 8,448 |
| | 2017 | 3,711 | 4,371 | 3,832 | 3,971 |
| | 2017 | 9,313 | 9,891 | 9,664 | 9,623 |
| Biovolume ($mm^3/L$) | 2008 | 0.16 | 0.15 | 0.13 | 0.15 |
| | 2009 | 0.20 | 0.13 | 0.12 | 0.15 |
| | 2010 | 0.10 | 0.09 | 0.08 | 0.09 |
| | 2011 | 0.07 | 0.07 | 0.06 | 0.07 |
| | 2012 | 0.10 | 0.09 | 0.08 | 0.09 |
| | 2013 | 0.21 | 0.18 | 0.48 | 0.29 |
| | 2014 | 0.16 | 0.18 | 0.15 | 0.17 |
| | 2015 | 0.20 | 0.25 | 0.24 | 0.23 |
| | 2017 | 0.08 | 0.08 | 0.08 | 0.08 |
| | 2017 | 0.28 | 0.29 | 0.28 | 0.28 |

**Figure 23 Mean epilimnetic phytoplankton density by year for Revelstoke**

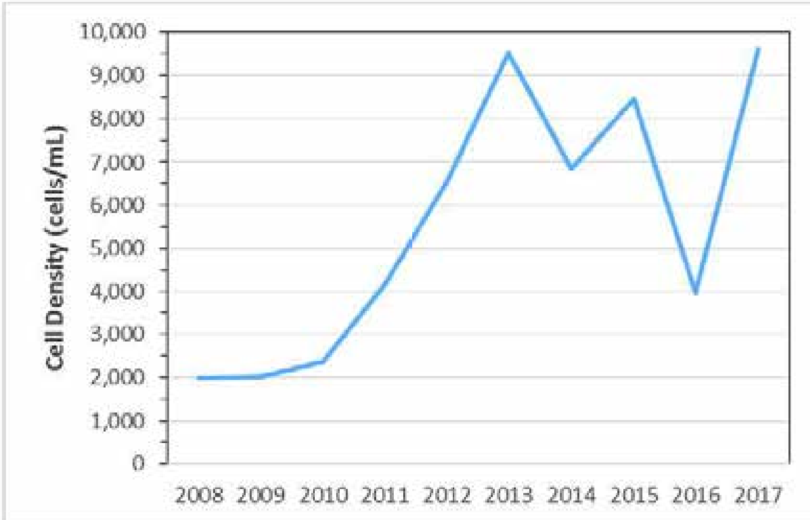
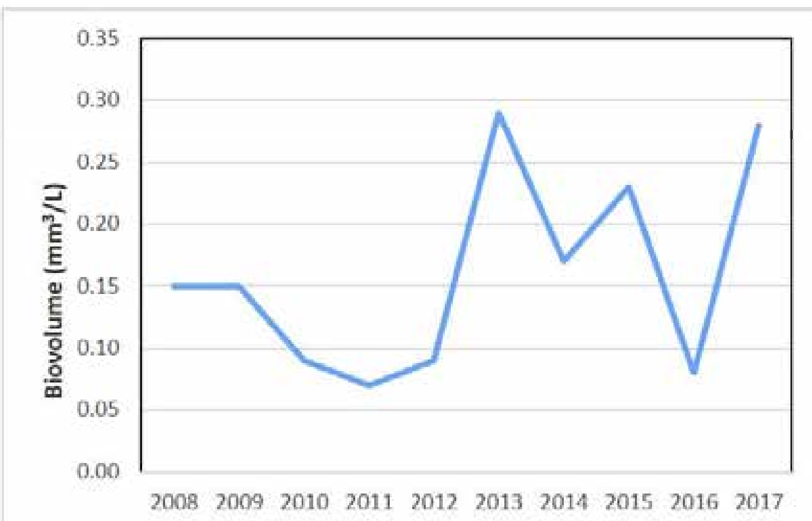



**Figure 24 Mean epilimnetic phytoplankton biovolume by year for Revelstoke**



## 3.5 Bacteria and Pico-cyanobacteria Density in 2017

### 3.5.1 Bacteria.

**Kinbasket**

The epilimnetic and hypolimnetic heterotrophic bacteria densities ranged from a low of 99,574 cells/mL in August in the Canoe Arm epilimnion to high or 352,845 cells/mL in the epilimnion of the Wood Arm in the July samples. The overall average density in the epilimnion was 167,000 cells/mL. This density is similar to 2015 (181,758 cells/mL) but considerably lower than 2011-2014 four year average of 405,290 cells/mL. There was very little difference in the monthly averages between stations or months in 2017, with the exception of the July densities in Kinbasket Reservoir (Figure 26).

**Table 10 2017 Picoplankton densities**

| | | Heterotrophic Bacteria (Cells/mL) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | April | May | June | July | Aug | Sept | Oct | Average |
| Epilimnion | Kin-Canoe | 179,498 | 128,259 | 185,986 | 165,758 | 99,574 | 130,858 | 175,201 | 152,162 |
| | Kin-Columbia | 175,948 | 136,112 | 214,907 | 300,638 | 138,297 | 212,851 | | 196,459 |
| | Kin-Forebay | 128,950 | 101,180 | 161,397 | 215,195 | 88,966 | 124,253 | 201,088 | 145,861 |
| | Kin-Wood | 108,095 | 99,789 | 119,997 | 352,845 | 109,154 | 224,435 | 195,023 | 172,762 |
| | Rev-Forebay | 162,142 | 107,014 | 152,604 | 323,250 | 123,037 | 136,024 | 315,461 | 188,505 |
| | Rev-Middle | 149,683 | 324,187 | 226,780 | 307,751 | 100,325 | 166,195 | 283,510 | 222,633 |
| | Rev-Upper | 141,556 | 139,092 | 182,886 | 297,021 | 135,237 | 195,079 | 183,304 | 182,025 |
| Hypolimnion | Kin-Canoe | 187,377 | 160,552 | 243,213 | 165,450 | 110,797 | 123,609 | 185,026 | 168,003 |
| | Kin-Columbia | 185,124 | 128,432 | 246,948 | 389,458 | 108,190 | 202,145 | | 210,050 |
| | Kin-Forebay | 153,001 | 103,079 | 108,770 | 126,167 | 113,817 | 160,361 | 209,187 | 139,198 |
| | Kin-Wood | 101,935 | 124,736 | 209,234 | 301,502 | 121,511 | 159,638 | 215,824 | 176,340 |
| | Rev-Forebay | 162,738 | 107,014 | 207,535 | 256,989 | 139,092 | 119,222 | 124,586 | 159,597 |
| | Rev-Middle | 147,040 | 145,520 | 210,188 | 287,669 | 153,907 | 184,436 | 405,801 | 219,223 |
| | Rev-Upper | 112,156 | 158,764 | 155,406 | 240,129 | 174,610 | 228,906 | 110,280 | 168,607 |
| | | Pico-cyano Bacteria (Cells/mL) | | | | | | | |
| | | April | May | June | July | Aug | Sept | Oct | Average |
| Epilimnion | Kin-Canoe | 6,703 | 5,166 | 34,450 | 33,011 | 17,883 | 11,270 | 8,452 | 16,705 |
| | Kin-Columbia | 6,420 | 2,851 | 31,335 | 35,762 | 21,861 | 4,426 | | 17,109 |
| | Kin-Forebay | 6,264 | 3,345 | 38,896 | 45,782 | 40,412 | 10,896 | 8,644 | 22,034 |
| | Kin-Wood | 7,359 | 15,822 | 17,387 | 34,442 | 24,730 | 15,996 | 7,562 | 17,614 |
| | Rev-Forebay | 3,600 | 4,173 | 12,220 | 23,716 | 20,571 | 11,127 | 2,365 | 11,110 |
| | Rev-Middle | 7,109 | 5,511 | 6,259 | 18,912 | 4,610 | 7,700 | 4,222 | 7,760 |
| | Rev-Upper | 3,855 | 2,676 | 6,249 | 6,382 | 5,941 | 2,517 | 7,549 | 5,024 |
| Hypolimnion | Kin-Canoe | 7,600 | 8,023 | 25,931 | 28,375 | 17,201 | 8,809 | 6,512 | 14,636 |
| | Kin-Columbia | 5,124 | 4,716 | 35,886 | 9,538 | 16,453 | 10,854 | | 13,762 |
| | Kin-Forebay | 4,405 | 7,392 | 25,752 | 44,973 | 21,559 | 14,019 | 10,857 | 18,422 |
| | Kin-Wood | 5,216 | 18,986 | 23,129 | 39,465 | 18,719 | 10,202 | 7,125 | 17,549 |
| | Rev-Forebay | 4,580 | 5,365 | 2,593 | 2,414 | 4,371 | 3,338 | 4,328 | 3,856 |
| | Rev-Middle | 3,656 | 4,963 | 5,519 | 8,379 | 6,166 | 6,789 | 4,130 | 5,657 |
| | Rev-Upper | 4,034 | 4,719 | 5,355 | 4,785 | 4,363 | 5,855 | 2,174 | 4,469 |

**Figure 25 Average density (Cells/mL) of heterotrophic bacteria at four sampling stations in Kinbasket Reservoir between the months of April through October 2017**

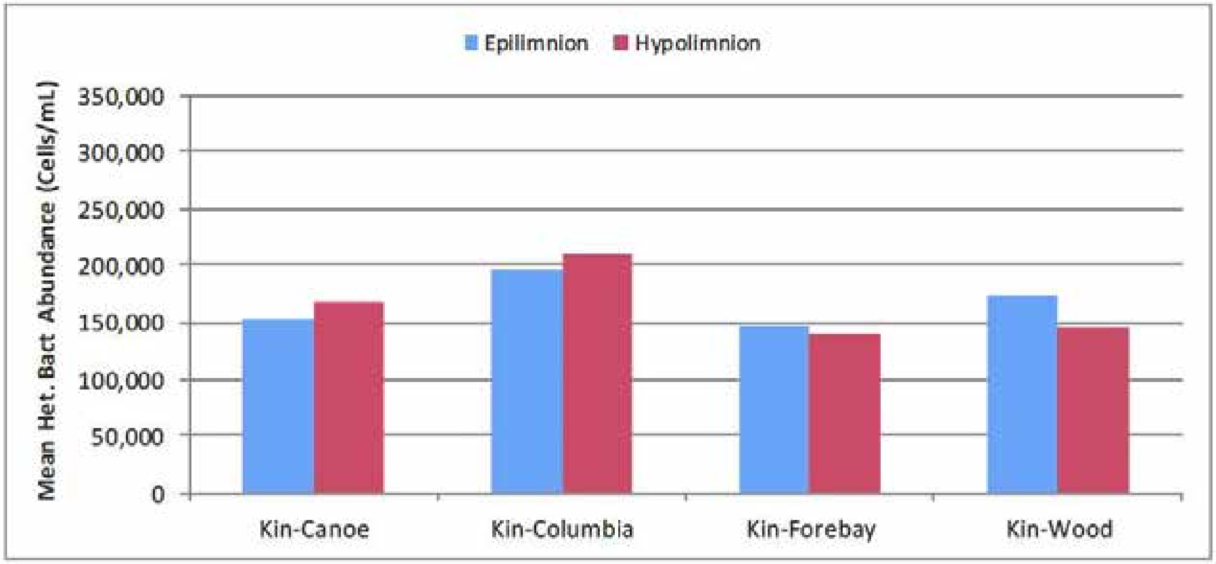
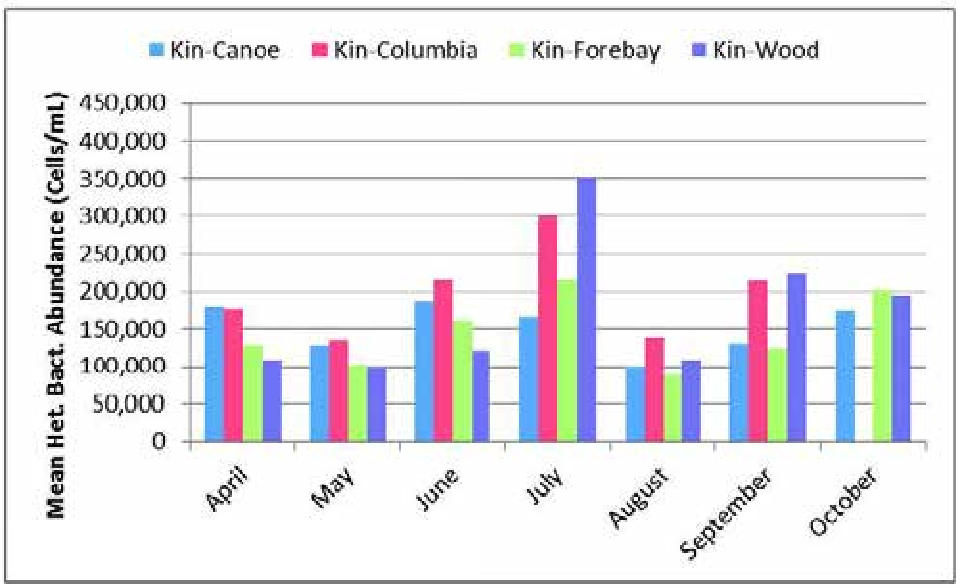


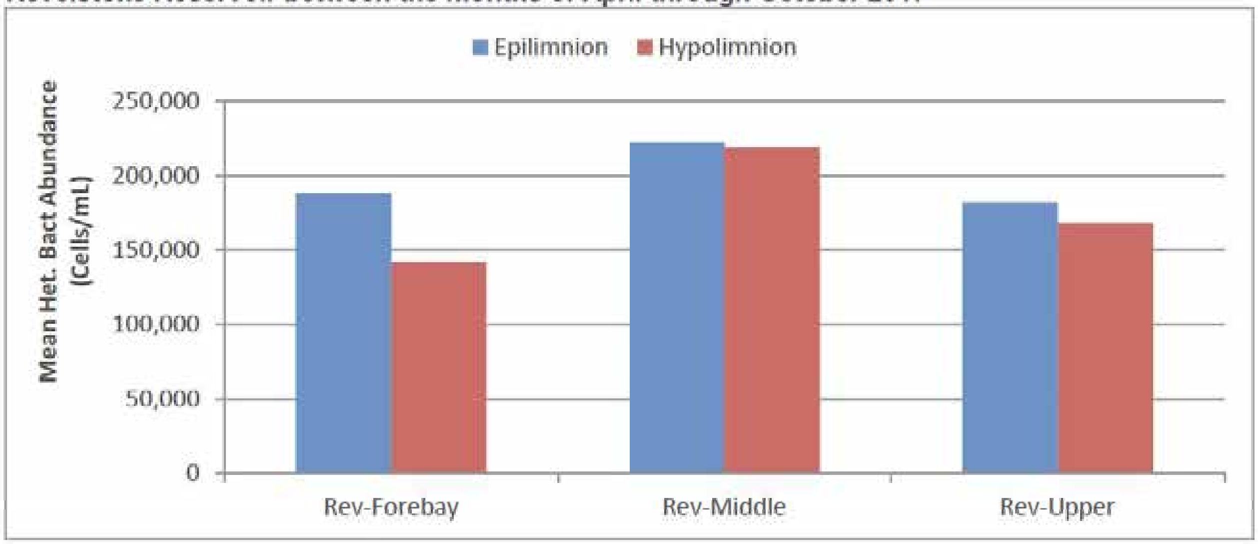

**Figure 26 Kinbasket Reservoir monthly average density (Cells/mL) of epilimnetic heterotrophic bacteria at four sampling stations in 2017**



## Revelstoke

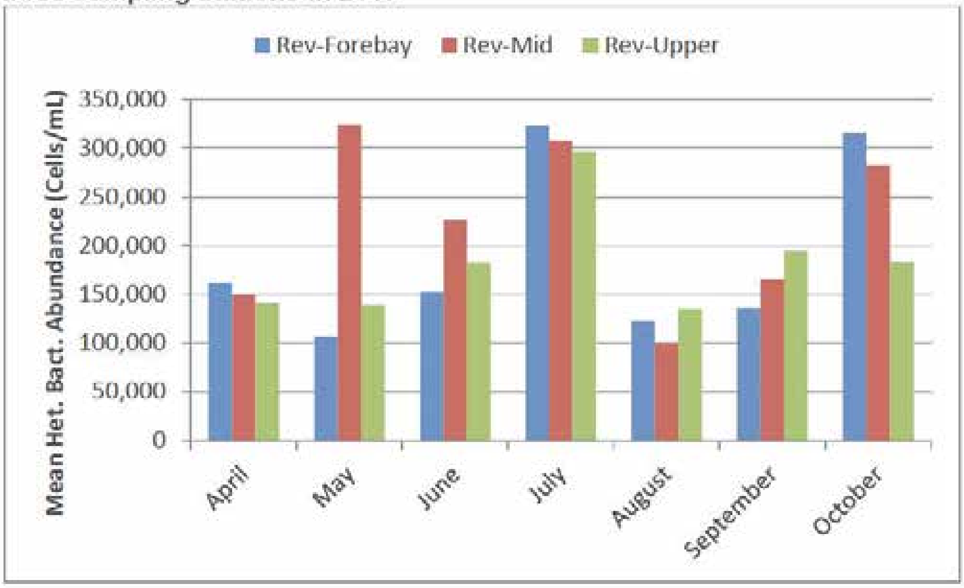
The epilimnetic average of heterotrophic bacteria ranged from 100,000 to 323,000 cells/mL (Table 10). These values are similar slightly lower than those observed in Revelstoke in 2014 and 2015 and more than 50% lower than observed in Revelstoke in 2011 and 2012. The Middle Station had the highest average epilimnion and hypolimnion densities (Figure 27).

**Figure 27 Average density (Cells/mL) of heterotrophic bacteria at three sampling stations in Revelstoke Reservoir between the months of April through October 2017**




Reservoir mean heterotrophic bacteria densities were variable with three peaks in in average densities (Figure 28). The month with the highest density in all station was July.

**Figure 28 Revelstoke Reservoir monthly average density (Cells/mL) of epilimnetic heterotrophic bacteria at three sampling stations in 2017**




### *3.5.2 Pico-cyanobacteria.*

## Kinbasket

Total seasonal average density of epilimnetic pico-cyanobacteria in Kinbasket Reservoir was 18,366 cells/mL. The forebay station had the highest average pico-cyanobacteria density in both the epilimnion and hypolimnion samples (Table 10 and Figure 29). The densities observed in 2014 through 2017 were considerably lower than the densities observed in 2011 and in line with the 2010 and 2012, and 2013 densities.

The highest epilimnetic densities were observed in June and July. Hypolimnetic total seasonal average density of pico-cyanobacteria averaged 16,092 cells/mL (Figure 30).

**Figure 29 Average density (Cells/mL) of pico-cyanobacteria at four sampling stations in Kinbasket Reservoir between the months of May through October 2017**

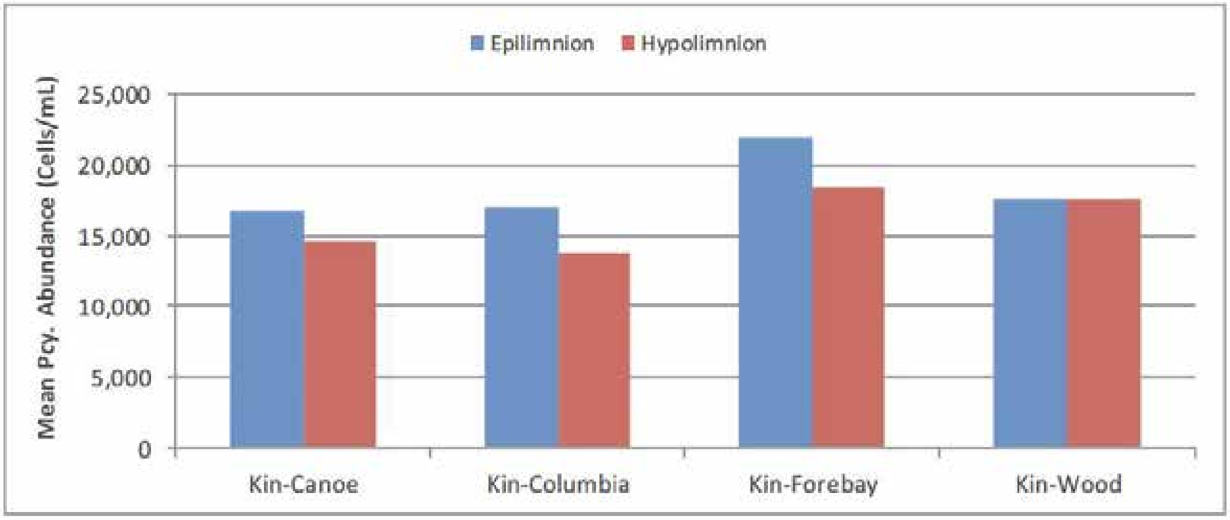
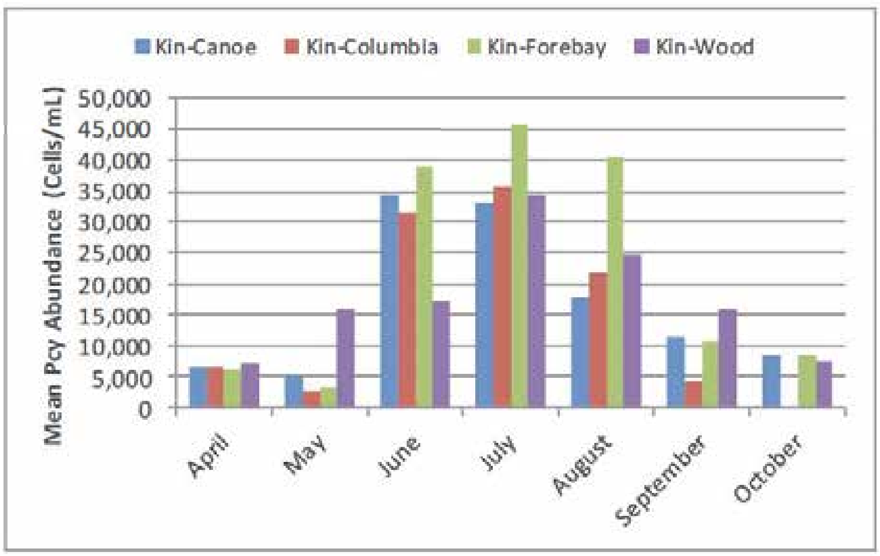


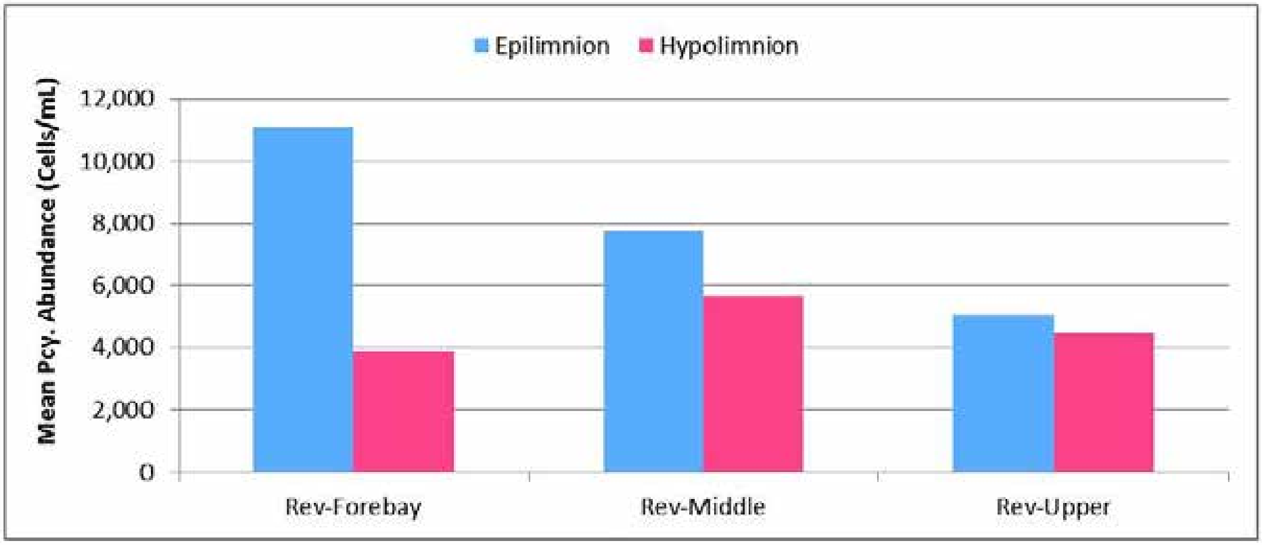

**Figure 30 Average monthly density (Cells/mL) of epilimnetic pico-cyanobacteria at four sampling stations in Kinbasket Reservoir**




## Revelstoke

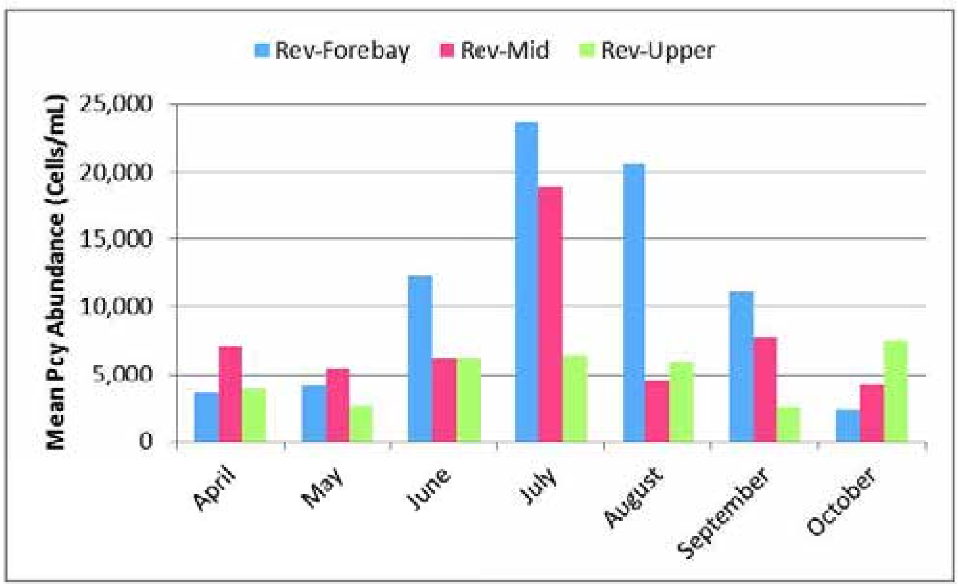
The average density in the epilimnion was approximately 7,965 cells/mL in Revelstoke Reservoir (Table 10). In the hypolimnion, the average density was 4,661 cells/mL. The Forebay station had the highest average density in the epilimnion and the greatest difference between the mean densities of epilimnion and hypolimnion (Figure 31).

**Figure 31 Average density (Cells/mL) of pico-cyanobacteria at three sampling stations in Revelstoke Reservoir between the months of May through October 2017**




The pico-cyano densities in Revelstoke Reservoir followed a typical seasonal pattern with low densities in the spring followed by a summer peak and then a fall decline (Figure 32).

**Figure 32 Average monthly density (Cells/mL) of epilimnetic pico-cyanobacteria at three sampling stations in Revelstoke Reservoir**



# SECTION 4.0 SUMMARY

Based on phytoplankton density and biovolume, Kinbasket and Revelstoke Reservoirs fall within the oligotrophic classification. They both exhibit a typical temperate zone pattern of low phytoplankton density in the spring followed by a significant increase in mid-summer and a subsequent decline.

