Columbia River Project Water Use Plan

Kinbasket Reservoir Fish and Wildlife Information Plan

Implementation Year 2

Reference: CLBMON-05

Kinbasket Reservoir Burbot Life History and Habitat Use Assessment

Study Period: April 2014 - July 2015

Canadian Columbia River Inter-Tribal Fisheries Commission.
7468 Mission Rd, Cranbrook, BC, V1C 7E5

March 14, 2016

WLR Monitoring Study CLBMON-05 (Year 2)

Kinbasket Reservoir Burbot Life History and Habitat Use Assessment

Prepared for:
BC Hydro
Water License Requirements Implementer
6911 Southpoint Drive, 11th Floor
Burnaby, BC
Attention: Philip Bradshaw

Prepared by:
M. Kang[1], PhD, R.P.Bio
W.G. Warnock[1], PhD
R.S. Cope[2], MSc, R.P. Bio
A. Prince[2], MSc, R.P. Bio

[1] Canadian Columbia River Inter-Tribal Fisheries Commission. 7468 Mission Rd, Cranbrook, BC, V1C 7E5
Email: mkang@ccrifc.org

[2] Westslope Fisheries Ltd. 800 Summit Dr, Cranbrook, BC, V1C 5J5
Email: westslope@telus.net

Cover Photo:

Looking upstream at Wood River with cod traps in foreground at low pool during spring capture session of Burbot. Photos in this document (C) Scott Cope, Westslope Fisheries Ltd.

Suggested citation:

Kang, M., Warnock, W.G, Cope, R.S. and A. Prince. 2015. WLR Monitoring Study CLBMON-05 (Year 2) Kinbasket Reservoir Burbot Life History and Habitat Use Assessment. Prepared for BC Hydro by the Canadian Columbia River Inter-Tribal Fisheries Commission and Westslope Fisheries Ltd., Cranbrook, BC.

EXECUTIVE SUMMARY

Burbot (*Lota lota*) were historically distributed throughout the Columbia and Canoe Rivers, and historic Kinbasket Lake, which were impounded by the construction of Mica Dam in 1973. Mica Dam created Kinbasket Reservoir, a 216 km long, 43,200 ha ultraoligotrophic water body. Burbot are present throughout Kinbasket Reservoir; this is a technical report that summarizes the findings of the second (2014-2015) of a three year monitoring study of their life history and habitat use.

Kinbasket reservoir has a normal operating range of approximately 35 m. The reservoir experiences rapid drawdown during the winter months from January to April, when reservoir elevations decline by an average of 4.3 m/month. Burbot spawn during this time period, and the success of their spawning may be affected by declining water levels. Burbot often spawn in shallow water, and developing eggs require several weeks to