The phytoplankton community in 2017 was similar in density to 2013-2015 but high biovolumes higher than typically observed since this sampling regime was implemented in 2008. This is most likely a result of an incremental increase in some of the larger taxa resulting in the disproportional increase in the biovolume within the systems.

To better ascertain the trends within the system regarding productivity a comprehensive assessment of the nutrient concentrations, phytoplankton, zooplankton, and fish communities should be conducted. This information, in addition to the primary productivity measurements taken over the past few years, would provide an adequate set of data to determine overall system condition and allow for short term predictions of future conditions.

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# Appendix A.

# Kinbasket and Revelstoke 2017 Taxa List and Number of Occurrences

| Scientific Group Name | Common Group Name | Taxa | Kinbasket | Revelstoke |
|---|---|---|---|---|
| Bacillariophyte | Diatoms | Achnanthidium sp. | 1 | 13 |
| | | Amphora (small) | 1 | |
| | | Asterionella formosa | 5 | 8 |
| | | Aulacoseira italica | | 1 |
| | | Cocconeis sp. | 1 | 1 |
| | | Cyclotella comta | 31 | 5 |
| | | Cyclotella glomerata | 93 | 53 |
| | | Cymbella sp. (large) | | 2 |
| | | Cymbella sp. (medium) | 2 | 2 |
| | | Cymbella sp. (small) | 1 | 4 |
| | | Diatoma sp. | 1 | 4 |
| | | Diploneis sp. | 1 | |
| | | Eucocconeis flexella | 1 | 1 |
| | | Fragilaria capucina | 9 | 18 |
| | | Fragilaria crotonensis | 34 | 24 |
| | | Gomphonema sp. (medium) | 1 | 4 |
| | | Hannaea arcus | | 2 |
| | | Navicula sp. (medium) | | 1 |
| | | Nitzschia sp. (medium) | 2 | 2 |
| | | Nitzschia sp. (small) | 6 | 10 |
| | | Rhizosolenia sp. | 2 | 1 |
| | | Staurosira construens | | 4 |
| | | Stephanodiscus sp. (large) | 36 | 12 |
| | | Stephanodiscus sp. (small) | 61 | 18 |
| | | Synedra acus | 89 | 57 |
| | | Synedra acus var. angustissima | 12 | 12 |
| | | Synedra nana | 2 | 3 |
| | | Synedra ulna | 5 | 13 |
| | | Tabellaria flocculosa | | 3 |

| Scientific Group Name | Common Group Name | Taxa | Kinbasket | Revelstoke |
|---|---|---|---|---|
| Chlorophyte | Coccoid Greens, Desmids, etc. | Acanthosphaera sp. | 1 | |
| | | Ankistrodesmus sp. | 11 | 3 |
| | | Ankyra | 1 | 1 |
| | | Aulomonas sp. | 2 | 2 |
| | | Carteria sp. | 1 | |
| | | Chlamydocapsa sp. | 38 | 39 |
| | | Chlamydomonas | 26 | 16 |
| | | Coelastrum sp. (cells) | 61 | 62 |
| | | Cosmarium sp. | 35 | 17 |
| | | Crucigenia sp. | 1 | |
| | | Dictyosphaerium (cells) | 10 | 1 |
| | | Elakatothrix sp. | 33 | 12 |
| | | Euglena | 76 | 62 |
| | | Gleotila sp. | 39 | 12 |
| | | Gloeococcus sp. | 47 | 41 |
| | | Gloeocystis | 7 | 3 |
| | | Golenkinia sp. | 1 | 7 |
| | | Monomastix sp. | 76 | 69 |
| | | Monoraphidium | 21 | 14 |
| | | Nephrocytium agardianum | | 1 |
| | | Nephroselmis | 114 | 105 |
| | | Oocystis sp. (cells) | 102 | 76 |
| | | Paramastix | 6 | 2 |
| | | Pediastrum sp. (small) | 1 | |
| | | Phacus (large) | 2 | 2 |
| | | Phacus (medium) | 29 | 24 |
| | | Phacus (small) | 42 | 33 |
| | | Planktosphaeria | 3 | 3 |
| | | Polytomella | 1 | 1 |
| | | Pseudosphaerocystis sp. | | 1 |
| | | Scenedesmus sp. | 11 | 7 |
| | | Scourfieldia | 116 | 94 |
| | | Sphaerocystis sp. | 1 | |
| | | Staurastrum sp. (large) | 1 | |
| | | Staurastrum sp. (small) | | 2 |
| | | Stichococcus minutissimus | | 1 |
| | | Tetraedron | 131 | 106 |

| Scientific Group Name | Common Group Name | Taxa | Kinbasket | Revelstoke |
|---|---|---|---|---|
| Chryso- & Cryptophyte | Flagellates | Bitrichia sp. | 4 | 2 |
| | | Chromulina sp. | 60 | 45 |
| | | Chroomonas acuta | 133 | 106 |
| | | Chrysocapsa planktonica | 2 | 2 |
| | | Chrysochromulina sp. | 7 | 6 |
| | | Chrysococcus | 96 | 89 |
| | | Chrysolykos sp. | | 3 |
| | | Codonomonas sp. | | 1 |
| | | Cryptomonas sp. (large) | 7 | 2 |
| | | Cryptomonas sp. (medium) | 109 | 81 |
| | | Cryptomonas sp. (small) | 53 | 29 |
| | | Cyathomonas truncata | 1 | 1 |
| | | Dinobryon sp. (medium) | 60 | 65 |
| | | Dinobryon sp. (small) | 3 | 9 |
| | | Dylakosoma sp. | 1 | |
| | | Gyromitus sp. | 25 | 31 |
| | | Kephyrion boreale | | 13 |
| | | Kephyrion sp. | 100 | 89 |
| | | Kephyriopsis sp. | 1 | |
| | | Komma sp. | 101 | 91 |
| | | Mallomonas sp. (large) | 4 | 2 |
| | | Mallomonas sp. (medium) | 41 | 32 |
| | | Mallomonas sp. (small) | 42 | 34 |
| | | Ochromonas sp. | 109 | 79 |
| | | Pseudokephrion sp. | 103 | 79 |
| | | Small microflagellates | 136 | 106 |
| | | Sphaleromantis sp | 1 | |
| | | Stenokalyx | 1 | |
| | | Trachelomonas sp. | 82 | 56 |
| | | Uroglena sp. (colony) | 1 | |

| Scientific Group Name | Common Group Name | Taxa | Kinbasket | Revelstoke |
|---|---|---|---|---|
| Cyanophyte | Blue-greens | Anabaena sp. | 3 | |
| | | Anabaenopsis sp. | | 1 |
| | | Aphanothecae sp. | | 17 |
| | | Aphanothece minutissimus | 45 | 42 |
| | | Chroococcus sp. (cells) | 102 | 104 |
| | | Lyngbya sp. (cells) | | 1 |
| | | Merismopedia sp. (cells) | 80 | 94 |
| | | Microcystis sp. (cells) | 3 | 2 |
| | | Planktothrix rubescens | 1 | |
| | | Planktothrix sp. | | 1 |
| | | Synechococcus sp. (coccoid) | 134 | 106 |
| | | Synechococcus sp. (rod) | 133 | 106 |
| | | Synechocystis | 90 | 76 |
| Dinophyte | Dinoflagellates | Amphidinium | 91 | 90 |
| | | Ceratium | 1 | |
| | | Gloeodinium sp. | 1 | 1 |
| | | Gymnodinium sp. (large) | 6 | 4 |
| | | Gymnodinium sp. (medium) | 78 | 63 |
| | | Gymnodinium sp. (small) | 67 | 47 |
| | | Peridinium spp. | 4 | 1 |

*Appendix 7*

*Zooplankton*
*Kinbasket and Revelstoke Reservoirs, 2017*

*Lidija Vidmanic*
*Limno Lab*

## Table of Contents



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## 1. Introduction

This report summarises the zooplankton data collected in 2017, with comparisons to available data from previous years and some historical data. The study of Kinbasket and Revelstoke Reservoirs macrozooplankton (length >150 µm), including their composition, abundance and biomass help to determine the current status of reservoirs. These results are a component of the study CLBMON-3 Kinbasket and Revelstoke Reservoirs Ecological Productivity conducted by BC Hydro under the Columbia Water Use Plan.

## 2. Methods

Samples were collected monthly at four stations in Kinbasket Reservoir during the highest production season. The Kinbasket sampling stations are located at Mica Forebay, Canoe Reach, Wood Arm, and Columbia Reach.

In Revelstoke Reservoir samples were collected at three stations. The stations Rev Upper, Rev Middle, and Rev Forebay are located along the length of the main body in Revelstoke Reservoir.

Samples were collected from April to October in both reservoirs during 2017sampling season, with a vertically hauled 153 µm mesh Wisconsin net with a 0.2 m throat diameter. The depth of each haul was 30 m. Duplicate samples were taken at each site of the reservoir.

Collected zooplankton samples were rinsed from the dolphin bucket and preserved in 70% ethanol. Zooplankton samples were analyzed for species density, biomass, and fecundity. Samples were re-suspended in tap water filtered through a 74 µm mesh and sub-sampled using a four-chambered Folsom-type plankton splitter. Splits were placed in gridded plastic petri dishes and stained with Rose Bengal to facilitate viewing with a Wild M3B dissecting microscope. For each replicate, organisms were identified to species level and counted until up to 200 organisms of the predominant species were recorded. If 150 organisms were counted by the end of a split, a new split was not started. The lengths of up to 30 organisms of each species were measured for use in biomass calculations, using a mouse cursor on a live television image of each organism. Lengths were converted to biomass (µg dry-weight) using empirical length-weight regression from McCauley (1984). The number of eggs carried by gravid *Daphnia* females and the lengths of these individuals were recorded for use in fecundity estimations. Zooplankton species were identified with reference to taxonomic keys (Sandercock and Scudder 1996, Pennak 1989, Wilson 1959, Brooks 1959).

## 3. Results – Kinbasket Reservoir

### 3.1 Species Present

Four calanoid copepod species were identified in the samples from Kinbasket Reservoir (Tab. 1). *Leptodiaptomus sicilis* (Forbes) and *Epischura nevadensis* (Lillj.) were present in samples during each sampling season, while *Leptodiaptomus ashlandi* (Marsh) and *Aglaodiaptomus leptopus*

(Forbes) were observed rarely. One cyclopoid copepod species, *Diacyclops bicuspidatus thomasi* (Forbes), was seen in samples during the studied period.

**Table 1. List of zooplankton species identified in Kinbasket Reservoir in 2003-2017. "+" indicates a consistently present species and "r" indicates a rarely present species.**

| | 2003 | 2004 | 2005 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Cladocera** | | | | | | | | | | | | | |
| *Alona sp.* | | | | | | r | | | r | | r | | |
| *Bosmina longirostris* | + | + | + | + | + | + | + | + | + | + | + | + | + |
| *Chydorus sphaericus* | | | + | | + | + | | | r | | | r | r |
| *Daphnia galeata mendotae* | + | + | + | + | + | + | + | + | + | + | + | + | + |
| *Daphnia rosea* | + | + | + | + | + | + | + | + | + | + | + | + | + |
| *Daphnia schoedleri* | + | + | + | + | + | + | + | + | + | + | + | + | + |
| *Diaphanosoma brachyurum* | | + | + | | + | + | | + | + | + | + | + | + |
| *Holopedium gibberum* | r | | | r | r | r | | | | r | r | r | + |
| *Leptodora kindtii* | + | + | + | + | | + | + | + | + | + | + | + | + |
| *Macrothrix sp.* | | | | | r | | | | | | | | |
| *Scapholeberis rammneri* | + | + | + | + | + | + | + | + | + | + | + | + | + |
| **Copepoda** | | | | | | | | | | | | | |
| *Aglaodiaptomus leptopus* | | r | | r | | | | | r | r | r | | r |
| *Diacyclops bicuspidatus* | + | + | + | + | + | + | + | + | + | + | + | + | + |
| *Epischura nevadensis* | + | + | + | + | + | + | + | + | + | + | + | + | + |
| *Leptodiaptomus ashlandi* | | r | r | | r | r | r | r | r | r | r | r | r |
| *Leptodiaptomus sicilis* | + | + | + | + | + | + | + | + | + | + | + | + | + |

Nine species of Cladocera were present in 2017 (Tab. 1). *Daphnia galeata mendotae* (Birge), *Daphnia schoedleri* (Sars), *Daphnia rosea* (Sars), *Bosmina longirostris* (O.F.M.) *Diaphanosoma brachyurum* (Lievin), *Scapholeberis rammneri* (Dumont and Pensaert) and *Leptodora kindtii* (Focke) were common, while other species were observed sporadically. *Daphnia* spp. were not identified to species for density counts.

## 3.2 Density and Biomass

For comparison with historical data the average at Mica Forebay station in Kinbasket was used. Zooplankton density values from 2003 to 2010 were higher than 10 ind/L and exceeded those values reported by the Division of Applied Biology, BC Research in 1977, Watson 1985 and Fleming and Smith 1988, while during the sampling period from 2011 to 2017 zooplankton densities were multiple times higher than those reported in 1984 and 1986 but similar to the densities found in 1977 (Fig. 1).

The seasonal average zooplankton density in Kinbasket Reservoir decreased in 2017 to 5.29 individuals/L from 7.25 individuals/L in 2016 (Fig. 2). The zooplankton density was numerically dominated by copepods, which averaged 80% of the 2017 community with 4.21 individuals/L. *Daphnia* spp comprised 11% with 0.59 individuals/L, and other cladocerans 9% with 0.49 individuals/L.

The average zooplankton densities for all four sampling stations in Kinbasket Reservoir fluctuated over the course of the studied period. It increased from 1.19 individuals/L in April to 10.18 individuals/L in July, and then gradually decreased to 2.59 individuals/L at the end of the sampling season (Tab. 2). Monthly averaged density of *Daphnia* for the whole reservoir increased gradually during the sampling season reaching its peak in August with 2.14 individuals/L (Fig.3).

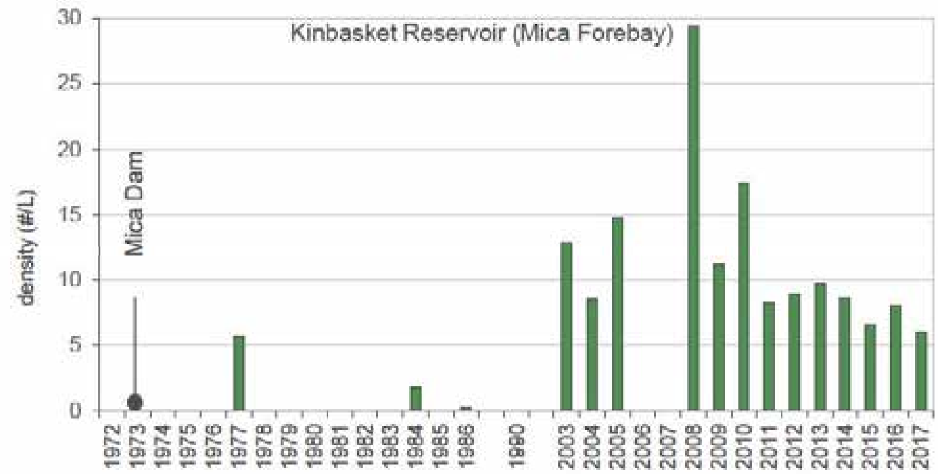


**Figure 1. Zooplankton density 1977-2017 at Mica Forebay in Kinbasket Reservoir**

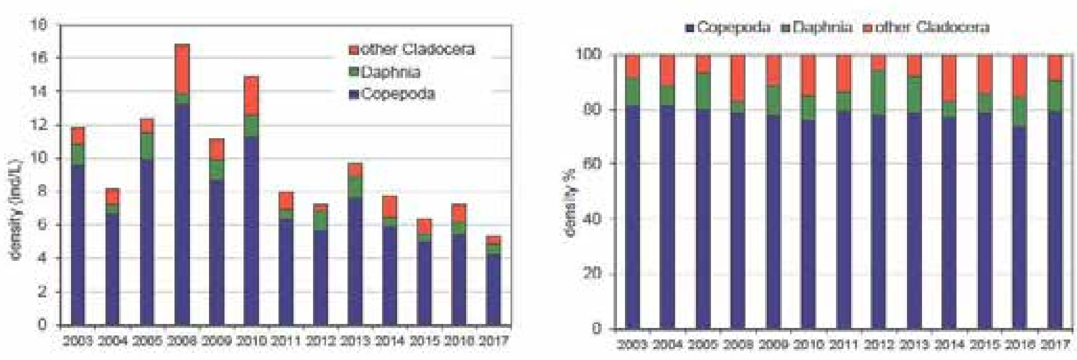


**Figure 2. Seasonal average zooplankton density in Kinbasket Reservoir 2003-2017**

**Table 2. Monthly average density and biomass of zooplankton in Kinbasket Reservoir in 2017. Density is in units of individuals/L, and biomass is in units of µg/L.**

| Density | | 24-Apr | 15-May | 19-Jun | 11-Jul | 14-Aug | 11-Sep | 16-Oct |
|---|---|---|---|---|---|---|---|---|
| | Copepoda | 1.16 | 1.28 | 5.25 | 8.59 | 6.45 | 4.67 | 1.32 |
| | *Daphnia* | 0.01 | 0.01 | 0.06 | 0.49 | 2.14 | 0.79 | 0.68 |
| | Other Cladocera* | 0.02 | 0.02 | 0.15 | 1.11 | 1.18 | 0.43 | 0.44 |
| | **Total Zooplankton** | **1.19** | **1.30** | **5.46** | **10.18** | **9.77** | **5.88** | **2.59** |
| **Biomass** | | 24-Apr | 15-May | 19-Jun | 11-Jul | 14-Aug | 11-Sep | 16-Oct |
| | Copepoda | 2.17 | 2.34 | 6.79 | 11.29 | 9.04 | 6.58 | 1.92 |
| | *Daphnia* | 0.14 | 0.15 | 1.24 | 17.77 | 43.84 | 17.53 | 12.16 |
| | Other Cladocera** | 0.10 | 0.04 | 0.24 | 3.05 | 4.11 | 2.08 | 1.49 |
| | **Total Zooplankton** | **2.42** | **2.53** | **8.28** | **32.11** | **56.99** | **26.19** | **16.06** |

*Values do not include *Daphnia* spp. density.
**Values do not include *Daphnia* spp. biomass.

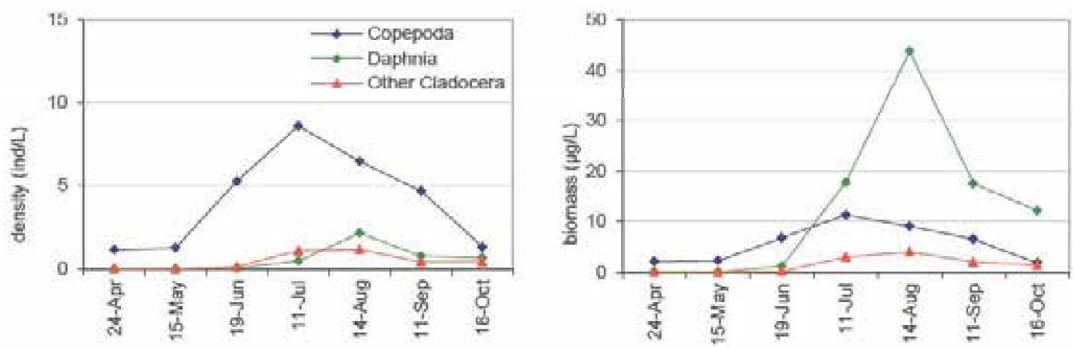


**Figure 3. Monthly zooplankton density and biomass averaged for the whole Kinbasket Reservoir 2017**

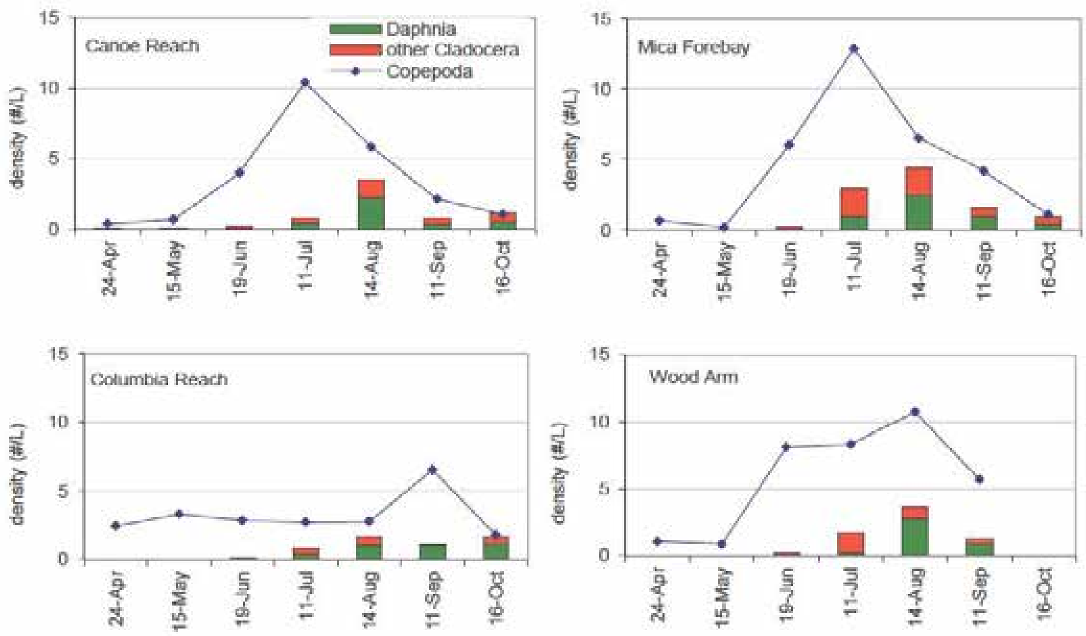


**Figure 4. Density of cladoceran and copepod zooplankton at four stations in Kinbasket Reservoir 2017**

Copepods were the most abundant zooplankton at all four stations. They numerically prevailed during the whole sampling season, with populations peaking during the summer. The highest copepod density was found in July at station Mica Forebay with 12.87 individuals/L (Fig. 4). The number of Cladocerans, mostly *Bosmina,* varied by season as well as along the reservoir. Cladocerans other than *Daphnia* were the most numerous in July-August at each sampling station. The highest density was found in July at Mica Forebay with 2.00 individuals/L. *Daphnia* was present during the whole sampling season at each station. The highest density of *Daphnia* was found in August at Wood Arm with 2.82 individuals/L. The proportion of *Daphnia* density were 12% at Canoe Reach and Mica Forebay, while at Columbia Reach and Wood Arm its proportions were 6% and 8 % respectively. (Tab. 3, Fig. 5)

**Table 3. Seasonal average zooplankton density and biomass at four sampling stations in Kinbasket Reservoir in 2017. Density is in units of individuals/L; biomass is in units of µg/L.**

| | | Canoe Reach | Mica Forebay | Columbia Reach | Wood Arm |
|---|---|---|---|---|---|
| **Density** | Copepoda | 3.50 | 4.51 | 3.21 | 5.83 |
| | *Daphnia* | 0.52 | 0.69 | 0.51 | 0.66 |
| | Other Cladocera | 0.42 | 0.75 | 0.30 | 0.44 |
| | **Total** | **4.43** | **5.96** | **4.02** | **7.01** |
| **Biomass** | Copepoda | 4.60 | 6.49 | 5.32 | 7.29 |
| | *Daphnia* | 13.69 | 16.31 | 10.10 | 13.08 |
| | Other Cladocera | 1.51 | 2.61 | 0.91 | 1.33 |
| | **Total** | **19.80** | **25.41** | **16.32** | **21.92** |

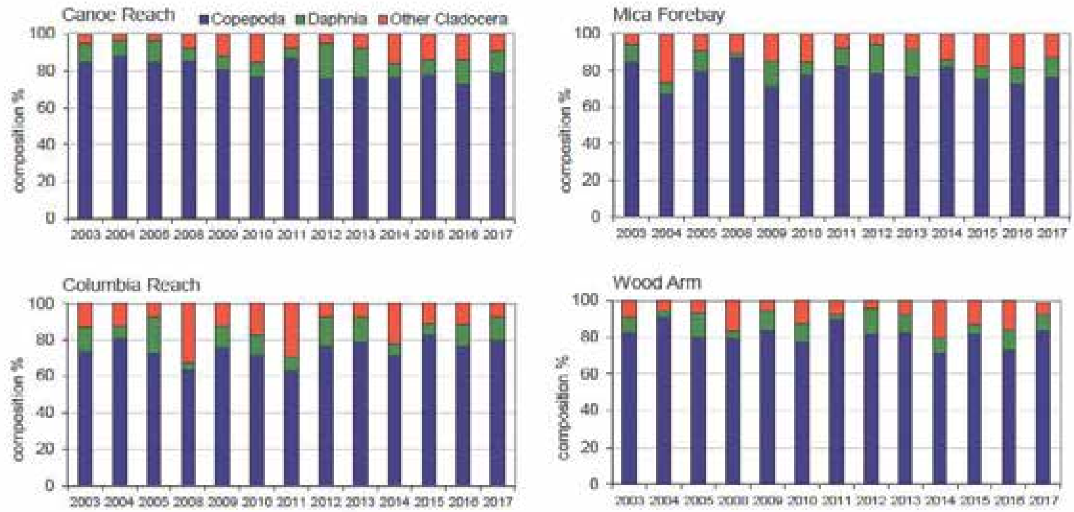


**Figure 5. Seasonal average % of zooplankton density composition at four stations in Kinbasket Reservoir in 2003-2017**

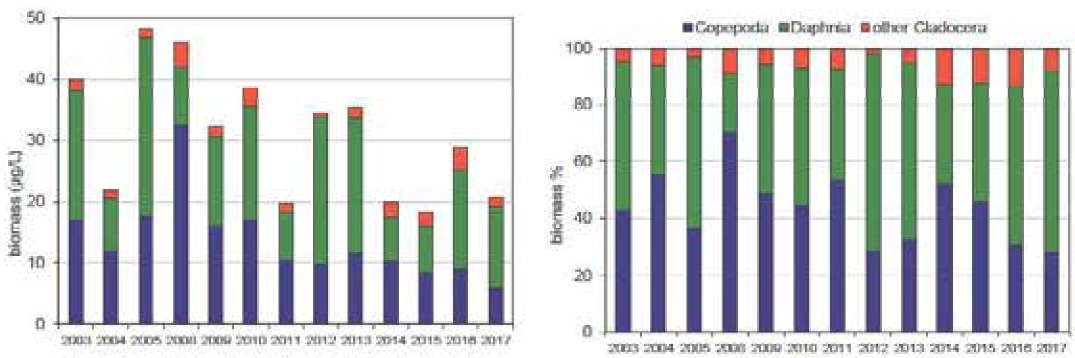


**Figure 6. Seasonal average zooplankton biomass in Kinbasket Reservoir 2003-2017**

Total zooplankton biomass, averaged for the whole reservoir, was 20.82 µg/L. Copepods contributed to 24% of the total zooplankton biomass with annual average biomass of 5.87 µg/L. *Other Cladocera* had average biomass 1.65 µg/L which comprised 8%, while *Daphnia* made up to 64% of the total zooplankton biomass with 13.30 µg/L (Fig. 6). Average zooplankton biomass for the four stations was low at the beginning of the sampling season. During the rest of the sampling season zooplankton biomass increased reaching its peak in August with 56.99 µg/L, dominated by *Daphnia* with 43.84 µg/L, which made up 77% of the total biomass at that time (Tab. 2, Fig. 3).

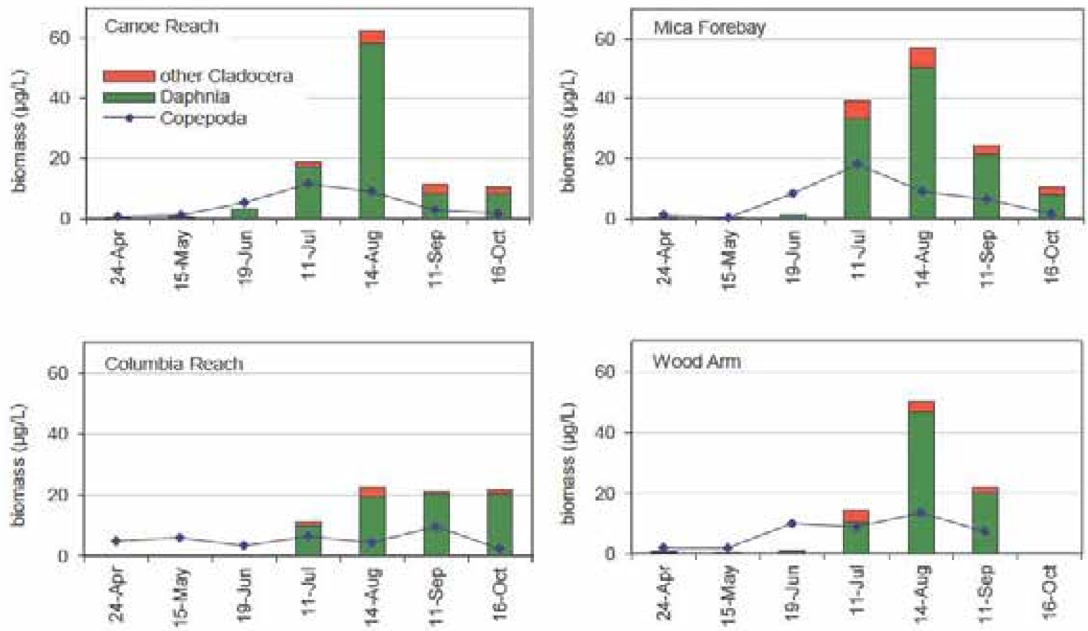


**Figure 7. Zooplankton biomass at four stations in Kinbasket Reservoir 2017**

*Daphnia* biomass increased over the course of the study period in 2017. Although *Daphnia* were present in the samples during the entire season with high biomass from August through October, they accounted for the highest proportion of zooplankton biomass in August (77%) and October (76%) (Fig. 3). The highest biomass of *Daphnia* was found in August at Canoe Reach with 58.36 µg/L (Fig. 7). *Daphnia* density and biomass in 2017 were the lowest at Columbia Reach station averaging 0.51 individuals/L contributing to 13% of zooplankton density, and 10.10 µg/L which made up 62% of total zooplankton biomass. During the same time period the highest annual average *Daphnia* density and biomass were found at station Mica Reach with 0.69 individuals/L and 16.31 µg/L when contributed to 12% of the zooplankton density and 64% of the zooplankton biomass ( Fig. 5, Fig.8, Fig. 9).

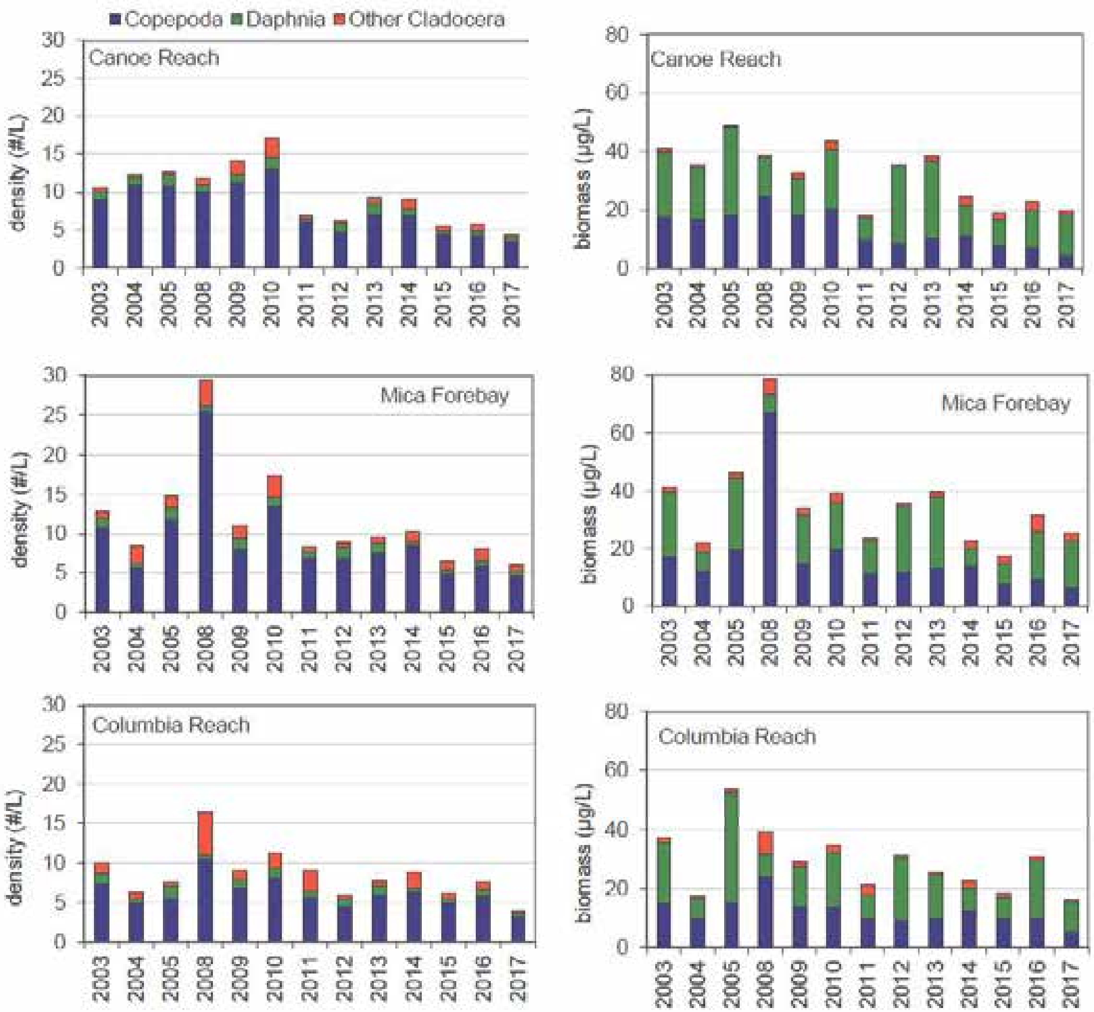


**Figure 8. Annual average zooplankton density (left) and biomass (right) at four stations in Kinbasket Reservoir 2003-2017**

In 2017 peak total zooplankton density averaged for the whole reservoir occurred in July at 10.18 individuals/L while the highest biomass was found in August with 56.99 µg/L (Tab. 2, Fig. 3). *Daphnia* was the most numerous in August with 2.14 individuals/L, and the highest biomass of 43.84 µg/L.

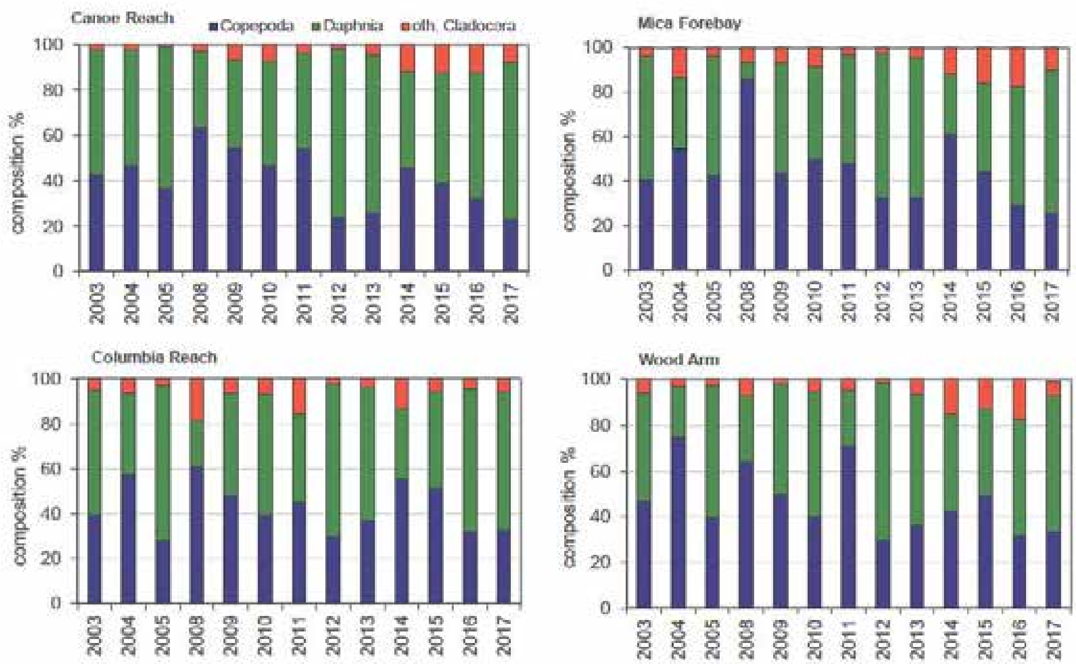


**Figure 9. Seasonal average % of zooplankton biomass composition at four stations in Kinbasket Reservoir in 2003-2017**

## 3.3 Daphnia Fecundity

In Kinbasket Reservoir *Daphnia* gravid females were present in samples during the entire sampling season 2017. The proportion of gravid females averaged 0.25 (Tab. 5). The seasonal average number of eggs per gravid female was 2.13. Across the sampling season the number of eggs per water volume averaged 0.26 eggs/L and the number of eggs per capita averaged 0.62 eggs/individual.

**Table 4. Fecundity data for *Daphnia* spp. in Kinbasket Reservoir in 2017. Values are seasonal averages, calculated for samples collected between April and October 2017.**

| | 2017 |
|---|---|
| Proportion of gravid females | 0.25 |
| # Eggs per gravid Female | 2.13 |
| # Eggs per Litre | 0.26 |
| # Eggs per Capita | 0.62 |

## 4. Results – Revelstoke Reservoir

### 4.1 Species Present

Three calanoid copepod species were identified in the samples from Revelstoke Reservoir (Tab. 6). *Leptodiaptomus sicilis* (Forbes) and *Epischura nevadensis* (Lillj.) were present in samples during the whole season while *Leptodiaptomus ashlandi* (Marsh) was observed occasionally. One cyclopoid copepod species, *Diacyclops bicuspidatus thomasi* (Forbes), was seen in samples from Revelstoke Reservoirs.

Seven species of Cladocera were identified in Revelstoke Reservoir during the study period in 2017 (Tab. 6). *Daphnia galeata mendotae* (Birge), *Daphnia pulex* (Leydig), *Daphnia rosea* (Sars), *Bosmina longirostris* (O.F.M.), *Holopedium gibberum* (Zaddach) and *Leptodora kindtii* (Focke) were common during the entire sampling season, while others were observed sporadically. *Daphnia* spp. were not identified to species for density counts. The predominant copepod was *D. bicuspidatus thomasi*, while *Daphnia* spp., and *B. longirostris* were the most numerous among the cladocerans

**Table 5. List of zooplankton species identified in Revelstoke Reservoir in 2003-2017. "+" indicates a consistently present species and "r" indicates a rarely present species.**

| | 2003 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Cladocera | | | | | | | | | | | |
| *Acroperus harpae* | r | | | | | | | | | | |
| *Alona sp.* | r | | | r | r | r | | | r | | |
| *Alonella nana* | | | | r | | | | | | | |
| *Biapertura affinis* | r | r | | | | | | | | | |
| *Bosmina longirostris* | + | + | + | + | + | + | + | + | + | + | + |
| *Ceriodaphnia sp.* | | r | | | | | | | | | |
| *Chydorus sp.* | r | | | | | | | | | | |
| *Chydorus sphaericus* | r | r | | r | r | | | | r | | |
| *Daphnia galeata mendotae* | + | + | + | + | + | + | + | + | + | + | + |
| *Daphnia rosea* | + | + | + | + | + | + | + | + | + | + | + |
| *Daphnia pulex* | + | + | + | + | + | + | + | + | + | + | + |
| *Diaphanosoma brachyurum* | | | r | | | r | r | | r | r | |
| *Holopedium gibberum* | + | + | + | + | + | + | + | + | + | + | + |
| *Ilyocryptus sp.* | | | | | | | | | r | | |
| *Leptodora kindtii* | + | + | + | + | + | + | + | + | + | + | + |
| *Scapholeberis rammneri* | r | r | r | r | r | r | + | + | r | r | + |
| Copepoda | | | | | | | | | | | |
| *Diacyclops bicuspidatus* | + | + | + | + | + | + | + | + | + | + | + |
| *Epischura nevadensis* | + | + | + | + | + | + | + | + | + | + | + |
| *Leptodiaptomus ashlandi* | + | + | + | + | + | + | + | + | + | + | + |
| *Leptodiaptomus sicilis* | + | + | + | + | + | + | + | + | + | + | + |

### 4.2 Density and Biomass

The seasonal average zooplankton densities observed in 2003, 2008-2017 were much higher than those reported for years 1984 and 1986 by Watson 1985 and Fleming and Smith 1988 (Fig. 10). For comparison with historical data the average at Rev Forebay in Revelstoke Reservoir was used.

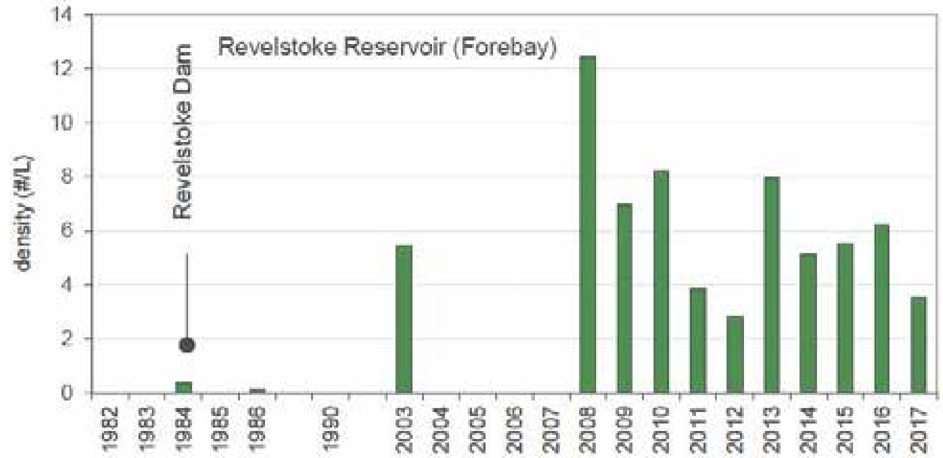


**Figure 10. Zooplankton density 1984-2017 at Rev Forebay in Revelstoke Reservoir**

The zooplankton community was primarily composed of copepods, which made up 78% of the zooplankton density and 22% of the zooplankton biomass during the studied period in 2017. *Daphnia* accounted for 12% of the density and 64% of the biomass during the same time period, while other cladocerans comprised 10% of density and 14% of biomass (Fig. 11 and Fig. 12).

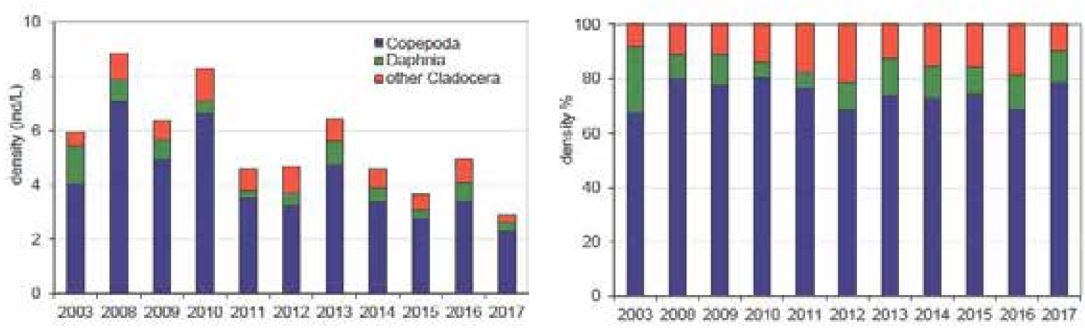


**Figure 11. Seasonal average composition of zooplankton density in Revelstoke Reservoir in 2003, 2008 – 2017**

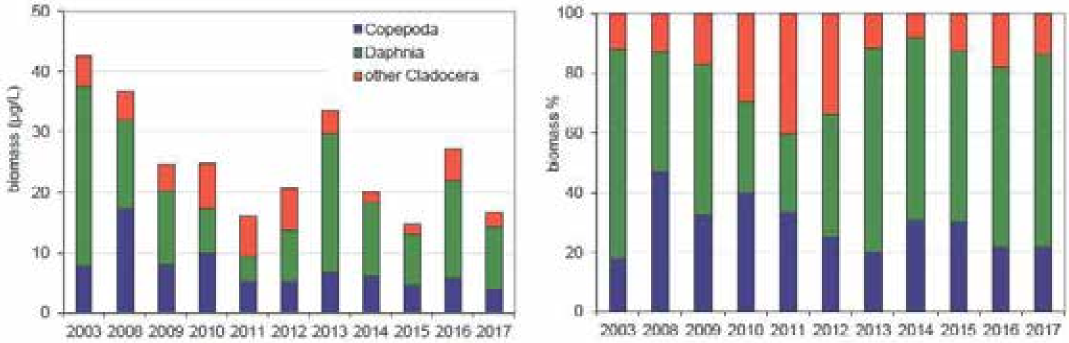


**Figure 12. Seasonal average composition of zooplankton biomass in Revelstoke Reservoir in 2003, 2008 – 2017**

The seasonal average zooplankton density in 2017 (April to October) decreased to 2.93 individuals/L from 4.99 individuals/L in 2016. Copepods were the most abundant with 2.29 individuals/L. Annual average density of *Daphnia* was 0.35 individuals/L, while density of other Cladocera (mainly *Bosmina*) was 0.29 individual/L. (Tab. 7, Fig. 11). Total zooplankton biomass, averaged for the whole reservoir was 16.74 µg/L. Copepods annual average biomass was 3.66 µg/L, while *Daphnia* and other cladocerans biomass was 10.79 µg/L, and 2.29 µg/L respectively (Tab. 7; Fig. 12).

**Table 6. Annual average zooplankton abundance and biomass in Revelstoke Reservoir 2017 (April to October).**

| | | ind/L | % |
|---|---|---|---|
| **Density** | Copepoda | 2.29 | 78 |
| | *Daphnia* | 0.35 | 12 |
| | other Cladocera | 0.29 | 10 |
| | **Total** | **2.93** | |

| | | µg/L | % |
|---|---|---|---|
| **Biomass** | Copepoda | 3.66 | 22 |
| | *Daphnia* | 10.79 | 64 |
| | other Cladocera | 2.29 | 14 |
| | **Total** | **16.74** | |

The seasonal average zooplankton densities in Revelstoke Reservoir decreased in comparison to the previous year. The highest zooplankton density averaged for the whole reservoir was in July with 5.04 individuals/L (Fig. 13). Seasonal average zooplankton biomass in 2017 also decreased in comparison to the previous year (Fig. 12). The highest zooplankton biomass averaged for the whole reservoir was found in October with 36.11 µg/L (Fig. 13). Among the stations, the highest total zooplankton density was seen at Rev Forebay in July with 8.05 individuals/L, while the highest biomass was found in October at station Rev Middle with 101.25 µg/L (Fig. 14).

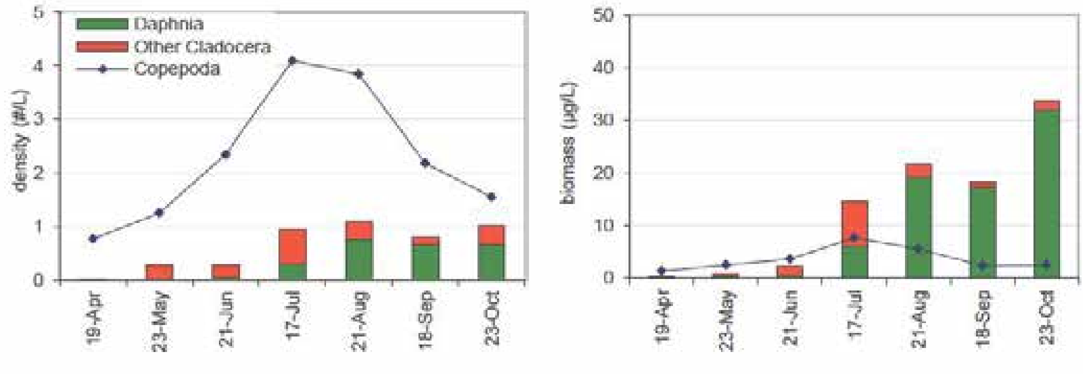


Figure 13. Monthly average zooplankton density and biomass in Revelstoke Reservoir in 2017

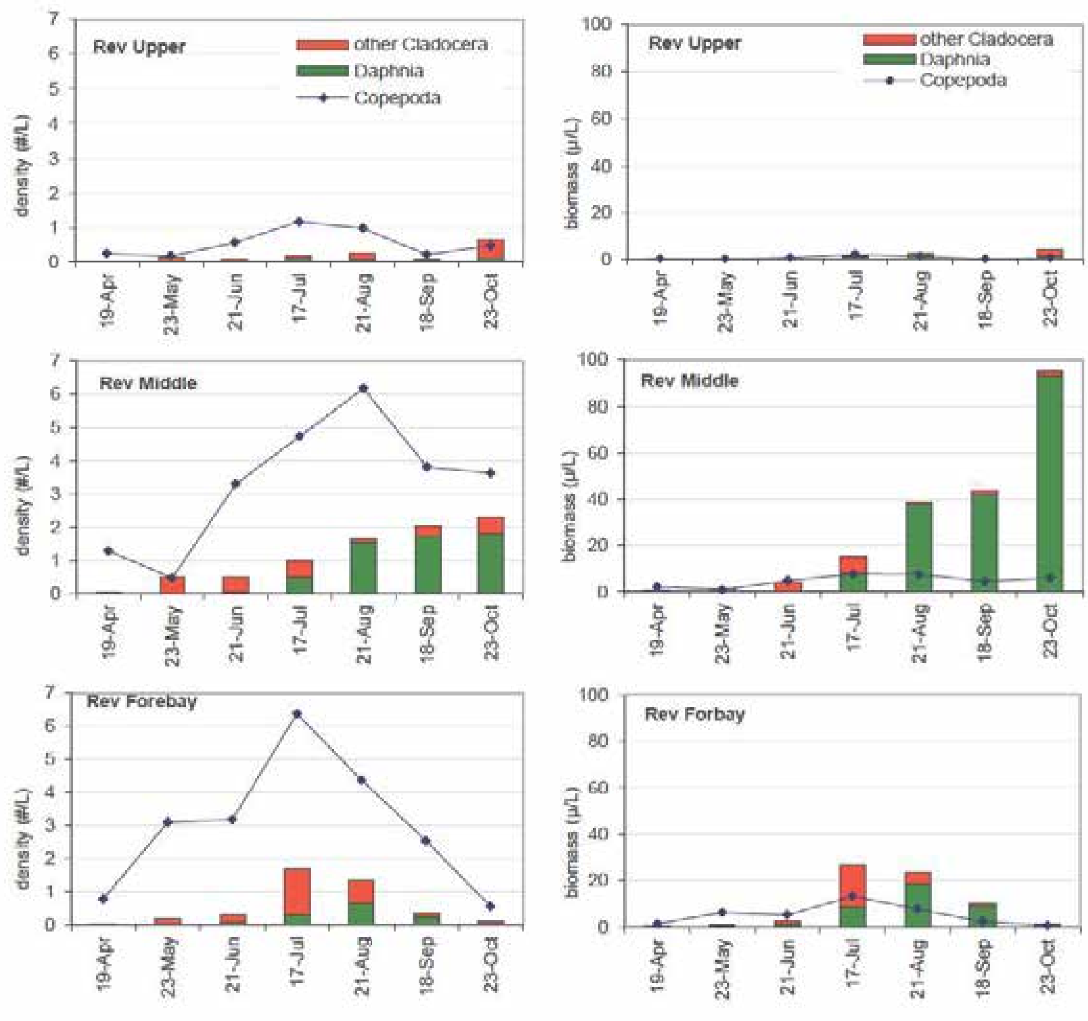


Figure 14. Zooplankton density and biomass at three stations in Revelstoke Reservoir 2017

During 2017 sampling season Copepods were the most numerous in July and August consisting mainly of *D. bicuspidatus thomasi*. They numerically prevailed during the whole sampling season, with the most numerous population of 6.37 individuals/L found at station Rev Forebay in July (Fig. 14).

The pattern of seasonal changes of zooplankton density and biomass was similar to the pattern in previous sampling seasons. In each year number of Copepoda increase at the beginning of the summer, reaching its maximum in May-August, and decrease during the fall, while *Daphnia* density increase at the end of summer and trough fall, and number of other Cladocera peaked in June or July (Fig. 13). Other Cladocerans were composed mainly of *Bosmina*, averaging 0.29 individuals/L in the whole reservoir. In July 2017, at station Rev Forebay the number of other cladocerans was the highest in the season due to a peak of *Bosmina* with 1.38 individuals/L (Fig. 14). In terms of biomass, other cladocerans contributed 14% to the total zooplankton biomass.

Number of *Daphnia* was low during the entire sampling season in 2017. It was less than 1 individual/L at each station except in July, August and September at Rev Middle. Although *Daphnia* were present in samples during the entire season, they accounted from 0.3% to 30% of the zooplankton community from April to October. Its density was relatively low averaging 0.01 to 0.76 individuals/L at all three stations (Fig. 13). However, *Daphnia* biomass was the highest of three zooplankton groups averaging 10.79 µg/L during the sampling season 2017 (Fig. 12, Tab.7). The highest *Daphnia* biomass was found at Rev Middle station with 92.80 µg/L in October, when *Daphnia* accounted for 92% of the total zooplankton biomass at that time (Fig. 14).

## 4.3 Seasonal and Along-Lake Patterns

The seasonal development of zooplankton density and biomass in Revelstoke Reservoir follow the usual pattern of increasing copepods in spring and early summer, and a cladoceran increase in the summer and fall (Fig. 13). Copepods dominated numerically during the entire sampling season. Other cladocerans were present with low numbers during the entire sampling season as well as *Daphnia* spp., which despite low density made up the majority of the zooplankton biomass from August to October.

During 2017 peak total zooplankton density occurred in July with 5.05 individuals/L (Tab. 8, Fig. 13). The peak total zooplankton biomass occurred in October with 36.11 µg/L, when *Daphnia* biomass contributed to 88% of the total zooplankton biomass with 31.87 µg/L.

Along the length of Revelstoke Reservoir zooplankton densities as well as biomass tended to be higher in the middle part of the basin and near the dam (Fig. 14).

**Table 7. Monthly average density and biomass of zooplankton in Revelstoke Reservoir in 2017. Density is in units of individuals/L, and biomass is in units of µg/L.**

| Density | | 19-Apr | 23-May | 21-Jun | 17-Jul | 21-Aug | 18-Sep | 23-Oct |
|---|---|---|---|---|---|---|---|---|
| | Copepoda | 0.77 | 1.25 | 2.35 | 4.09 | 3.84 | 2.19 | 1.56 |
| | *Daphnia* | 0.01 | 0.01 | 0.04 | 0.30 | 0.76 | 0.66 | 0.66 |
| | Other Cladocera* | 0.02 | 0.26 | 0.24 | 0.65 | 0.33 | 0.15 | 0.37 |
| | **Total Zooplankton** | **0.80** | **1.53** | **2.63** | **5.05** | **4.93** | **3.00** | **2.58** |
| **Biomass** | | 19-Apr | 23-May | 21-Jun | 17-Jul | 21-Aug | 18-Sep | 23-Oct |
| | Copepoda | 1.34 | 2.49 | 3.65 | 7.73 | 5.57 | 2.35 | 2.48 |
| | *Daphnia* | 0.18 | 0.21 | 0.52 | 6.05 | 19.36 | 17.33 | 31.87 |
| | Other Cladocera** | 0.07 | 0.69 | 1.84 | 8.57 | 2.24 | 0.86 | 1.76 |
| | **Total Zooplankton** | **1.59** | **3.39** | **6.01** | **22.35** | **27.17** | **20.54** | **36.11** |

*Values do not include *Daphnia* spp. density.
**Values do not include *Daphnia* spp. biomass.

## 4.4 Daphnia Fecundity

*Daphnia* spp. gravid females were observed in Revelstoke Reservoir throughout the sampling season. The proportion of females that were gravid was variable across the season and along the reservoir. The proportion of gravid females averaged 0.08 in 2017 (Tab. 10). The seasonal average number of eggs per gravid female was 2.04. Across the sampling season the number of eggs per water volume averaged 0.08 eggs/L, and the number of eggs per capita averaged 0.18 eggs/individual over the study period in 2017.

**Table 8. Fecundity data for *Daphnia* spp. in Revelstoke Reservoir 2017. Values are seasonal averages, calculated for samples collected between April and October.**

| | 2017 |
|---|---|
| Proportion of gravid females | 0.08 |
| # Eggs per gravid Female | 2.04 |
| # Eggs per Litre | 0.08 |
| # Eggs per Capita | 0.18 |

## 4.5 Additional sampling from 20m and 60m

In July, August and September 2017 additional samples were collected by towing Wisconsin net from depths of 20m and 60 m to the water surface. Samples were collected at two stations in Revelstoke (Rev Middle and Rev Forebay) and at one station in Kinbasket Reservoir (Forebay). There were significant differences in zooplankton densities between samples taken from 20, 30 and 60m (Fig. 15).

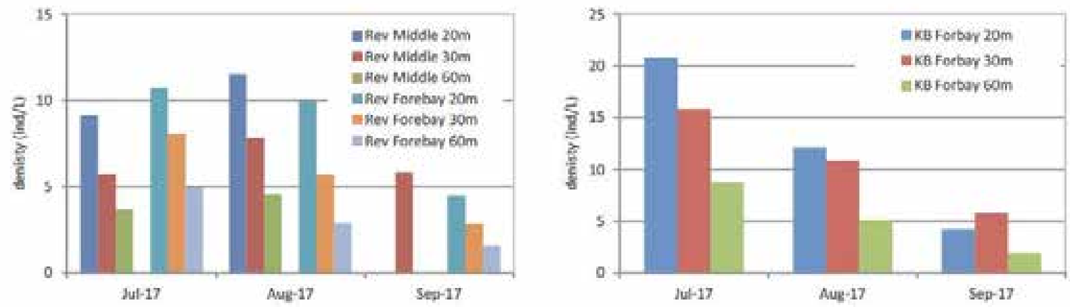


**Figure 15. Zooplankton density- samples taken from 20m, 30m and 60m in Revelstoke (left) and Kinbasket Reservoir (right).**

Densities of zooplankton in samples taken from 20m were more than twice higher than those sampled from 60m, and about 0.5 times higher than samples taken from 30m. However if densities in samples taken from 30 and 60 meters we recalculate as they are taken from 20 m, the results are brought to the similar level (Fig.16). Based on the obtained results, it can be concluded that sampling from 20m and 30m are grabbing from the same zooplankton cluster located above 20m depth, while sampling from 60m, additional small amount of zooplankton patch is sampled located in the lower part of the water column (under 30m depth).

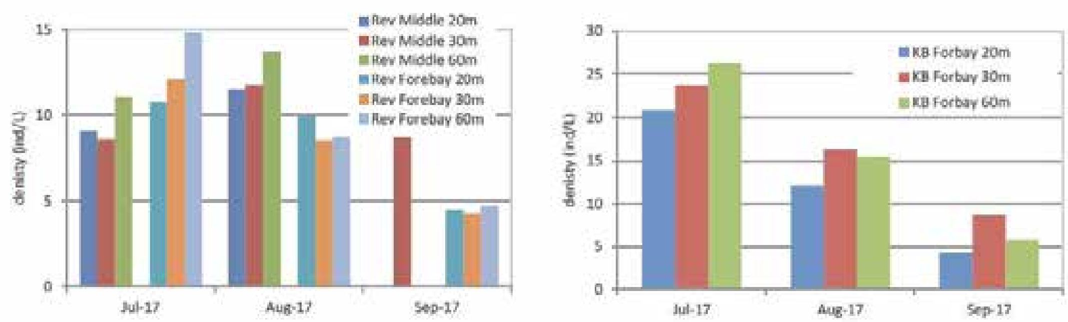


**Figure 16. Zooplankton density- samples taken from 20m, 30m and 60m in Revelstoke (left) and Kinbasket Reservoir (right), calculated as taken from 20m depth.**

## 5. Conclusions

Both Reservoirs Kinbasket and Revelstoke are oligotrophic with a moderate zooplankton density. The zooplankton community is diverse and has a relatively stable cladoceran population with a moderate proportion of *Daphnia* spp., considered as a favourable food for kokanee. Density and biomass of *Daphnia* spp. in both reservoirs decreased in 2017 in comparison to the previous year.

In comparison to historical data it is notable that zooplankton abundance in both reservoirs, Kinbasket and Revelstoke has increased over the time period. These changes have likely been due to combination of climatic changes, predation, nutrients availability, grazeable algae and especially of shifting from riverine (before impoundment) toward lake habitat.

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*Appendix 8*

*Moorings*
*Kinbasket and Revelstoke Reservoirs, 2017*

*Roger Pieters and Greg Lawrence*
*University of British Columbia*

# Moorings,
# Kinbasket and Revelstoke Reservoirs, 2017

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Looking toward Revelstoke Dam, 25 May 2018.

Prepared for

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March 14, 2019

## Contents



## List of Figures

## 1. Introduction

This report provides an update on the collection of data from moored temperature recorders at fixed sites in Kinbasket and Revelstoke Reservoirs for the B.C. Hydro project "CLBMON-56 Addendum #1 to CLBMON-3 Kinbasket and Revelstoke Reservoirs Ecological Productivity Monitoring Program - Mica Project Units 5 and 6 Addendum." The overall plan and goals are briefly summarized, and selected data from the moorings are presented.

The goal of the ongoing CLMBON-3 project has been to collect long-term data describing basic processes needed to understand reservoir limnology, to investigate long-term trends in pelagic conditions, and to improve our understanding of the effect of reservoir operation on ecosystem function. To address the effect of the addition of two turbines to the Mica powerhouse (Mica 5 and Mica 6), the goal of the CLBMON-56 addendum is to collect data from moorings of temperature recorders at fixed locations.

Included in this work is collection of data from two base locations: the forebay of Revelstoke Reservoir and the forebay of Kinbasket Reservoir. The goal is to collect data from these two base locations throughout the duration of the project. Instruments have also been moored at other locations, such as at the mid and upper sampling stations in Revelstoke Reservoir.

Data from moored temperature recorders will complement data gathered by conductivity-temperature-depth (CTD) surveys for CLBMON-3, conducted on average once a month from May to October (Pieters and Lawrence 2019). Temperature recorders will provide data with high temporal resolution, observing reservoir behaviour between the monthly CTD surveys.

Data from the moorings will provide information about how rapid changes in inflows and outflows affect a variety of processes such as internal seiches, interflows, and transport of water into the photic zone. These processes are important, for example, to the replenishment of nutrients needed for pelagic productivity in the photic zone (Pieters and Lawrence 2012). Work for CLBMON-56 includes measurement of wind and other meteorological data at the surface of the reservoir.

## 2. Methods

During the summer of 2012, a trial of four different types of moorings was undertaken in the forebay of Revelstoke Reservoir. These four types have subsequently been used for moorings at other locations. The four types of moorings are given in Table 2.1 and illustrated in Figure 2.1. The location of all moorings is given in Table 2.2.

**Table 2.1** Type of moorings

| Name | Description |
|---|---|
| SUB | Subsurface mooring |
| BOOM | Line from log boom near dam |
| SPAR | Spar mooring |
| PROF | Autonomous profiler |

**Table 2.2** Location of moorings

| Name | UTM Easting(11U)/Northing | Latitude/ Longitude |
|---|---|---|
| Rev FB SUB | 416,926E 5,657,518N | 51° 3.790 N 118° 11.132 W |
| Rev FB BOOM | 416,468E 5,656,304N | 51° 3.131 N 118° 11.507 W |
| Rev FB PROF | 417,057E 5,657,845N | 51° 3.968 N 118° 11.024 W |
| Rev FB SPAR | 416,846E 5,657,294N | 51° 3.668 N 118° 11.197 W |
| Rev LAF* PROF | 413,627E 5,677,983N | 51° 14.799 N 118° 14.250 W |
| Rev LAF* SPAR | 413,857E 5,677,722N | 51° 14.662 N 118° 14.049 W |
| Rev MID SUB | 398,452E 5,699,022N | 51° 25.997 N 118° 27.652 W |
| Rev UP SUB | 385,521E 5,731,847N | 51° 43.550 N 118° 39.451 W |
| Kin FB SUB | 393,754E 5,772,744N | 52° 5.702N 118° 33.058 W |
| Kin FB BOOM | 392,223E 5,771,051N | 52° 4.772 N 118° 34.368 W |
| Kin MID SPAR | 400,307E 5,775,586N | 52° 7.309 N 118° 27.371 W |
| Kin COL SPAR | 426,190E 5,756,949N | 51° 57.500 N 118° 04.450 W |

* Near La Forme Creek, ~18 km north of Revelstoke Dam, and 30 km south of Rev MID at Downie.

From July 2012 to August 2018, 64 moorings were deployed and recovered in a variety of locations. The location, type and duration of moorings are summarized in Table 2.3.

**Table 2.3** Moorings, 2012 to 2018

| N | RES | LOC | TYPE | START | END |
|---|---|---|---|---|---|
| 201 | REV | FB | SUB | 16-Aug-2012 | 11-Oct-2012 |
| 202 | REV | FB | TB* | 18-Jul-2012 | 11-Oct-2012 |
| 203 | REV | FB | SPAR | 16-Aug-2012 | 11-Oct-2012 |
| 204 | REV | FB | PROF | 11-Sep-2012 | 11-Oct-2012 |
| 205 | REV | FB | SUB | 11-Oct-2012 | 26-Aug-2013 |
| 206 | REV | FB | BOOM | 11-Oct-2012 | 26-Aug-2013 |
| 207 | REV | MID | SUB | 12-Sep-2012 | 26-Aug-2013 |
| 208 | REV | UP | SUB | 12-Sep-2012 | 26-Aug-2013 |
| 209 | KIN | FB | SUB | 13-Sep-2012 | 30-Aug-2013 |
| 210 | KIN | FB | BOOM | 13-Sep-2012 | 30-Aug-2013 |
| 211 | REV | FB | SPAR | 25-Apr-2013 | 20-May-2014 |
| 212 | REV | FB | PROF | 25-Apr-2013 | 20-May-2014 |
| 213 | REV | MID | SPAR | 26-Apr-2013 | 20-May-2014 |
| 214 | REV | MID | PROF | 26-Apr-2013 | 20-May-2014 |
| 215 | REV | FB | SUB | 28-Aug-2013 | 22-Aug-2014 |
| 216 | REV | FB | BOOM | 28-Aug-2013 | 22-Aug-2014 |
| 217 | REV | MID | SUB | 29-Aug-2013 | 22-Aug-2014 |
| 218 | REV | UP | SUB | 29-Aug-2013 | 22-Aug-2014 |
| 219 | REV | UP | PROF | 29-Aug-2013 | 22-Aug-2014 |
| 220 | KIN | FB | SUB | 30-Aug-2013 | 29-Aug-2014 |
| 221 | KIN | FB | BOOM | 30-Aug-2013 | 29-Aug-2014 |
| 222 | REV | FB | PROF | 23-May-2014 | 22-Aug-2014 |
| 223 | REV | MID | SPAR | 11-Jul-2014 | 22-Aug-2014 |
| 224 | REV | MID | PROF | 11-Jul-2014 | 22-Aug-2014 |
| 225 | REV | FB | SUB | 27-Aug-2014 | 28-Aug-2015 |
| 226 | REV | FB | BOOM | 27-Aug-2014 | 28-Aug-2015 |
| 227 | REV | FB | PROF | 27-Aug-2014 | 28-May-2015 |
| 228 | REV | MID | SUB | 28-Aug-2014 | 28-Aug-2015 |
| 229 | REV | MID | PROF | 28-Aug-2014 | 28-May-2015 |
| 230 | REV | UP | SUB | 28-Aug-2014 | 28-Aug-2015 |
| 231 | KIN | FB | SUB | 29-Aug-2014 | 02-Sep-2015 |
| 232 | KIN | FB | BOOM | 29-Aug-2014 | 11-Dec-2014 |
| 233 | KIN | FB | BOOM2 | 25-May-2015 | 02-Sep-2015 |
| 234 | REV | MID | PROF | 02-Jun-2015 | 26-May-2016 |
| 235 | REV | FB | PROF | 03-Jun-2015 | 26-May-2016 |
| 236 | REV | LAF | PROF | 03-Jun-2015 | 26-May-2016 |
| 237 | REV | LAF | SPAR | 03-Jun-2015 | 26-May-2016 |
| 238 | REV | FB | SUB | 01-Sep-2015 | 19-Aug-2016 |
| 239 | REV | FB | BOOM | 01-Sep-2015 | 19-Aug-2016 |
| 240 | REV | MID | SUB | 01-Sep-2015 | 19-Aug-2016 |
| 241 | REV | UP | SUB | 01-Sep-2015 | 19-Aug-2016 |
| 242 | KIN | FB | SUB | 02-Sep-2015 | 24-Aug-2016 |
| 243 | KIN | FB | BOOM | 02-Sep-2015 | 24-Aug-2016 |

**Table 2.3** Moorings, 2012 to 2018 continued

| N | RES | LOC | TYPE | START | END |
|---|---|---|---|---|---|
| 244 | KIN | MID | SPAR | 01-Jun-2016 | 24-Aug-2016 |
| 245 | REV | FB | PROF | 01-Jun-2016 | 31-May-2017 |
| 246 | REV | LAF | PROF | 02-Jun-2016 | 31-May-2017 |
| 247 | REV | MID | PROF | 02-Jun-2016 | 31-May-2017 |
| 248 | REV | FB | SUB | 23-Aug-2016 | 29-Aug-2017 |
| 249 | REV | FB | BOOM | 23-Aug-2016 | 22-Jun-2017 |
| 250 | REV | MID | SUB | 25-Aug-2016 | 25-Aug-2017 |
| 251 | REV | UP | SUB | 25-Aug-2016 | 28-Aug-2017 |
| 252 | KIN | FB | SUB | 24-Aug-2016 | 30-Aug-2017 |
| 253 | KIN | FB | BOOM | 24-Aug-2016 | 25-Apr-2017 |
| 254 | KIN | FB | BOOM2 | 03-May-2017 | 30-Aug-2017 |
| 254 | KIN | FB | BOOM2 | 03-May-2017 | 30-Aug-2017 |
| 255 | KIN | MID | SPAR | 08-Jun-2017 | 16-Oct-2017 |
| 256 | KIN | COL | SPAR | 08-Jun-2017 | 18-Oct-2017 |
| 257 | REV | FB | PROF | 07-Jun-2017 | 25-May-2018 |
| 258 | REV | MID | PROF | 07-Jun-2017 | 25-May-2018 |
| 259 | REV | MID | SUB | 28-Aug-2017 | 23-Aug-2018 |
| 260 | REV | UP | SUB | 31-Aug-2017 | 23-Aug-2018 |
| 261 | REV | FB | SUB | 31-Aug-2017 | 24-Aug-2018 |
| 262 | REV | FB | BOOM | 31-Aug-2017 | 24-Aug-2018 |
| 263 | KIN | FB | SUB | 30-Aug-2017 | 29-Aug-2018 |
| 264 | KIN | FB | BOOM | 30-May-2018 | 16-Oct-2018 |

* Trial line of Onset TidBits at Revelstoke Dam boom, see Pieters and Lawrence (2016b).

Temperature recorders consisted of Onset Hobo Water Temp Pro V2 (HWTP) recorders, Seabird SBE56 recorders and RBR SoloT recorders. The characteristics of the temperature recorders are given in Table 2.4. Because of their low cost, HWTP recorders were typically used every 2 m while the more accurate, but more expensive SBE56 or SoloT recorders were used every 20 m.

**Table 2.4** Temperature recorders

| Instrument | Resolution | Accuracy | Time response | Typical annual sample rate | Max depth |
|---|---|---|---|---|---|
| HWTP | 0.02°C | ±0.2 °C | 5 min | 15 min | 120 m |
| SBE56 | 0.0001°C | ±0.002 °C | 0.5 sec | 10 sec | 1500 m |
| RBR SoloT | 0.00005 °C | ±0.002 °C | ~1 sec | 5 sec | 1700 m |

To assess movement of the moorings, pressure (depth) recorders were also used. These were either RBR Duo TD recorders which measure both temperature and pressure, or RBR SoloD recorders.

The SUB, SPAR and BOOM moorings used 5/8 inch Samson Quick Splice single-braid bi-polymer olefin line (specific gravity 0.94, weight 7.0 kg/100 m, average strength

3000 kg). The line was chosen to be buoyant, have good handling, low abrasion and little stretch.

All except the BOOM moorings use an Interocean Model 111 acoustic release, which is located just above the anchor. Upon receiving a coded acoustic signal, the release disconnects from the anchor, and the float carries the mooring and release to the surface (or frees the SPAR). This allows for recovery of the mooring without the anchor, and makes it possible to recover the moorings from a smaller boat without the need for a crane. The option of extended-life battery enables deployments for up to one year.

A schematic of the four types of moorings is shown in Figure 2.1 for Revelstoke Forebay, and are described as follows. Moorings at other locations were similar in design.

**REV FB BOOM** The short line attached to the log boom near the dam is meant to record temperature in the near surface, which is not sampled by Rev FB SUB (below). This line rises and falls with water level. A steel weight of approximately 35 lbs (16 kg) was attached at the bottom of the line to keep it vertical.

**REV FB SUB** This is a subsurface mooring: the float is below the water surface. In Revelstoke there is little water level variation so the float can be located a few meters below the surface, and depending on water clarity, the float can be seen from the boat. The float consists of two 14 inch (36 cm) diameter hard shell trawl floats which together provide approximately 80 lbs (36 kg) of floatation at the top of the mooring, balanced by 160 lbs (72 kg) of steel anchor at the bottom. As the mooring anchor sits at the bottom, it does not rise and fall with changes in water level, but remains at a fixed elevation. Use of a subsurface float means the mooring is much less likely to be snagged by surface debris or moved by ice. Instruments are concentrated in the upper part of the mooring, both above and below the level of the intake (~ 30 m depth), see Figure 2.1.

**REV FB SPAR** The spar buoy consists of an 8 ft (2.4 m) aluminum pole holding three close-cell foam floats with a combined floatation of ~120 lbs (54 kg). The spar is held upright by 5.5 m of ¼ inch chain weighing ~11 lbs (5 kg) attached directly to the spar, and by a weight of 25 lbs (11 kg) at 34 m.

**REV FB PROF** In addition to traditional temperature recorders, an experimental tethered autonomous profiler was also moored in Revelstoke forebay. The profiler consists of a Teledyne Webb Apex APF9I profiler. This type of profiler is normally deployed in the open ocean where it parks at depth (e.g. 1000 m), and rises on a regular basis (e.g. every 10 days) to collect a profile of temperature, conductivity and other parameters; upon reaching the ocean surface, the data and GPS location of the profiler is telemetered by ARGO satellite. The profiler then returns to depth to await the next cycle. There are thousands of these profilers throughout the oceans collecting data that would otherwise be very costly to gather by boat.[1] Most of these ocean profilers are treated as expendable, lasting about three years.

We were able to purchase three Apex profilers through the NSERC Research Tools and Instruments program. The three profilers were specifically designed to slide up and down a low friction tether consisting of nylon coated stainless steel wire held taut by 80 lbs (36 kg) of subsurface floatation at the top and 160 lbs (72 kg) of anchor at the bottom. The tether makes these profilers suitable for mooring in lakes and reservoirs. Since the profiler does not rise all the way to the surface, it does not have satellite communications, and instead data is recorded within the profiler. The profiler is capable of collecting daily CTD profiles for a year. Once recovered, the data is uploaded, and the batteries are changed for the next deployment. These profilers use a Seabird SBE 41cp CTD, and a Seapoint turbidity sensor.

[1] See http://www.argo.ucsd.edu/About_Argo.html

## 3. Temperature Moorings

In this section, data from the temperature moorings are shown as both line and contour plots. In the line plots, the temperature is plotted on the y-axis, and the temperature at each depth is plotted in a different color (color gives depth). In the contour plots the depth is plotted on the y-axis, and each temperature is given a different color (color gives temperature). All data are shown in days of 2008, the first year of the CLBMON-3 program.

### 3.1 Temperature Moorings in Revelstoke Reservoir

**REV FB SUB (Figure 3.1.1 and 3.1.2)** Data from 2012 to 2018, are shown as both a line plot (Figure 3.1.1) and a contour plot (Figure 3.1.2). There were short (< 1 week) gaps in the data at the end of August during which time the mooring was serviced. There was also a gap of about one month in the data in September 2015 due to an acoustic release that malfunctioned and opened shortly after deployment. The mooring was found floating on the surface, recovered and redeployed. Temperature recorders were at nominal depths (relative to full pool) of 4.4 to 125 m.

The line plot shows that the near surface (4.4 m) temperature briefly reaches just over 20 °C in July or August of most years (Figure 3.1.1). The temperature near the bottom (125 m) varied around the temperature of maximum density (4 °C), rising slowly to just over 5 °C during the summer, and cooling below 4 °C in winter. What is evident is that there was significantly more cooling in the winters of 2013-2014, 2016-2017 and 2017-2018 than in the other winters on record. This may have resulted from colder weather or windier conditions.

The mooring shows the seasonal temperature cycle as follows:

- The warm surface layer cools and deepens beginning in late August.
- Fall turnover begins in December and the entire water column cools from ~6 °C to a minimum of 1 to 3 °C in March.
- Some periods of reverse stratification were observed in the winters of 2013-2014, 2016-2017 and 2017-2018. Reverse stratification occurs when the water column is < 4 °C; as the surface cools further, this colder and less dense water resists mixing into the warmer (closer to 4 °C) and more dense water at depth.
- Spring turnover begins in March as the entire reservoir warms from winter minimum up to 4.0 °C by April.
- Persistent summer temperature stratification occurs after April.
- The summer stratification is modulated by internal waves at a variety of time scales (see examples in Pieters and Lawrence 2016).

- During summer, the temperature at the bottom (125 m) is comparatively steady, rising very slowly by ~0.2 °C/month, which is similar to that observed in other deep lakes.

The contour plot (Figure 3.1.2) shows the warm (>15 °C) surface layer is limited to the top 10 to 20 m during the summer. At the same time, there is a layer of water around 8 °C that extends from about 10 to 50 m which indicates the interflow.

**REV FB BOOM (Figures 3.2.1 and 3.2.2)** A line with instruments was hung from the log boom just upstream of Revelstoke Dam as part of the base mooring in Revelstoke Forebay, to collect data from the top 10 m of the water column. Data were not available from 22 June to 31 August 2017 as the line was removed for replacement of the log boom during this time.

For the most part, the temperature was relatively uniform in the top 10 m, though there were some periods of stratification within the top 10 m during summer. The coldest temperature at 0.5 m was 0.25 °C in March 2017.

**REV MID SUB (Figures 3.3.1 and 3.3.2)** This mooring was deployed at the Rev MID sampling station near Downie Arm. At this location, about halfway up Revelstoke Reservoir, turnover occurred from late October to November each year, earlier than at the Rev FB station, but this may simply reflect that the Rev MID station is shallower. In addition, fall and spring turnover at the Rev MID mooring showed more periods of temporary stratification than at Rev FB, and included slightly longer and cooler periods of reverse stratification. Summer temperature stratification began at Rev MID after the reservoir reached ~4 °C in April in most years.

**REV UP SUB (Figure 3.4.1 and 3.4.2)** This mooring was deployed near the Rev UP sampling station. This station is not only shallower but more riverine, showing less temperature stratification than at the MID and FB sites, as can be seen by comparing the contour plots. Reduced stratification was particularly noticeable during high flows in the summer of 2015 (Figure 3.4.1).

At the start of the first deployment in September 2012 there was little temperature stratification, and fall turnover began on 4 October 2012 (day 1739, Figure 3.4.1). During fall turnover, the temperature showed fewer periods of secondary stratification than at the MID and FB moorings. However, unlike the MID and FB moorings, the temperature at the UP mooring did not cool monotonically but included periods of 5 to 10 days when the entire water column warmed, possibly due to the influence of upstream inflow. During spring turnover, the shallower water column warmed faster than at the MID and FB moorings, and, in some years, summer stratification began sooner, in late March and early April.

## 3.2 Temperature Moorings in Kinbasket Reservoir

**KIN FB SUB (Figures 3.5.1 and 3.5.2)** Because of the large water level variations in Kinbasket Reservoir, the top of the Kin FB SUB mooring had to be kept deeper, just below the minimum water level (40 m below full pool). To provide data from the upper water column at high water level, the Kin FB BOOM mooring was longer, extending to 40 m depth.

Data from 40 to 180 m depth are shown in Figures 3.5.1 and 3.5.2. In summer, the temperature at 40 m reaches 10 to 13 °C (Figure 3.5.1). In fall, the temperature at shallower depths cools (Figure 3.5.1) as the surface layer deepens (Figure 3.5.2) until the entire water column is close to the temperature of maximum density (4 °C) in January of each year.

From February to April, reverse stratification is observed. As shallower water cools below the temperature of maximum density, 4 °C, it becomes less dense, and this colder buoyant water caps the warmer water near 4 °C. Like in Revelstoke, longer periods of reverse stratification were observed in the 2013-2014, 2016-2017 and 2017-2018 winters, suggesting these winters were colder and/or windier. Note that in the winter of 2012-2013, the entire water column cooled slightly (0.2 °C) below 4 °C.

In Kinbasket forebay, there was no distinct period of either fall or spring turnover (Figure 3.5.1), in contrast to Revelstoke Reservoir (Figures 3.1.1, 3.3.1, and 3.4.1). For example, the surface layer mixed to 80 m depth by 22 December 2013 (day 1818), and this surface layer reached 4 °C around 15 January 2013 (day 1842). However, the 0 to 80 m layer then cooled below 4 °C to develop reverse stratification, without seeming to mix with water below 100 m depth.

One possibility is that a small salinity stratification may have affected turnover. There was a slight salinity stratification observed in some CTD profiles. For example, on 23 April 2013 the conductivity increased from ~150 μS/cm at 100 m to 180 μS/cm at the bottom (Figure B1c in Pieters and Lawrence 2014). Pressure effects may also play a role below ~150 m.

Also, complete spring turnover did not occur; rather, the top 80 m warmed through 4 °C, leaving the deep temperature below 4 °C (e.g. 3.6 °C in spring 2013). The deep water warmed gradually (~0.05 °C/mo) through the summer, suggesting a small degree of exchange with water above 100 m, similar to that observed in Revelstoke Reservoir. Note, that the deep water remained well oxygenated (e.g. Figure B1e in Pieters and Lawrence 2018).

**KIN FB BOOM (Figures 3.6.1 and 3.6.2)** Unfortunately, in 2012-2013 the instruments on the boom mooring below 2 m were lost (likely due to a shackle that was not closed tightly). In 2013-2014, the mooring appeared to have rubbed against a line holding the log boom in place, and instruments below 16 m were lost. In December 2014 the boom broke, and the boom and instrument line were found on shore. The top two instruments were broken but the rest were undamaged and the mooring was redeployed in May 2015. The line was removed for repair of the boom from 25 April to 3 May 2017. Finally, the entire line was lost when the boom broke over the 2017-2018 winter. Available data are plotted in Figures 3.6.1 and 3.6.2, and show a seasonal cycle similar to that in Revelstoke Reservoir.

## 4. Profilers

From 2012 to 2018, three profilers were deployed at various locations in Revelstoke Reservoir (Table 2.3). In this report, all available profiler data has been plotted over the same time period for a given year, May to November, which is the stratified productive season. The time, depth, temperature, salinity, and turbidity scales have been kept the same in all figures to facilitate comparison between locations and years. The only exception is the salinity scale for Rev UP in 2014, in which the lower bound of the salinity scale was set to 25 rather than 30 mg/L to accommodate fresh water observed during the spring (Figure 4.5c). The 1% light levels determined from Sea-Bird profiles (Pieters and Lawrence, 2018) are marked with black plus signs (+) in the second panel of each figure.

To understand the patterns observed in the profiler data, consider briefly the summer circulation of Revelstoke Reservoir. The flow and conductivity in Revelstoke Reservoir can be roughly divided into two periods (Pieters and Lawrence, 2019). In the first period, during spring and early summer, inflow from Kinbasket Reservoir is relatively low, and inflow to Revelstoke Reservoir is dominated by relatively fresh snowmelt from local tributaries. This typically results in the development of relatively low salinity which extends throughout the top 60 m of the reservoir by mid-July.

In mid-July, a big change occurs in most years with the sudden increase of deep outflow from Kinbasket Reservoir, from less than 100 $m^3/s$ to greater than 1000 $m^3/s$. This outflow is cool and slightly more saline, and forms an interflow along the length of the reservoir centered on the outlet at Revelstoke Dam (30 m depth). This interflow is typically inserted into the less saline spring melt water, and remnants of the low salinity water can, in some years, be observed both near the surface and around 60 m depth all the way into October (e.g. Figure 4.3b). After October, fall cooling and deepening of the surface layer act to mix the interflow below with the remnants of spring inflow water near the surface.

**Revelstoke FB Profiler, Sep-Oct 2012 (Figure 4.1)** The first profiler was deployed as a trial for one month from 11 September to 11 October 2012, sampling every 4.9 hours, and collecting a total of 146 profiles. Temperature, raw salinity and turbidity data are shown as contour plots in Figure 4.1. This data is plotted on a large time scale for comparison with subsequent data. The profiler data was shown on expanded scale in the previous report (Figure 3.5, Pieters and Lawrence, 2016).

**Revelstoke UP Profiler, Aug – Nov 2013 (Figure 4.2)** In 2013-2014, the three profilers were deployed at the Rev FB, MID and UP stations. While the profilers were successfully recovered, data was accidently erased from the Rev FB and Rev MID profilers (the self-test command erases memory). The data from the Rev UP profiler is shown here for the 2013 productive season. There is little stratification in temperature (as observed in the temperature moorings, Figures 3.4.1 and 3.4.2), and little stratification in salinity and turbidity as well.

**Revelstoke FB Profiler, May – Nov, 2014 (Figure 4.3)** This is the first plot showing the evolution of temperature, salinity and turbidity over the whole productivity season. The emergence of thermal stratification is seen beginning in late May (Figure 4.3a). At the same time, a deepening layer of slightly fresher water is evident in salinity (Figure 4.3b, late May to mid-August).

From mid-August to mid-October the interflow is evident as a layer of slightly increased salinity centered on 30 m (Figure 4.3b). The interflow is modulated by internal motions with a period of 5 to 15 days, which can bring the interflow into the photic zone, and even bring the interflow to the surface. After mid-October, the interflow was mixed to the surface by fall cooling. By mid-November, the surface layer extended to the bottom of the interflow, 60-70 m depth. Turbidity shows occasional pulses, as well as an increase near the bottom in the fall (Figure 4.3c).

**Revelstoke MID Profiler, July – Nov, 2014 (Figure 4.4)** The profiler at Rev MID shows a similar seasonal pattern as that at Rev FB, except that the interflow appears a little sooner, in early August (Figure 4.4c). White bars mark occasions when the profiler failed to rise to the surface.

**Revelstoke UP Profiler, May – Aug, 2014 (Figure 4.5)** There were many occasions when the profiler failed to rise to the surface, especially toward the end of the record. As observed in the previous fall, there was little stratification in temperature, salinity, or turbidity at Rev UP (Figure 4.5). However, the presence of slightly more saline (and less turbid) water from Kinbasket Reservoir can be seen in late July, first below 20 m and then throughout the water column.

**Revelstoke FB, LAF and MID Profilers, May – Nov, 2015 (Figure 4.6 - 4.8)** In May 2015, the profiler that had previously been at the Rev UP station was deployed near La Forme Creek (station Rev LAF), which is located about 18 km upstream of the Rev FB station, but downstream of the Rev MID station. The purpose was to understand the variation in internal motions between the Rev FB and Rev MID stations.

Note that, after 21 September 2015 (day 261), the Rev LAF profiler no longer rose to the surface due to a problem with the internal pump.

In 2015, the flow from Kinbasket Reservoir did not drop as much in the spring, remaining much higher through the summer. As a result, the interflow appeared earlier in the year: it was observed at the Rev MID station by the end of June 2015 (Figure 4.8b), at Rev LAF by early July 2015 (Figure 4.7b), and at Rev FB by mid-July 2015 (Figure 4.6b).

**Revelstoke FB, LAF and MID Profilers, May – Nov, 2016 (Figure 4.9 - 4.11)** In May 2016, the profilers were re-deployed in the same locations along the lower reach of Revelstoke Reservoir (Figures 4.9 – 4.11). Note, there were times when a profiler did not reach the surface indicated by the white bars; the ballasting of each profiler was adjusted in May 2017. In October 2016, the profiler at LAF stopped rising, and testing revealed that the buoyancy pump was stuck; the profiler has been returned to the manufacturer for service.

In May 2016, the salinity of the surface water began to decline, and this layer of fresher water deepened through June to August (e.g. FB, Figure 4.9b). In 2016, the interflow of Kinbasket water was first observed in mid-July at the MID profiler (Figure 4.11b), then in late-July at the LAF profiler (Figure 4.10b), and finally in early August at the FB profiler (Figure 4.9b). The interflow was, at times, in the photic zone.

**Revelstoke FB and MID Profilers, May – Nov, 2017 (Figure 4.12 - 4.13)** In May 2017, the profilers were re-deployed at the Revelstoke FB and MID stations (Figures 4.12 – 4.13). Note, that despite adjusting the ballast, there were times when a profiler did not reach the surface indicated by the white bars.

A similar pattern was observed as in previous years. In May 2017, the salinity of the surface water began to decline, and this layer of fresher water deepened through June to August (Figures 4.12b and 4.13b). In 2017, the interflow of Kinbasket water was first observed in mid-July at the MID profiler (Figure 4.13b), then in late-July at the FB profiler (Figure 4.12b).

**Acknowledgements**

We thank B. Manson, P. Bourget and K. Bray for their assistance in the field. We thank E. Pieters, A. Sharp, K. Lywe, C. Huang, M. Mewhort, A. Quainoo, T. Rodgers, A. Law, D. Robb, G. Sharma and P. Buskas for assistance with instrument setup and upload, and the UBC Work-Learn and NSERC Undergraduate Summer Research Awards programs for salary subsidy. We gratefully acknowledge funding provided by B.C. Hydro. We acknowledge the NSERC Research Tools and Instruments program for funding the purchase of the profilers.

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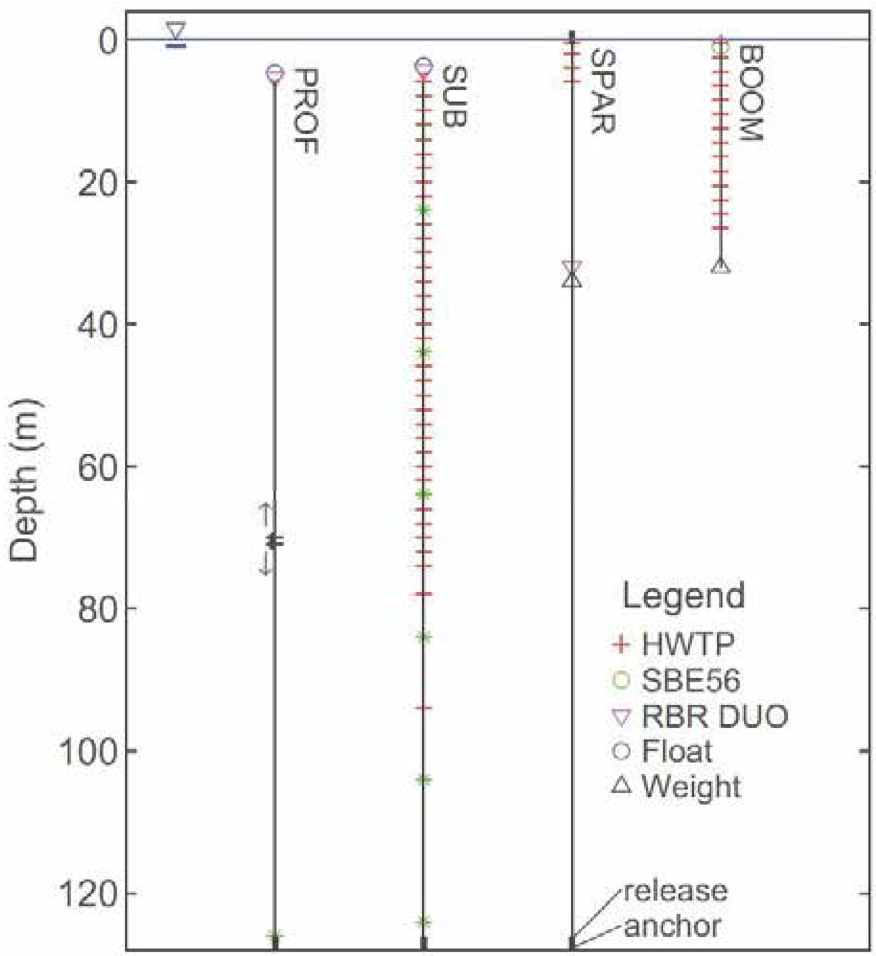
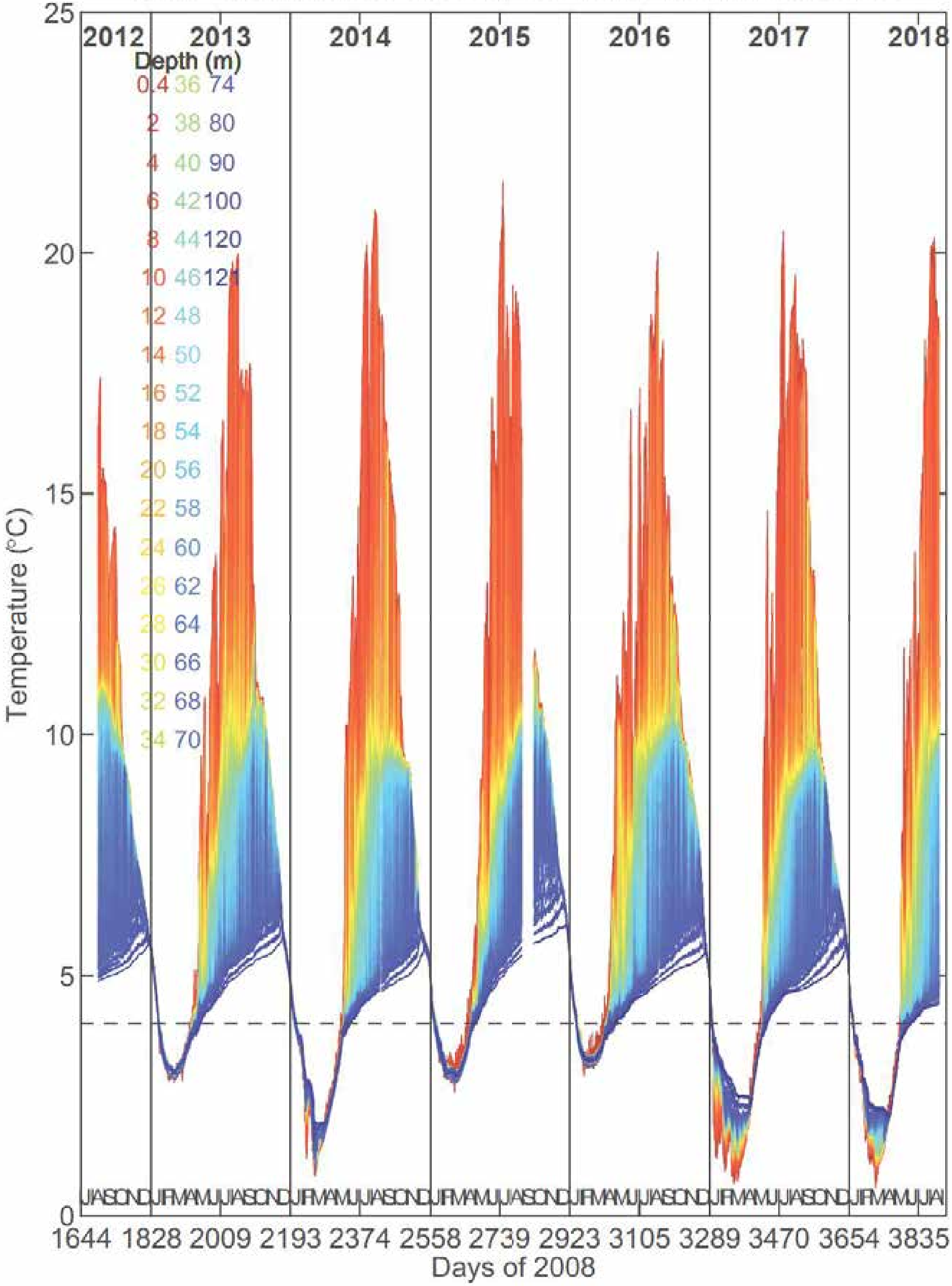
**Figure 2.1** Revelstoke Forebay Moorings, 2012



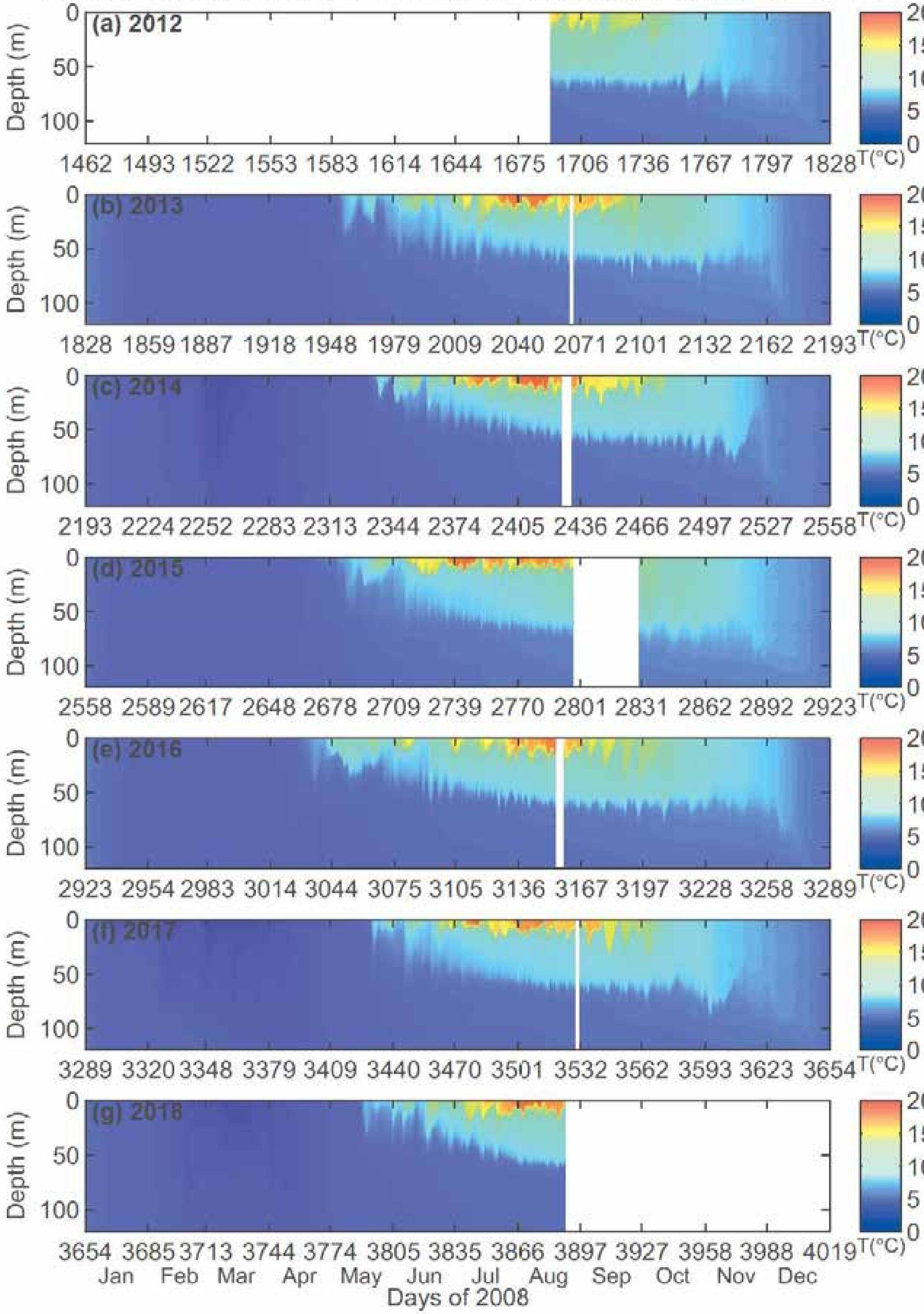

/ocean/rpieters/kr/moor/schem/moorschemRevFB2012.m fig= 1 2014−Oct−01

**Figure 3.1.1** Revelstoke Forebay Subsurface Mooring, 2012–2018



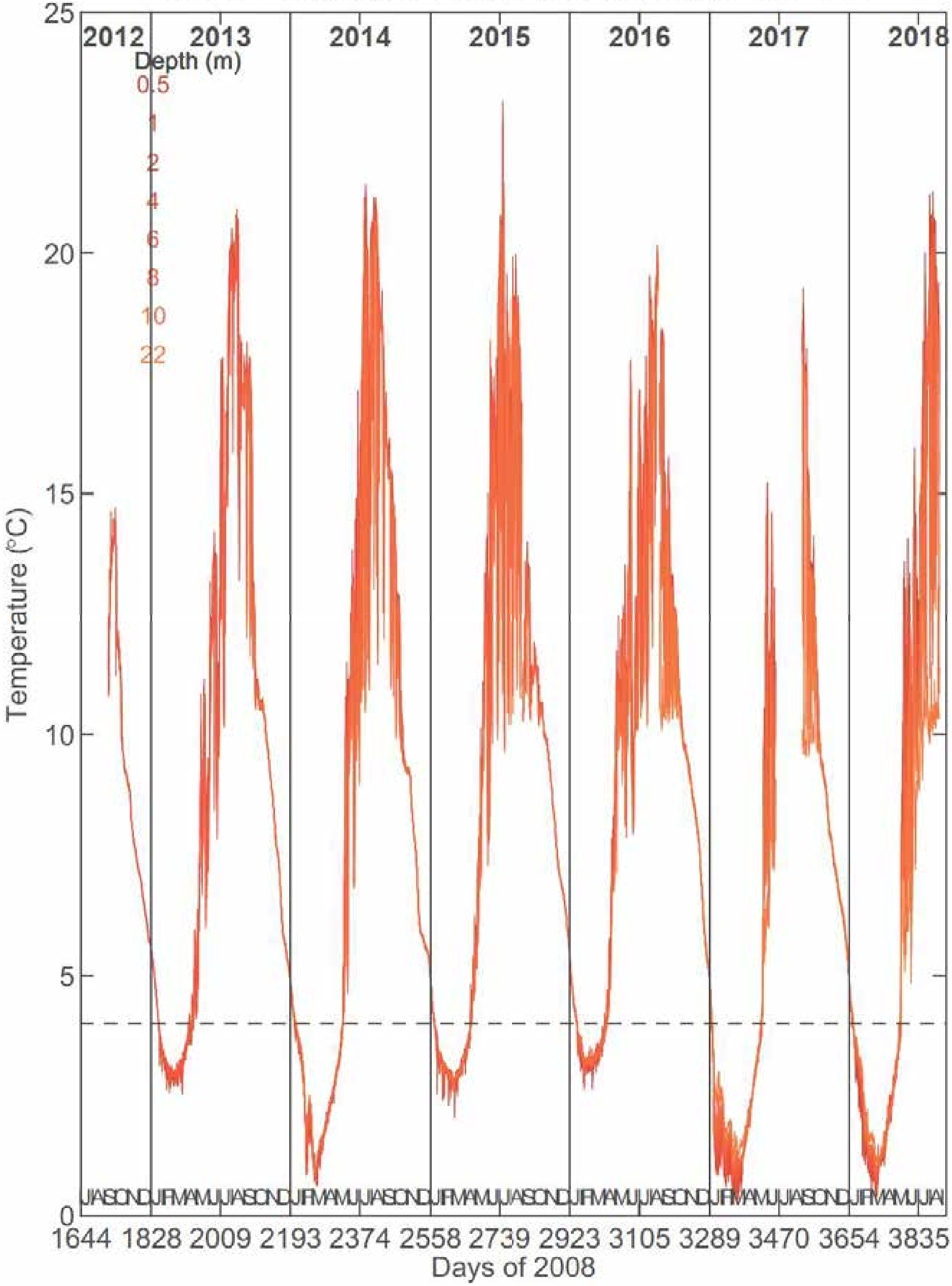

/ocean/rpieters/kr/moor/plot18/plotlineall.m fig= 1 2019-Jan-24

**Figure 3.1.2** Revelstoke Forebay Subsurface Mooring, 2012−2018



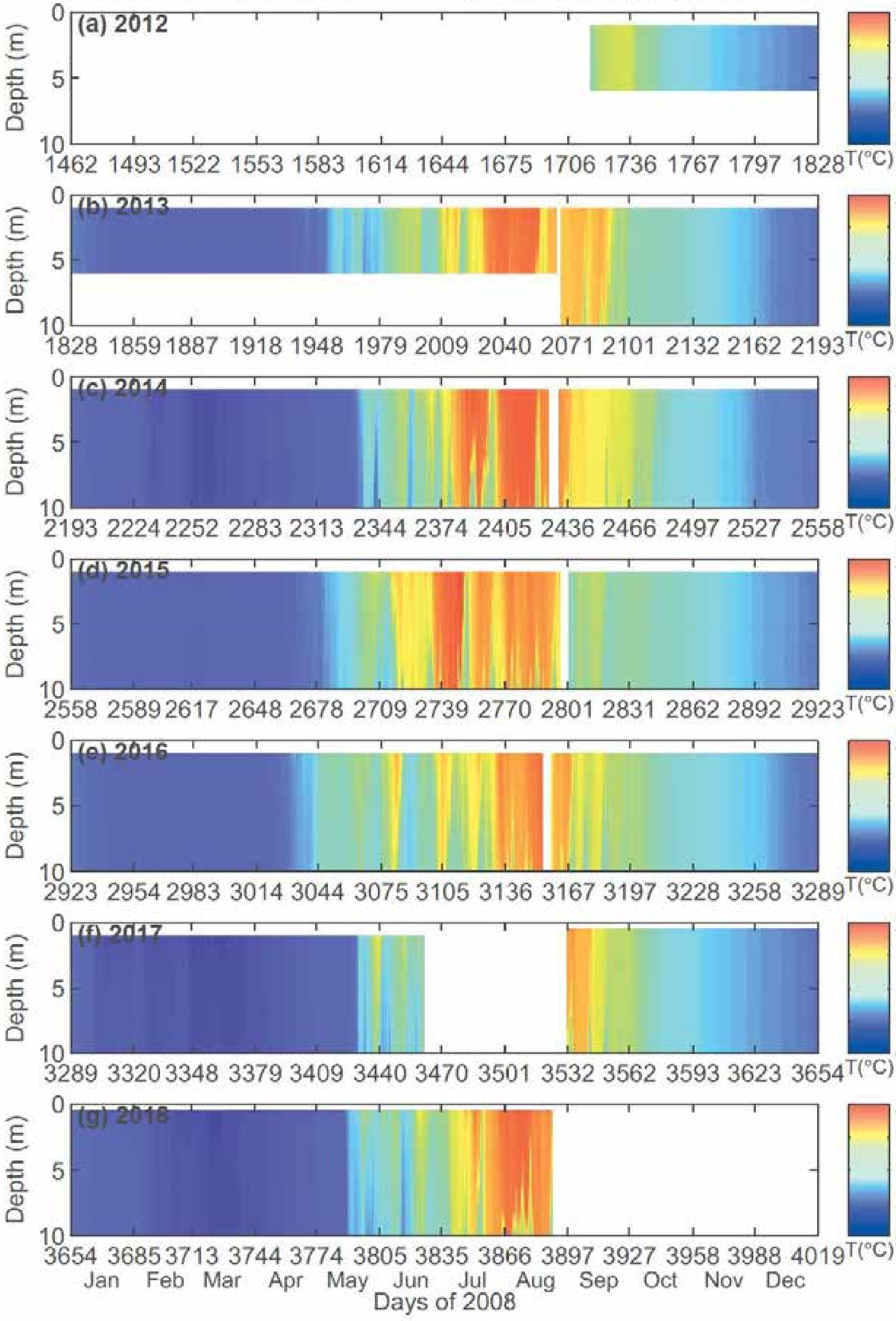

/ocean/rpieters/kr/moor/plot18/plotcontyrall.m fig= 1 2019−Jan−24

**Figure 3.2.1** Revelstoke Forebay Boom Mooring, 2012–2018



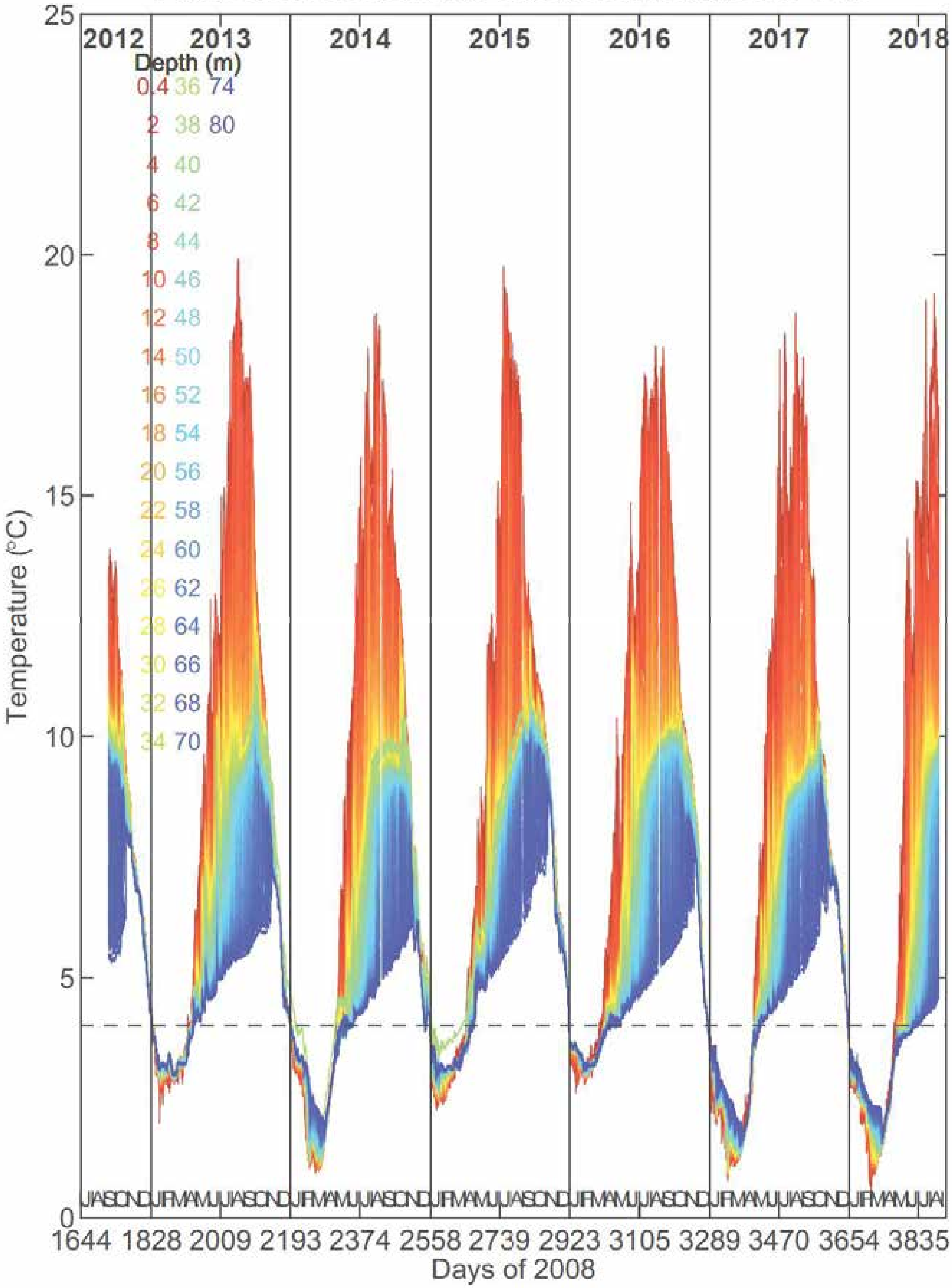

/ocean/rpieters/kr/moor/plot18/plotlineall.m fig= 2 2019-Jan-24

**Figure 3.2.2** Revelstoke Forebay Boom Mooring, 2012−2018



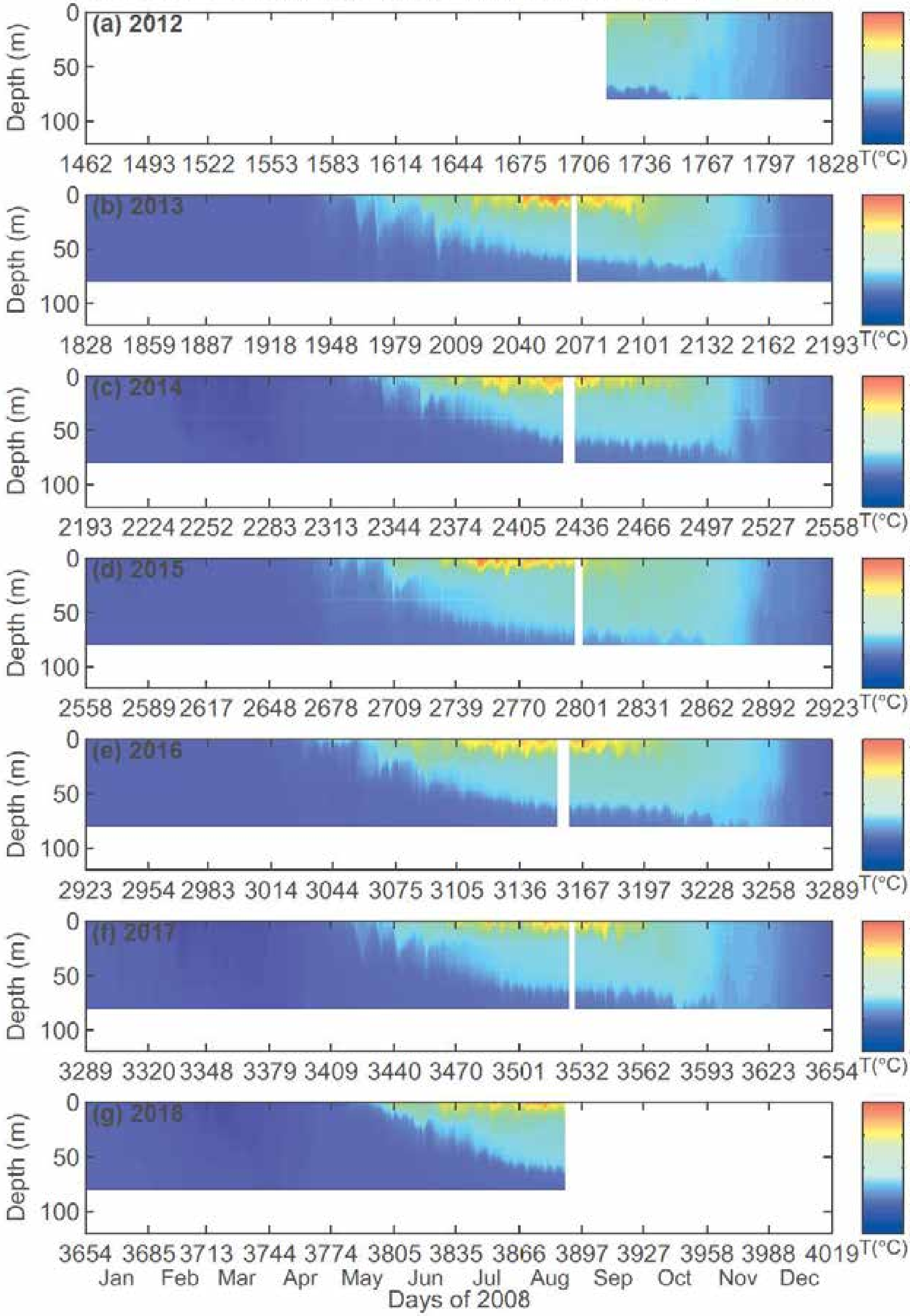

/ocean/rpieters/kr/moor/plot18/plotcontyrall.m fig= 2 2019−Jan−24

**Figure 3.3.1** Revelstoke Mid Subsurface Mooring, 2012−2018



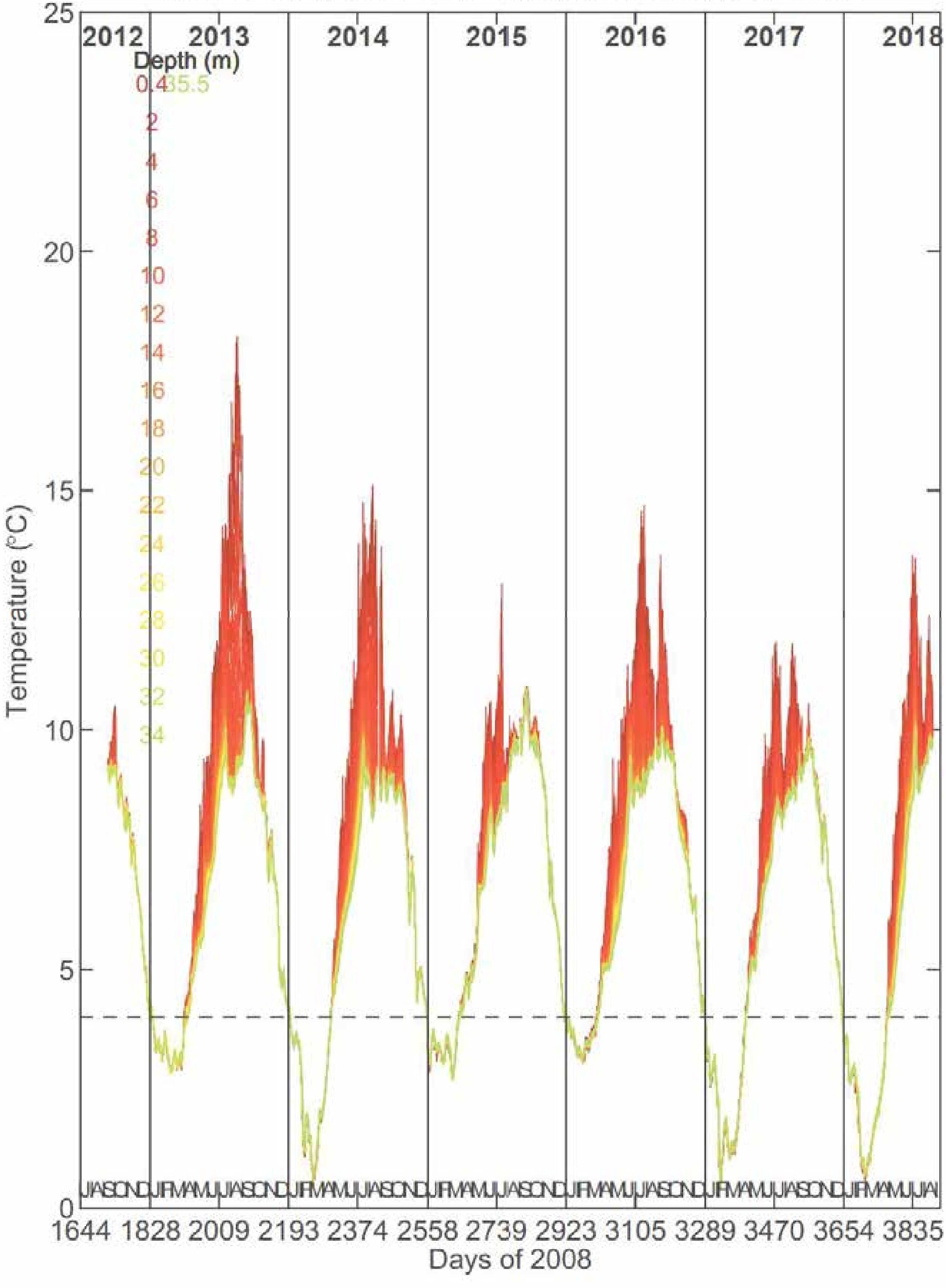

/ocean/rpieters/kr/moor/plot18/plotlineall.m fig= 3 2019−Jan−24

**Figure 3.3.2** Revelstoke Mid Subsurface Mooring, 2012−2018



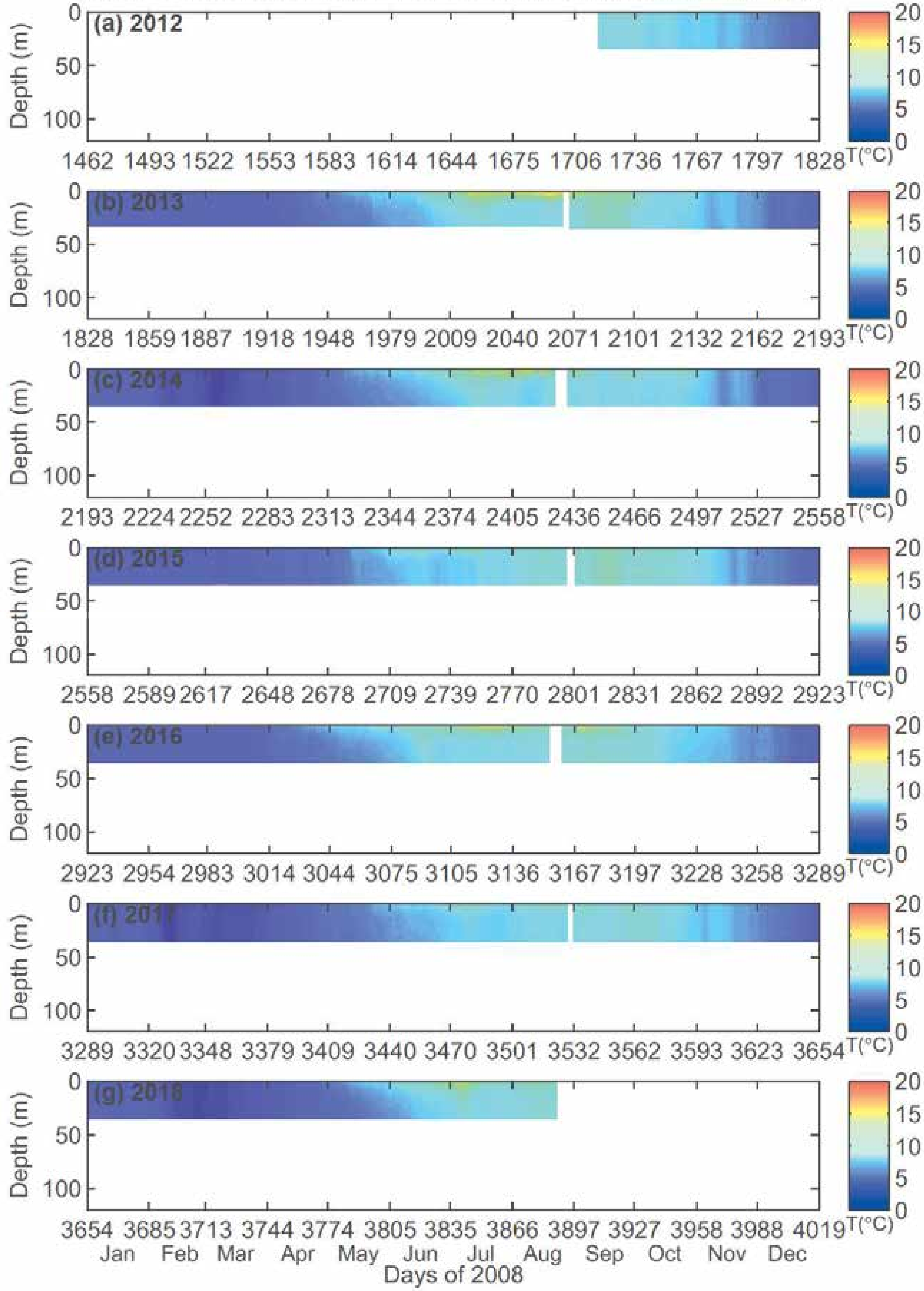

/ocean/rpieters/kr/moor/plot18/plotcontyrall.m fig= 3 2019−Jan−24

**Figure 3.4.1** Revelstoke Up Subsurface Mooring, 2012−2018




/ocean/rpieters/kr/moor/plot18/plotlineall.m fig= 4 2019−Jan−24

**Figure 3.4.2** Revelstoke Up Subsurface Mooring, 2012−2018

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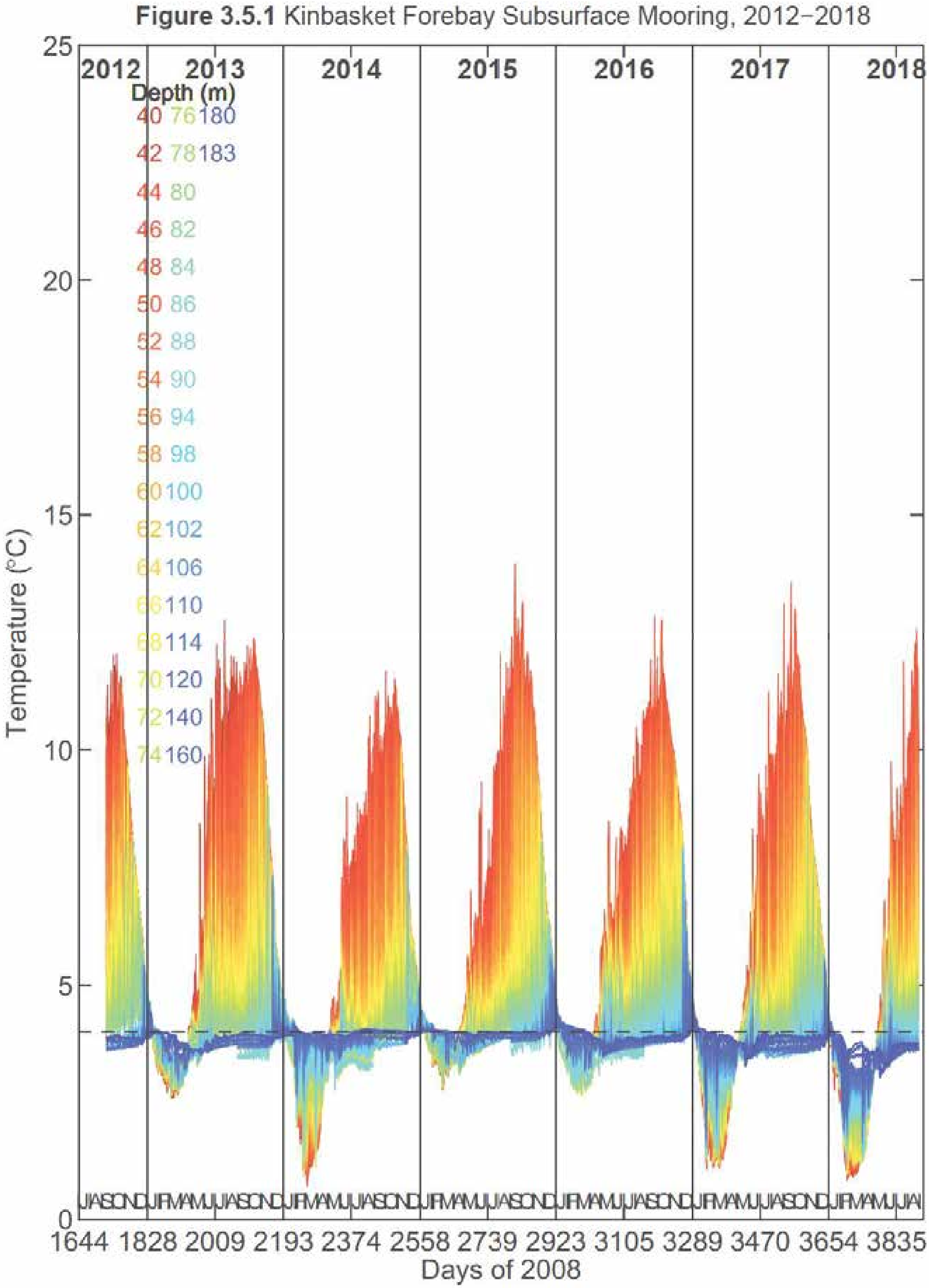
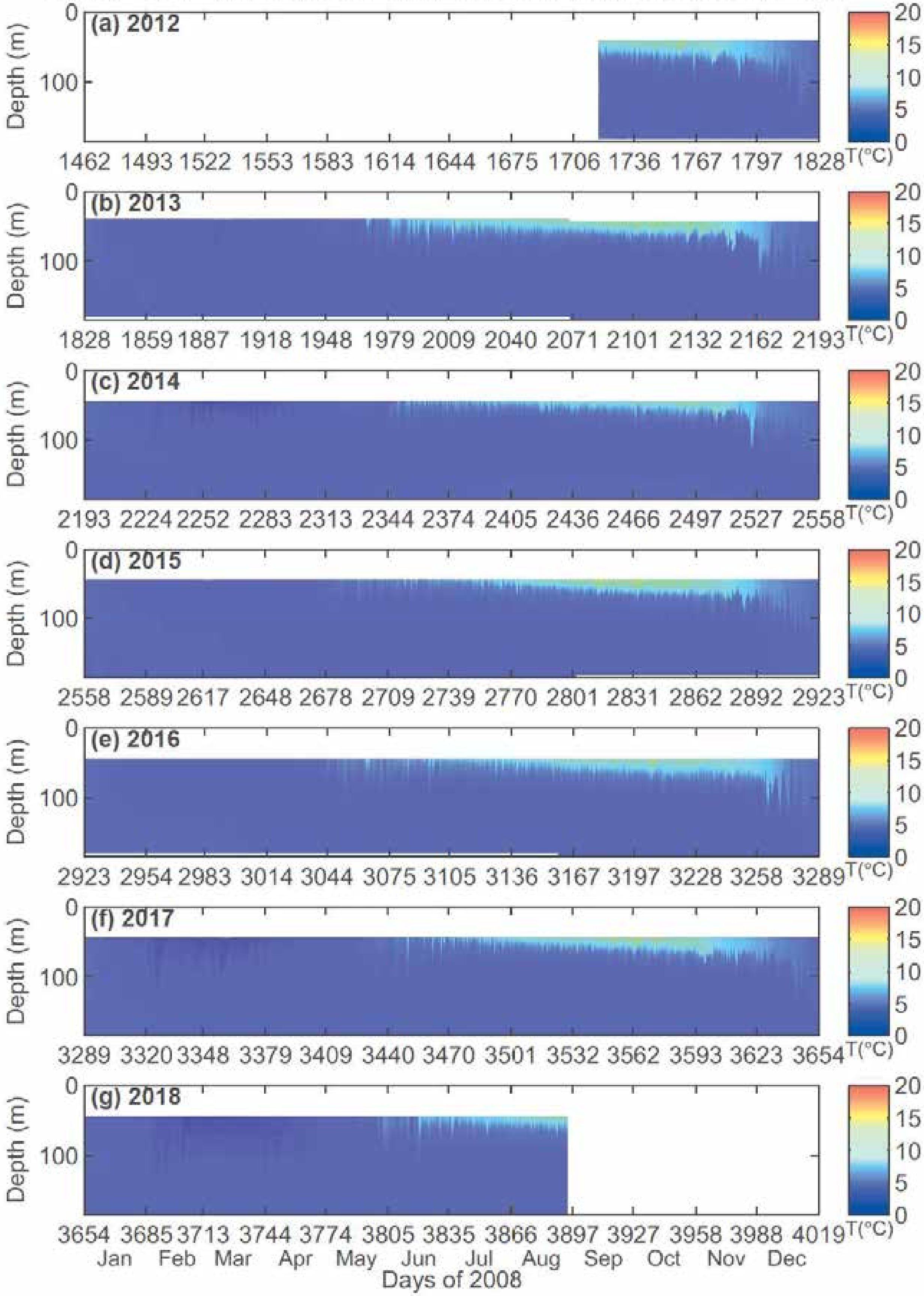


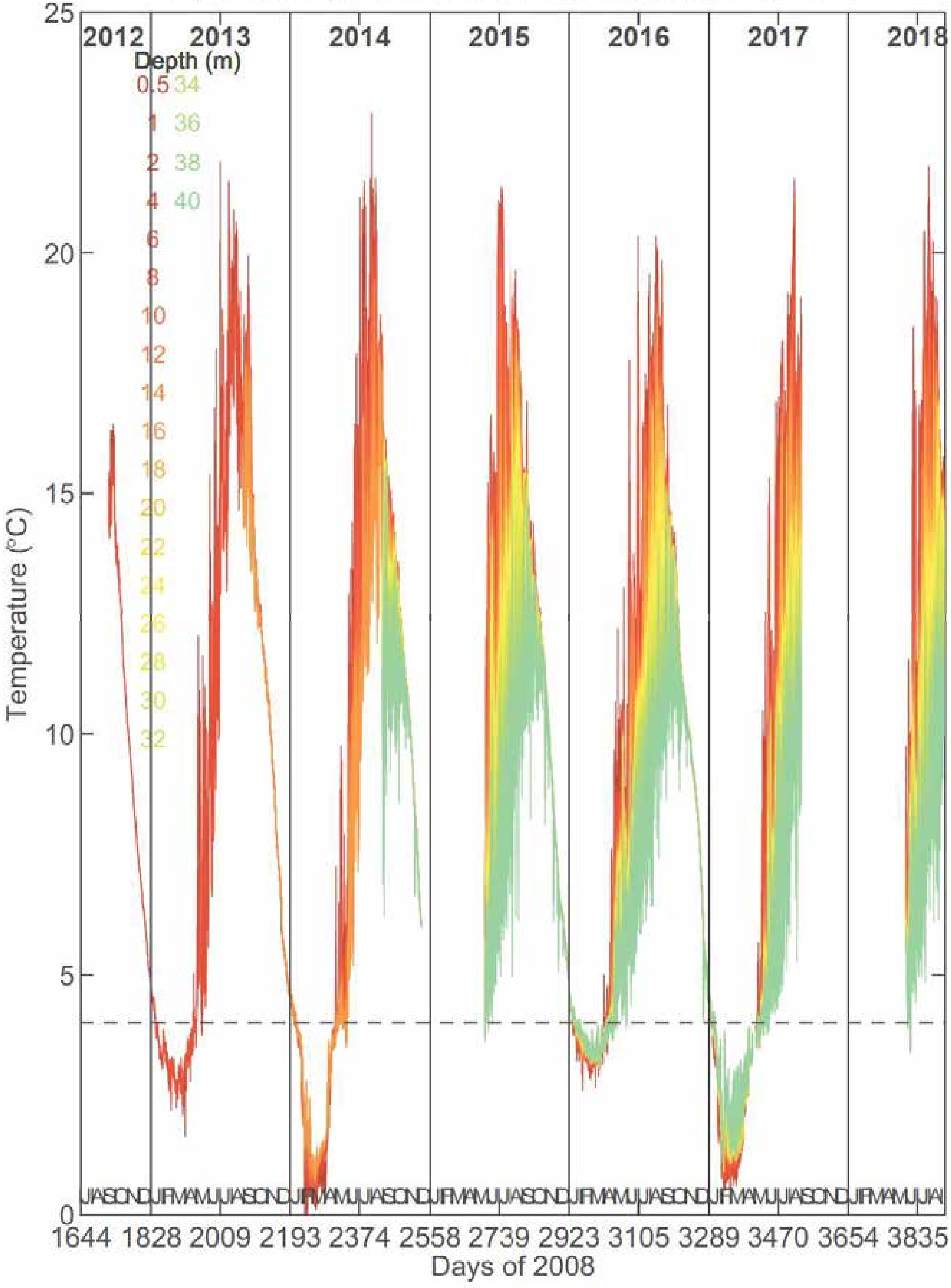

/ocean/rpieters/kr/moor/plot18/plotlineall.m fig= 5 2019−Mar−12

**Figure 3.5.2** Kinbasket Forebay Subsurface Mooring, 2012−2018



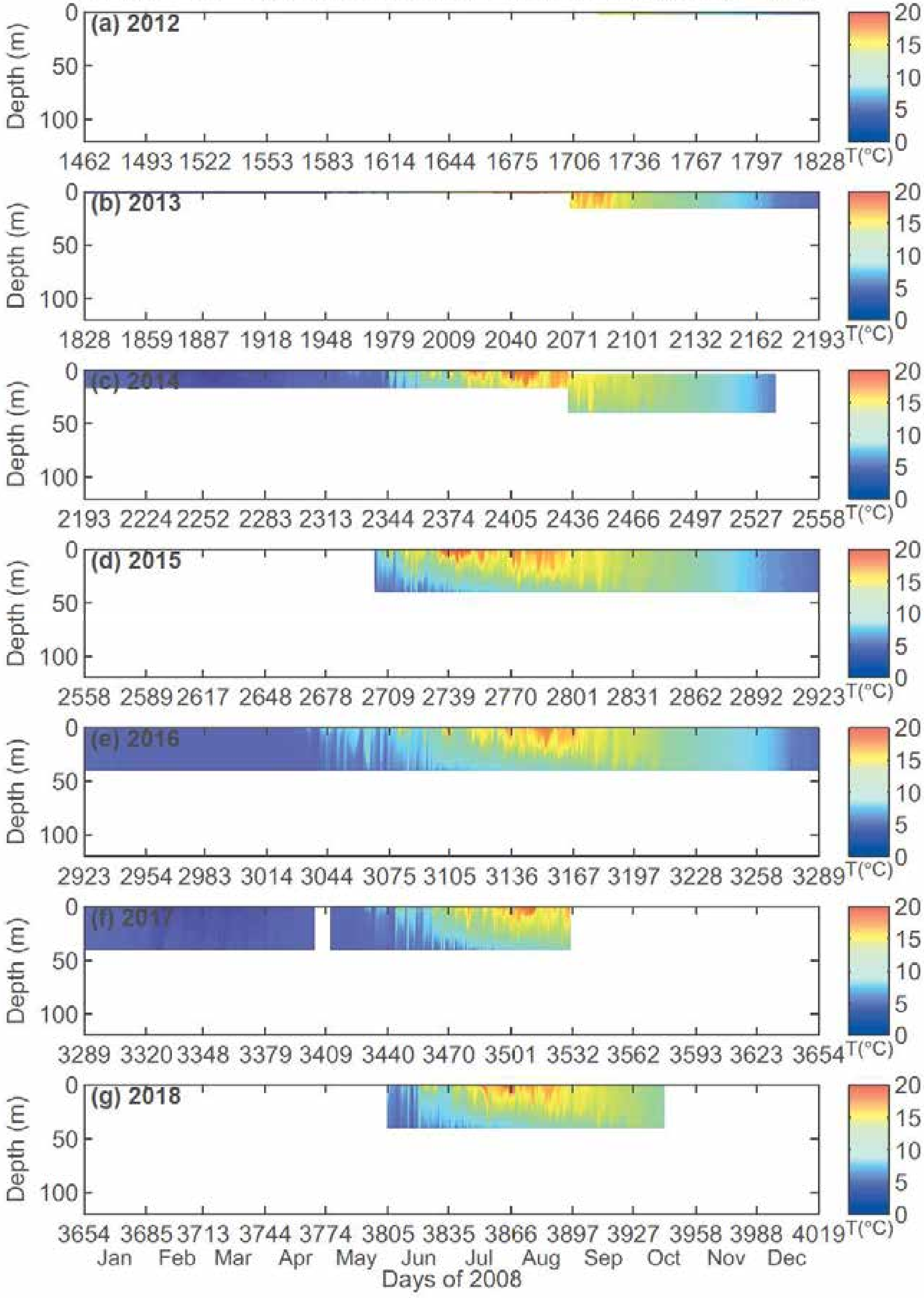

/ocean/rpieters/kr/moor/plot18/plctcontyrall.m fig= 5 2019-Mar-12

**Figure 3.6.1** Kinbasket Forebay Boom Mooring, 2012−2018



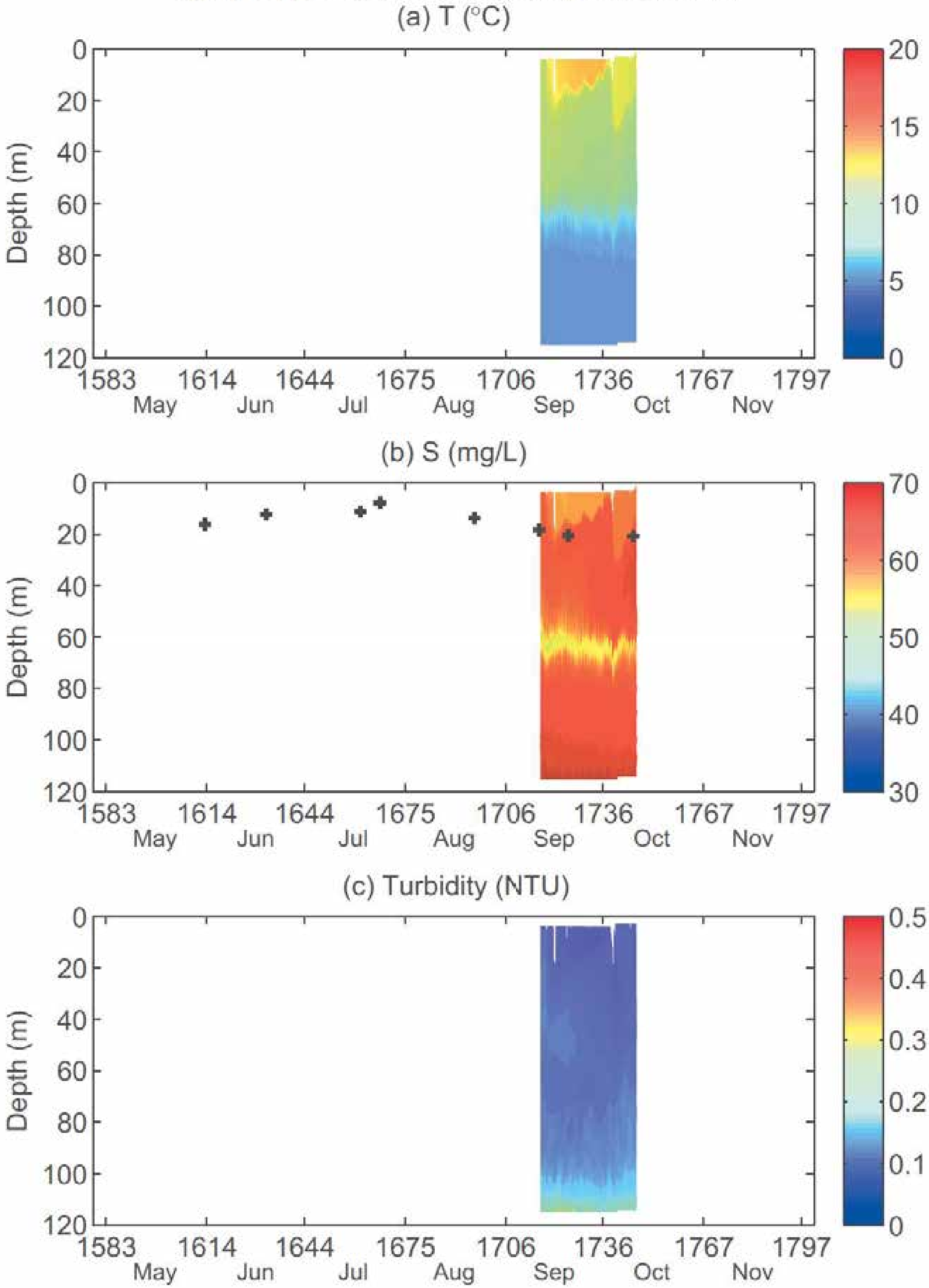

/ocean/rpieters/kr/moor/plot18/plotlineall.m fig= 6 2019−Jan−24

**Figure 3.6.2** Kinbasket Forebay Boom Mooring, 2012−2018



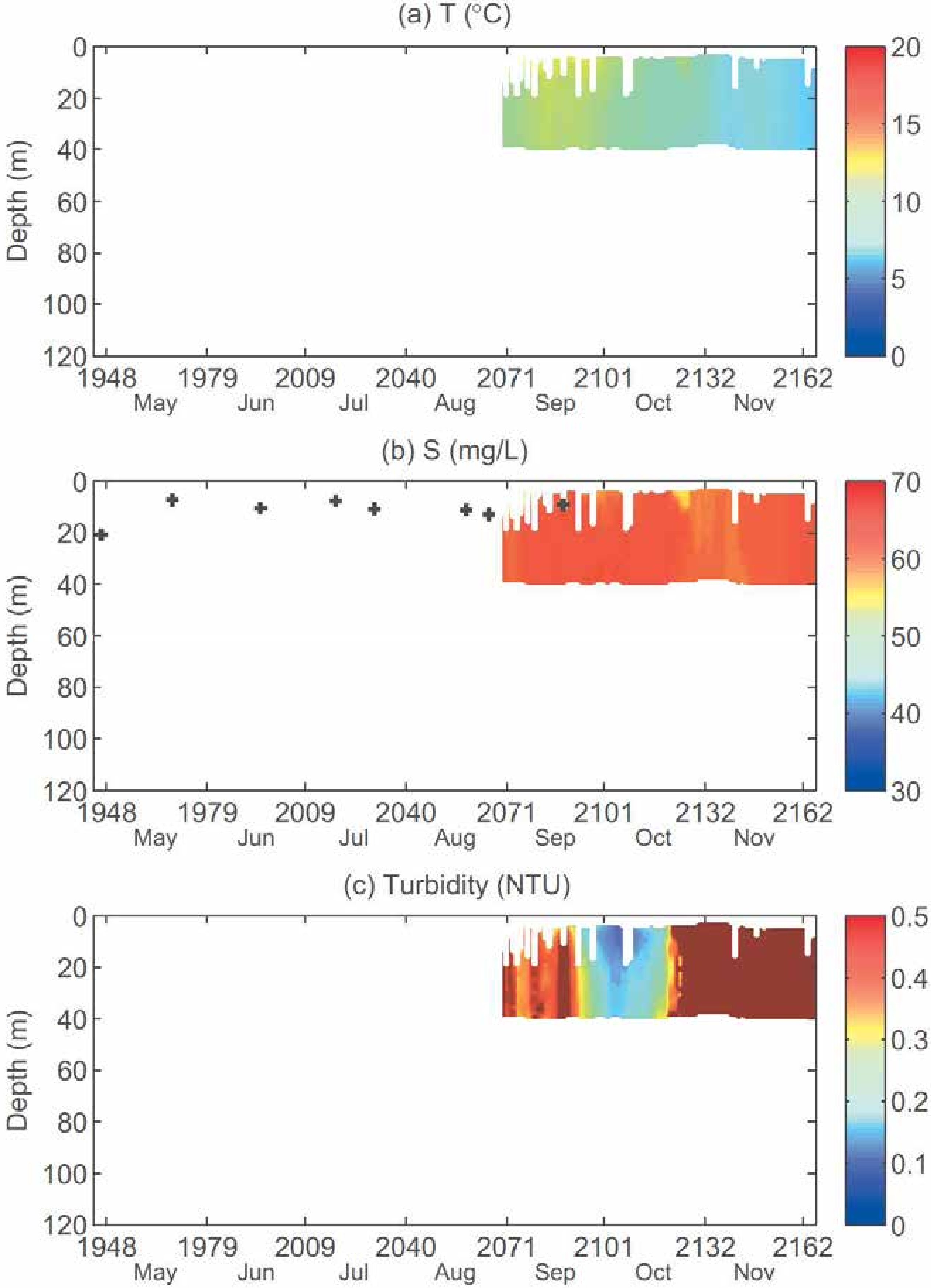

/ocean/rpieters/kr/moor/plot18/plotcontyrall.m fig= 6 2019-Mar-11

**Figure 4.1** Rev FB Profiler, May to Nov, 2012



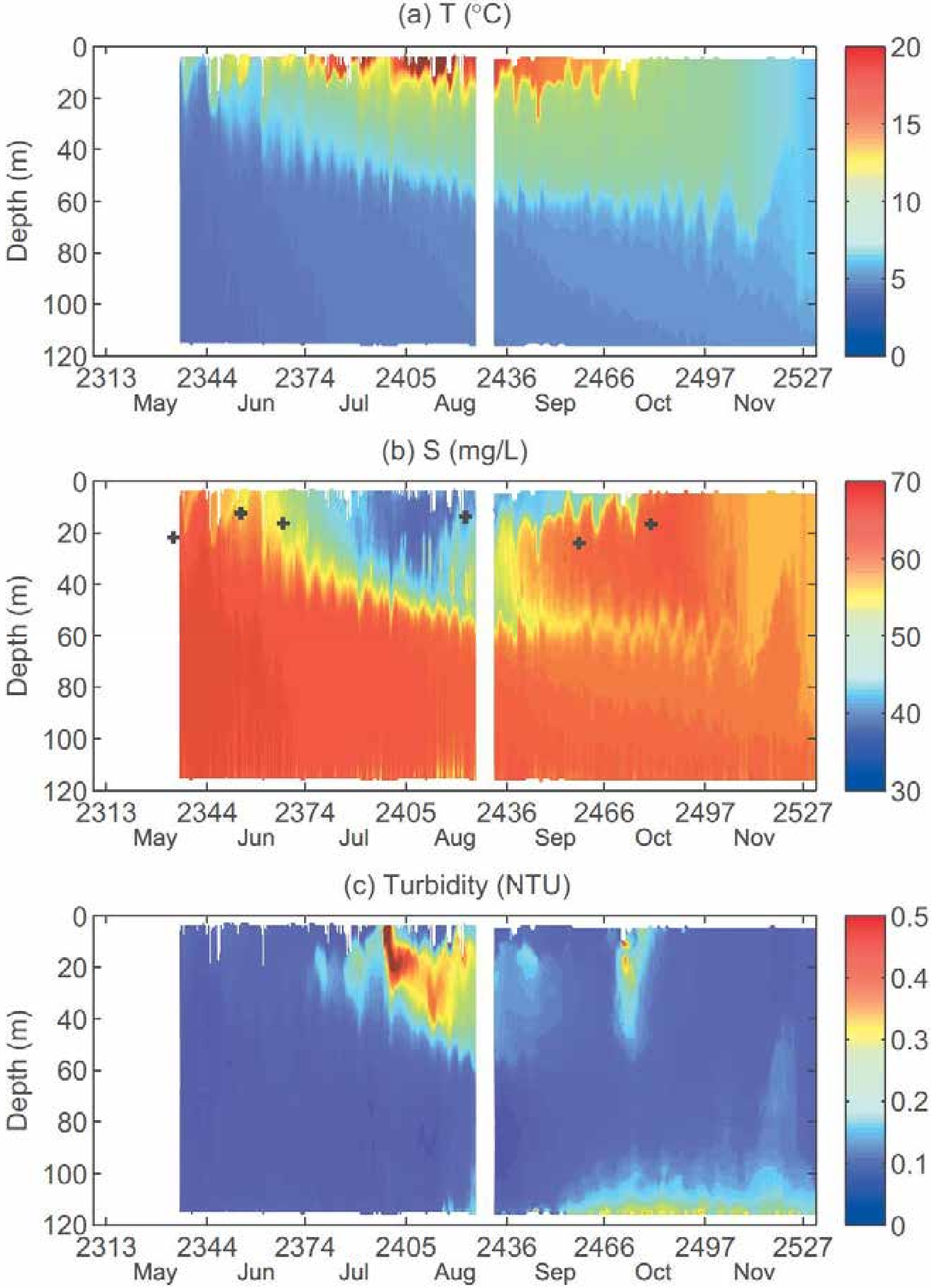

/ocean/rpieters/kr/prof/plot17/profcontcombo2.m fig= 6 2018-Jan-02

**Figure 4.2** Rev Up Profiler, May to Nov, 2013



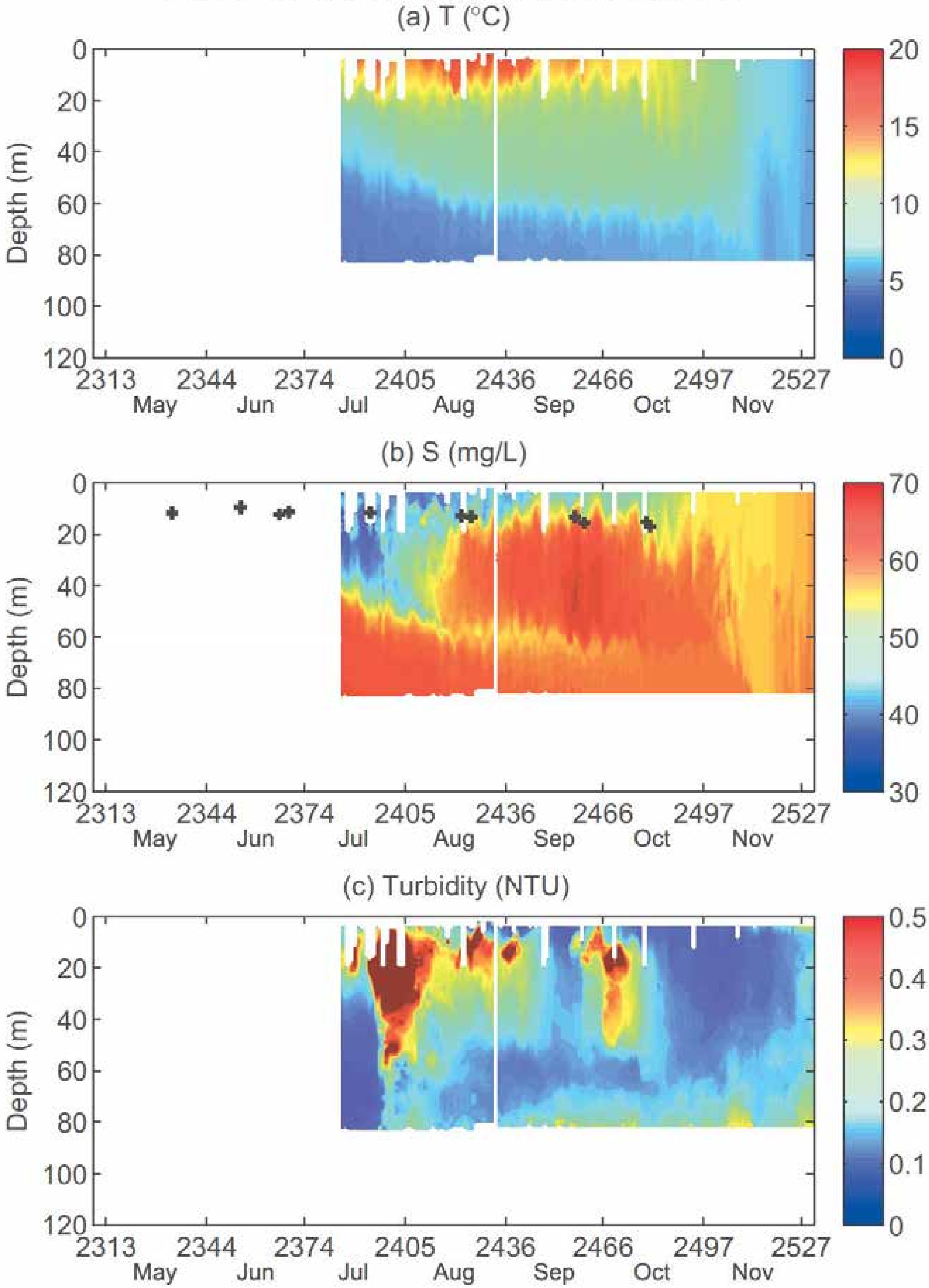

/ocean/rpieters/kr/prof/plot17/profcontcombo2.m fig= 7 2018-Jan-02

**Figure 4.3** Rev FB Profiler, May to Nov, 2014



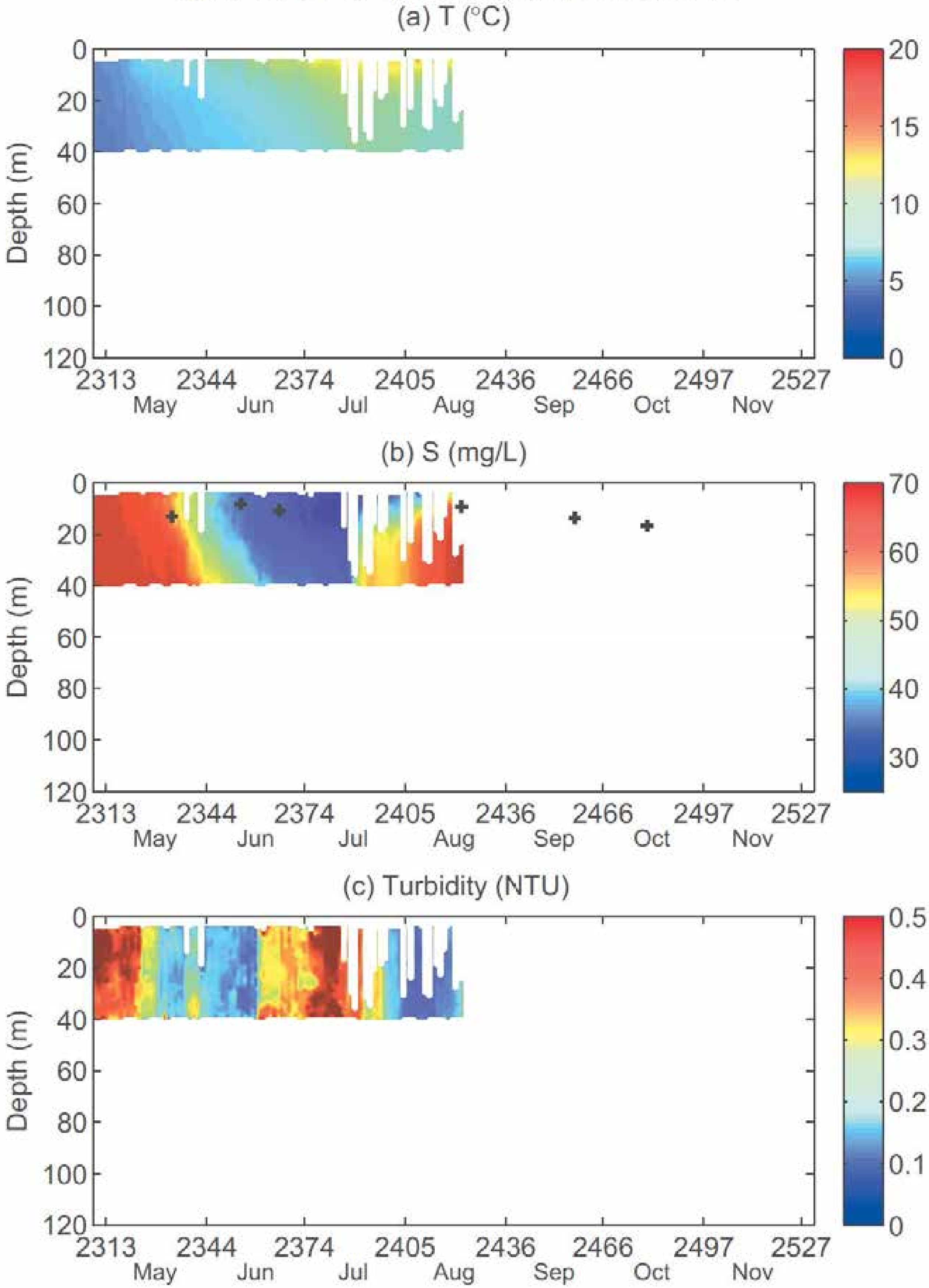

/ocean/rpieters/kr/prof/plot17/profcontcombo2.m fig= 1 2018-Jan-02

**Figure 4.4** Rev MID Profiler, May to Nov, 2014



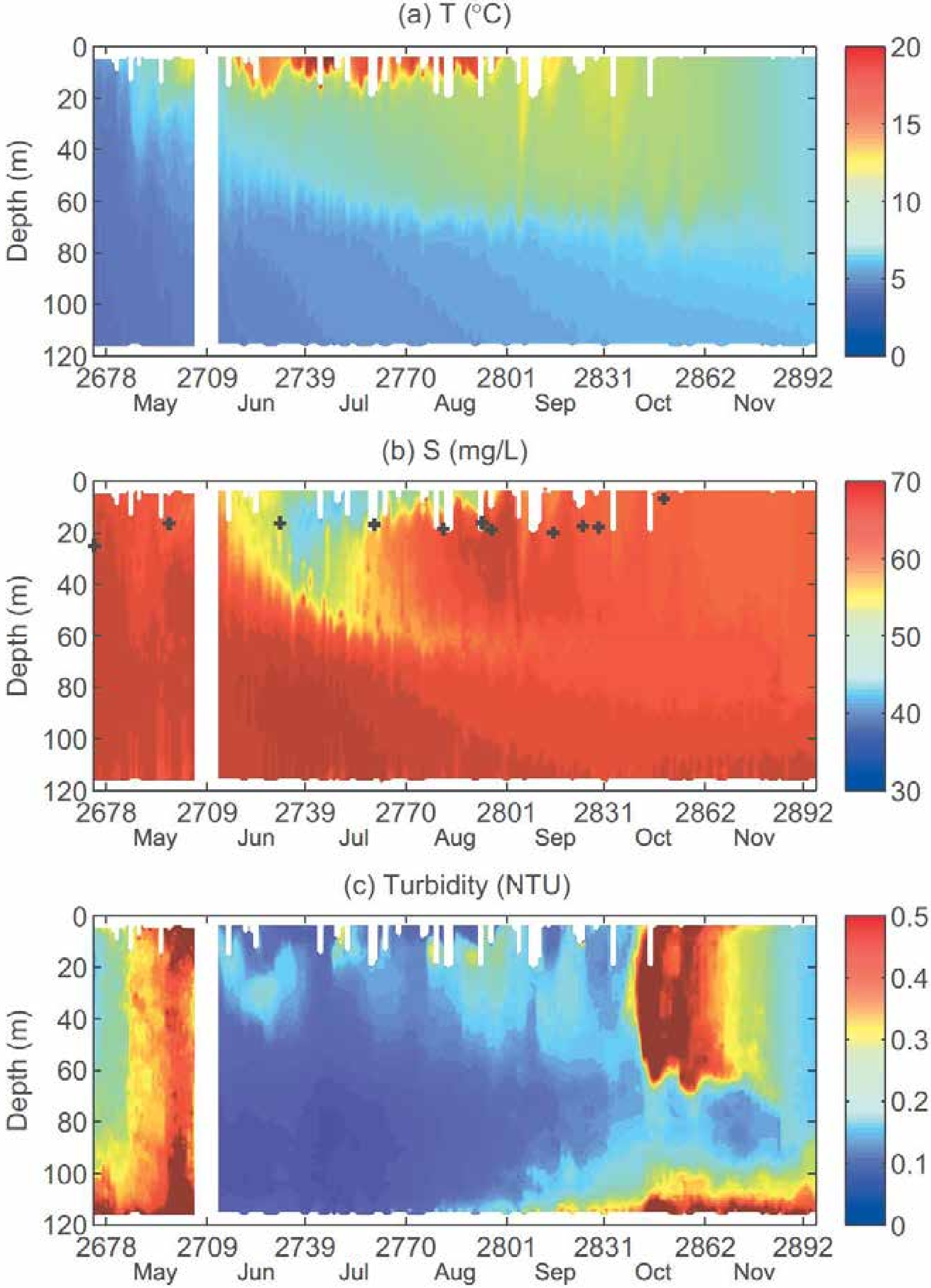

/ocean/rpieters/kr/prof/plot17/profcontcombo2.m fig= 2 2018-Jan-02

**Figure 4.5** Rev Up Profiler, May to Nov, 2014



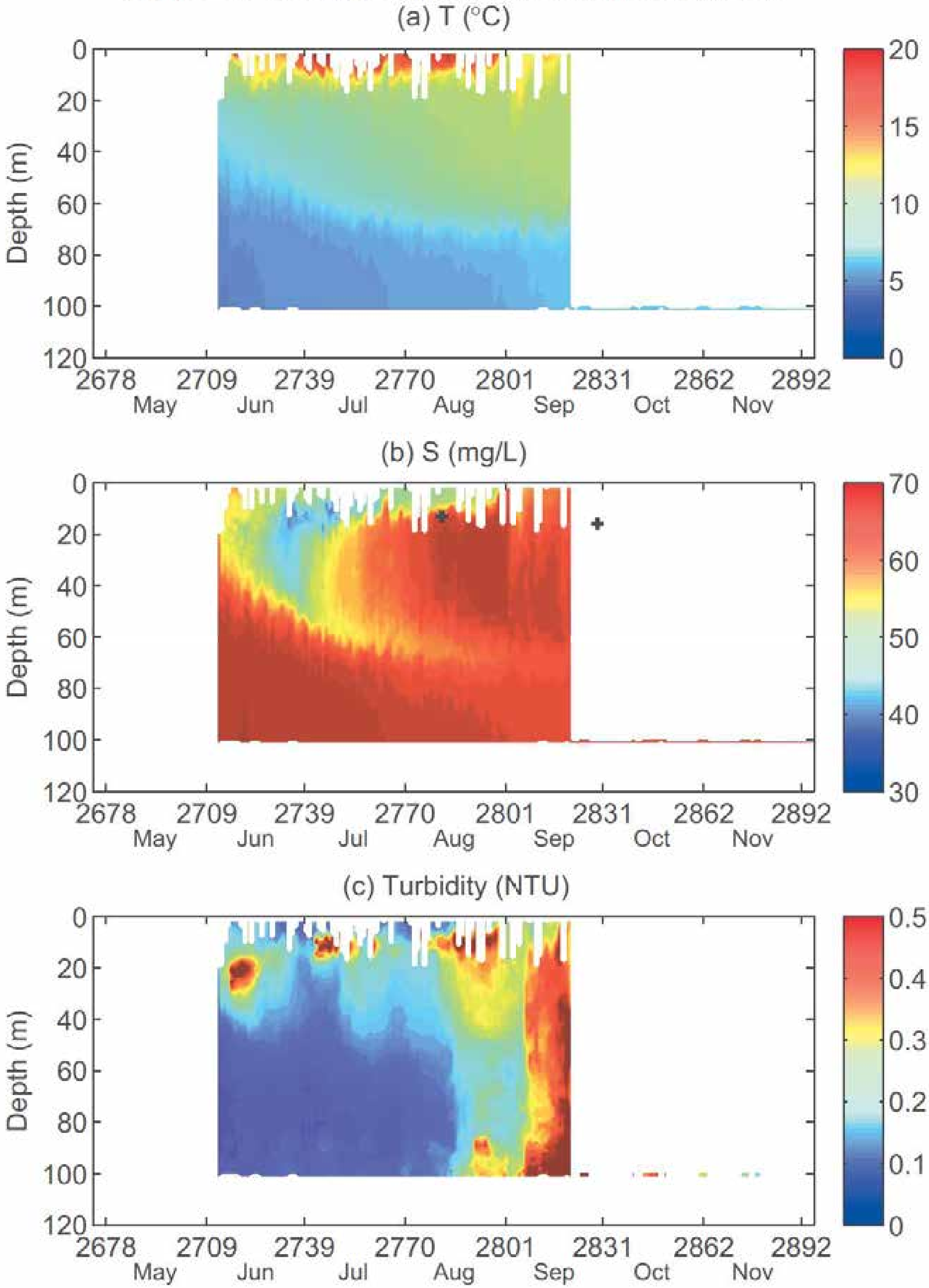

/ocean/rpieters/kr/prof/plot17/profcontcombo2.m fig= 8 2018-Jan-02

**Figure 4.6** Rev FB Profiler, May to Nov, 2015



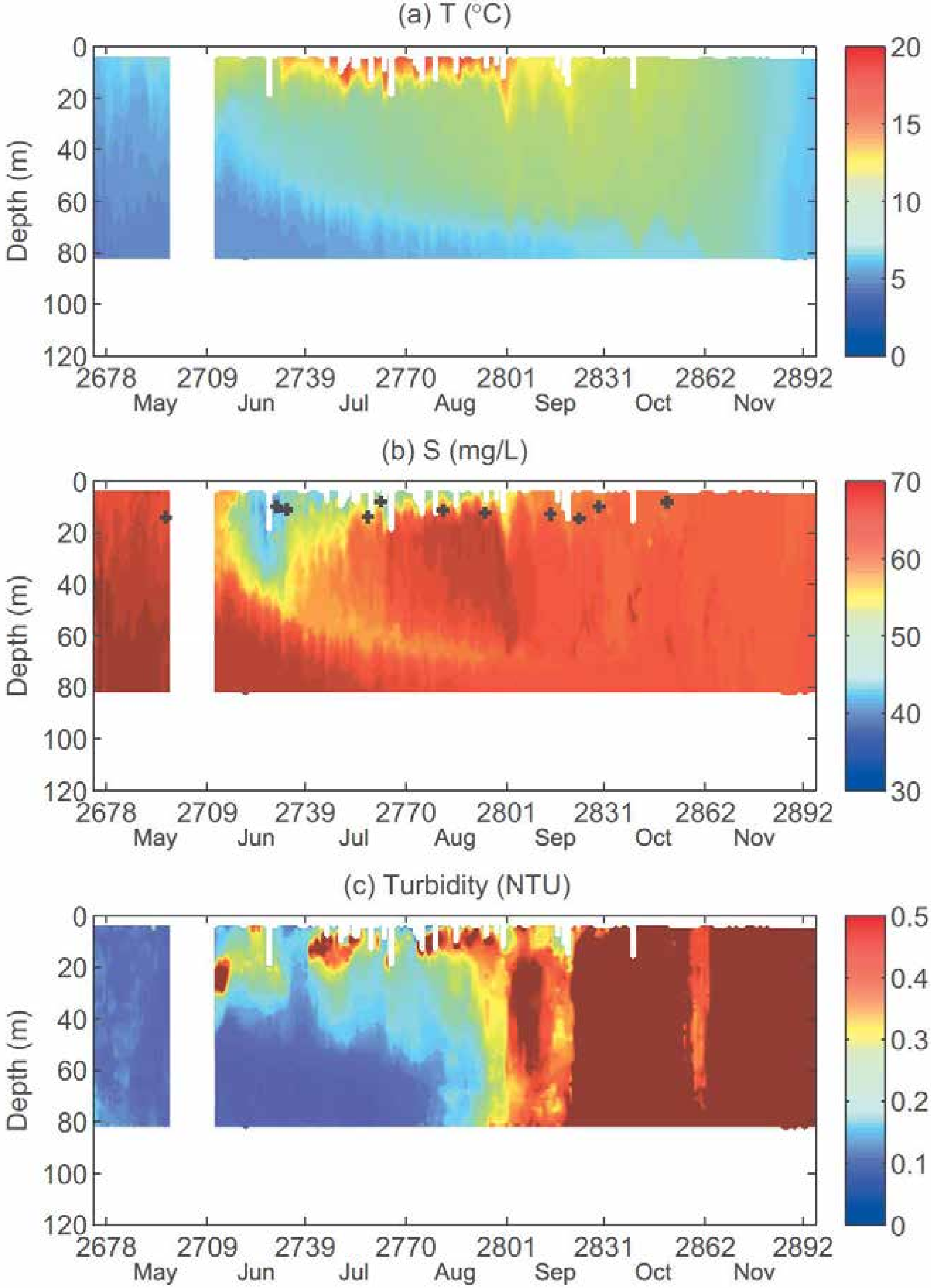

/ocean/rpieters/kr/prof/plot17/profcontcombo2.m fig= 3 2018-Jan-02

**Figure 4.7** Rev LA FORME Profiler, May to Nov, 2015



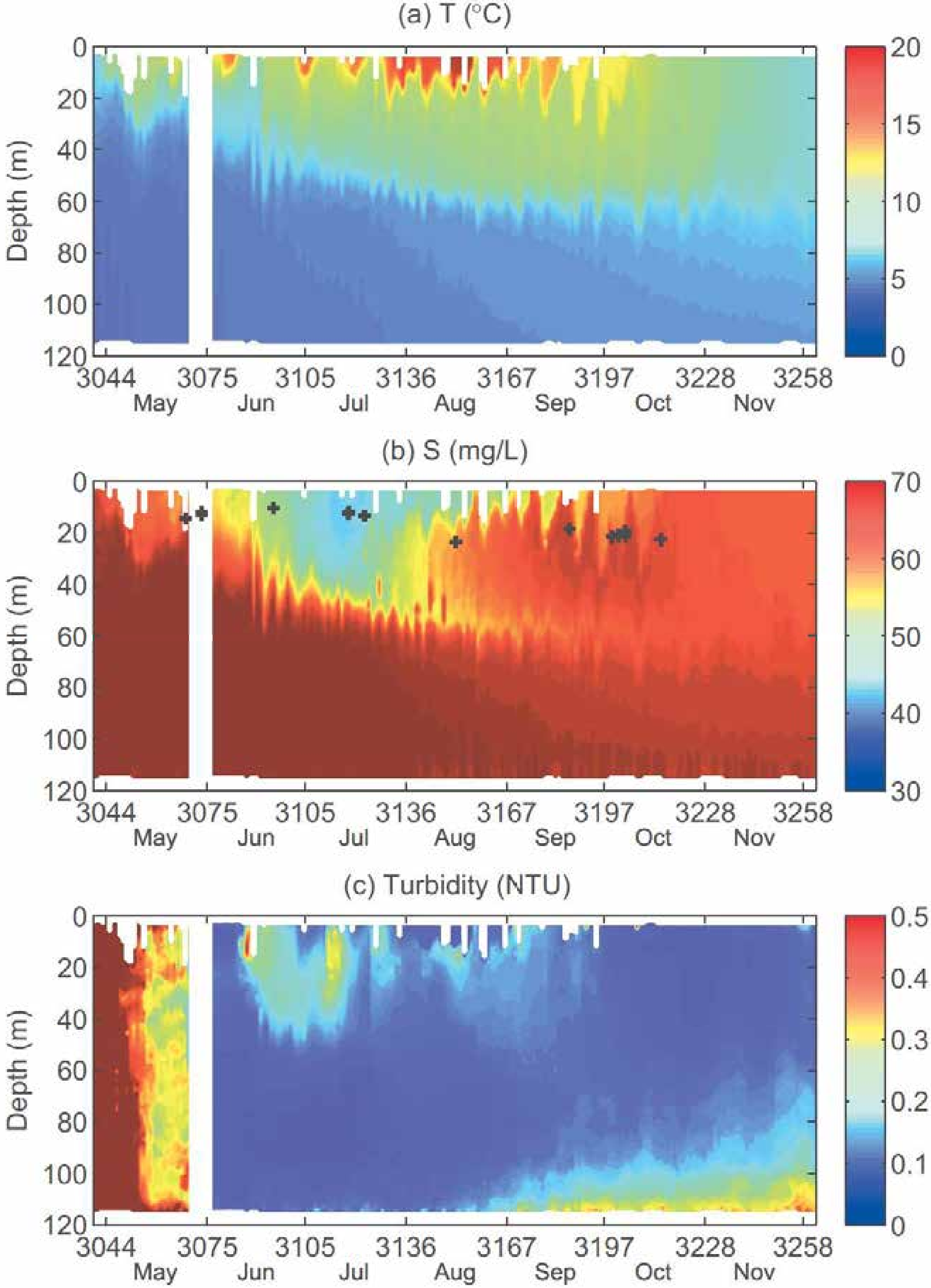

/ocean/rpieters/kr/prof/plot17/profcontcombo2.m fig= 5 2018-Jan-02

**Figure 4.8** Rev MID Profiler, May to Nov, 2015



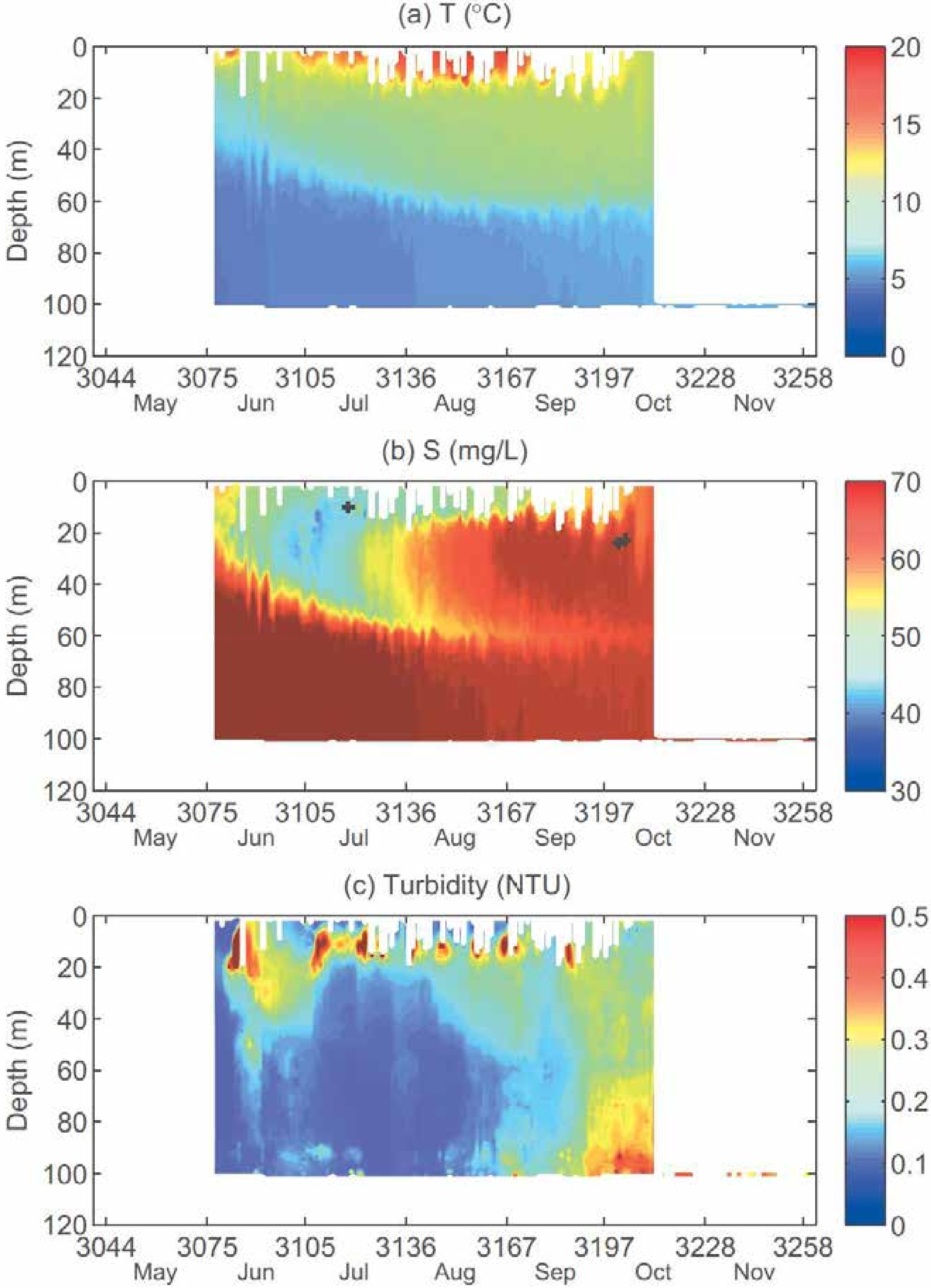

/ocean/rpieters/kr/prof/plot17/profcontcombo2.m fig= 4 2018−Jan−02

**Figure 4.9** Rev FB Profiler, May to Nov, 2016




/ocean/rpieters/kr/prof/plot17/profcontcombo2.m fig= 9 2018-Jan-02

**Figure 4.10** Rev LA FORME Profiler, May to Nov, 2016




/ocean/rpieters/kr/prof/plot17/profcntcombo2.m fig= 10 2018-Jan-02

**Figure 4.11** Rev MID Profiler, May to Nov, 2016

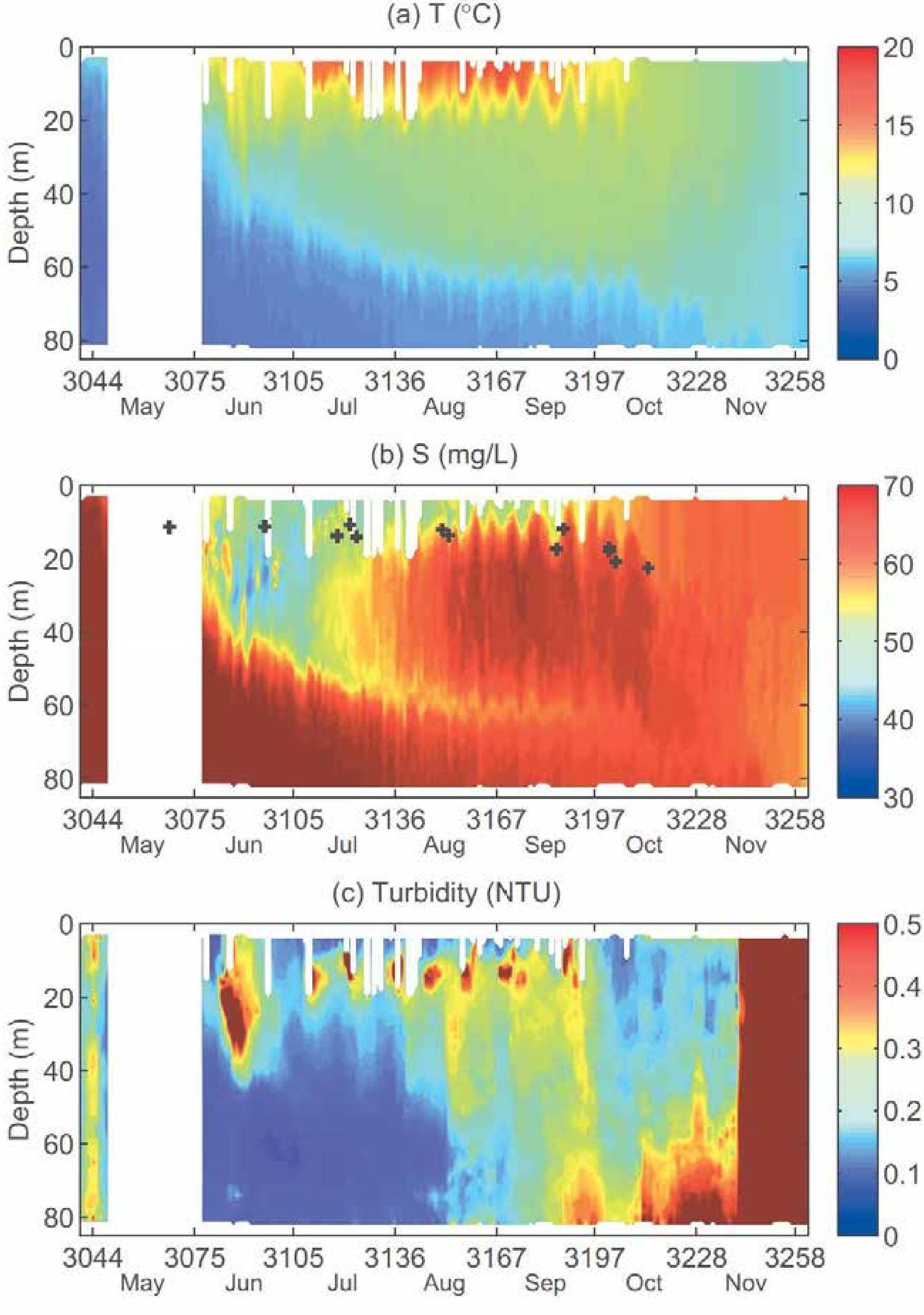



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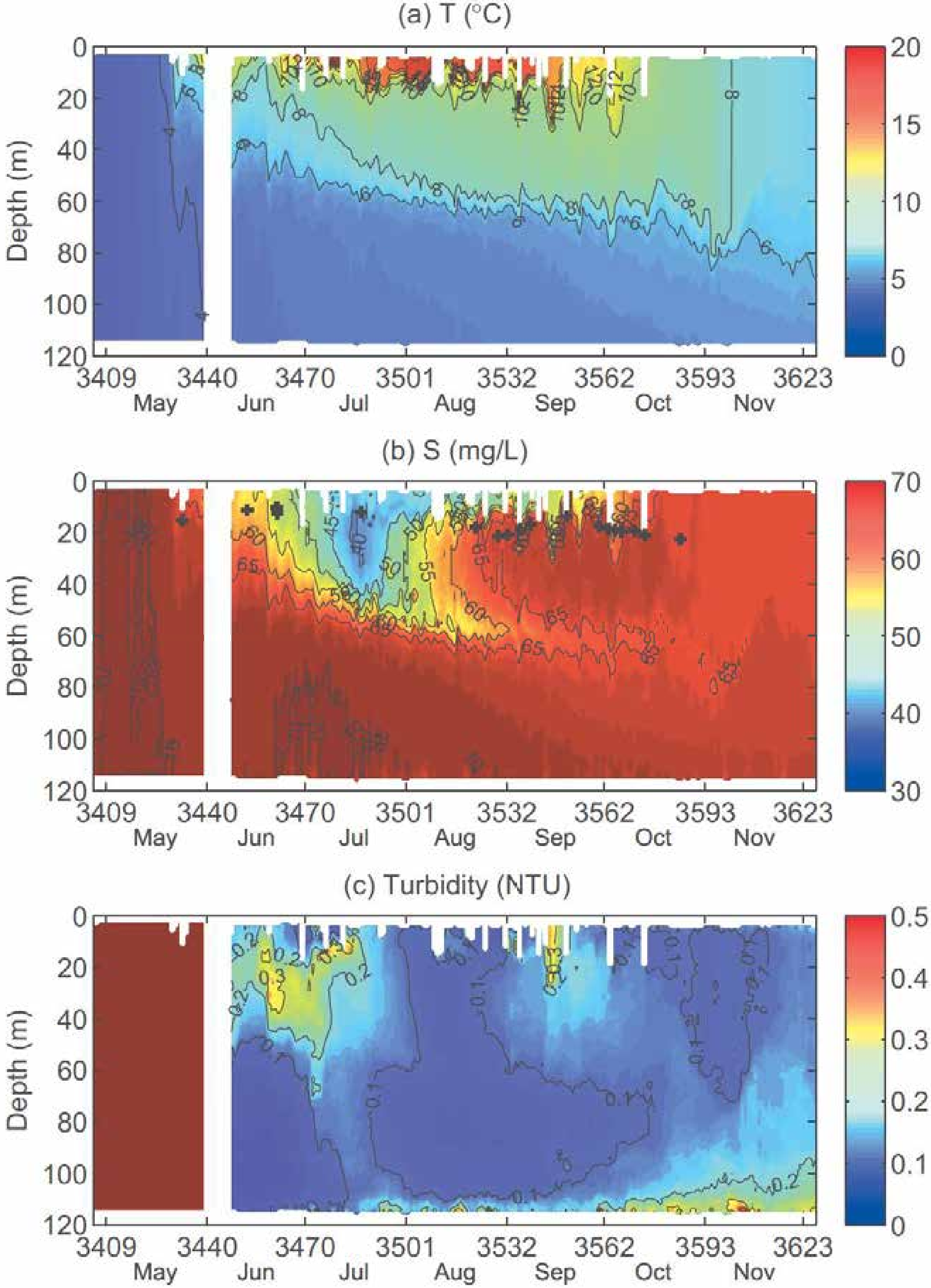
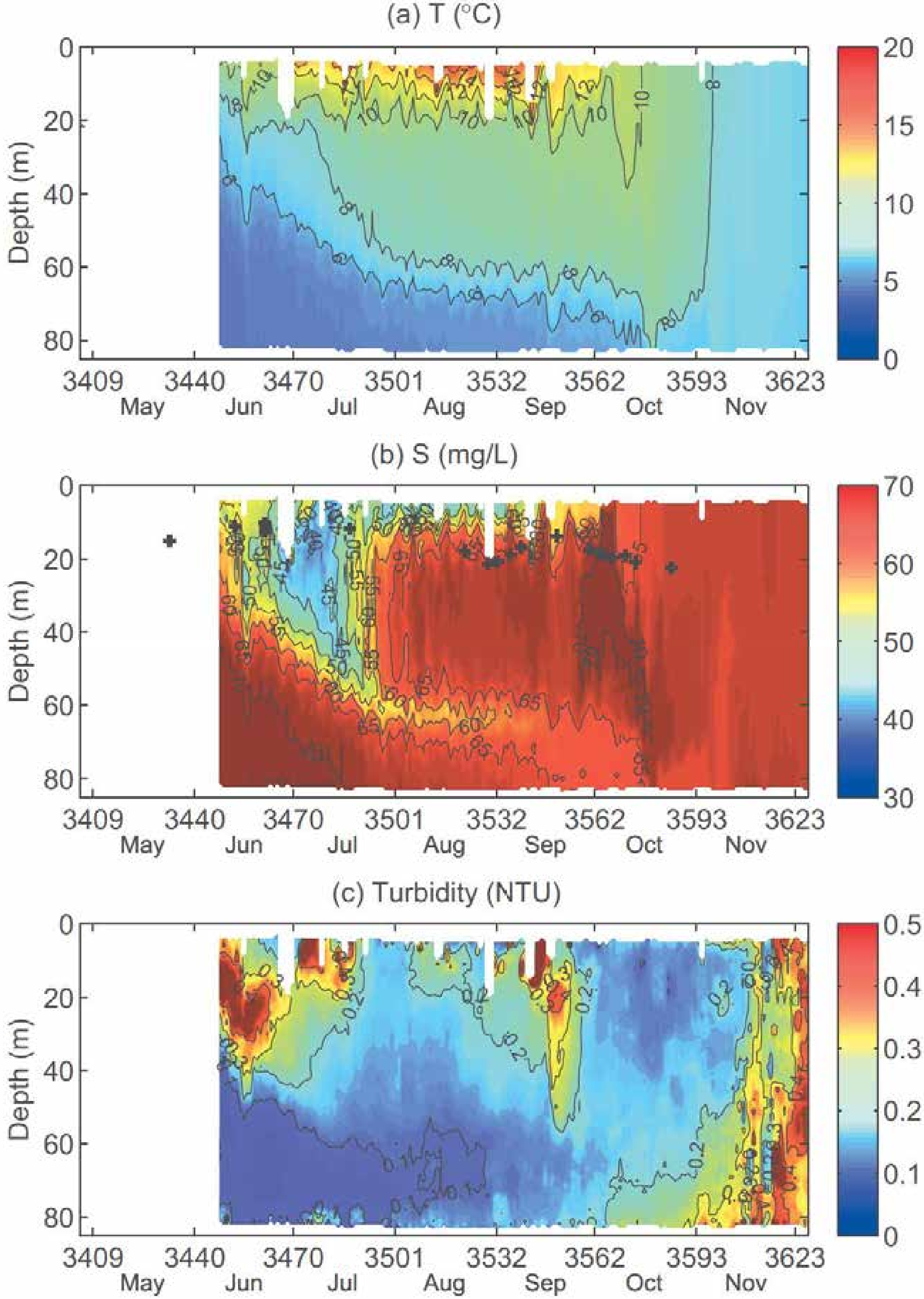
**Figure 4.12** Rev FB Profiler, May to Nov, 2017




/ocean/rpieters/kr/prof/plot18/profcontcombo2.m fig= 12 2019-Jan-10

**Figure 4.13** Rev MID Profiler, May to Nov, 2017

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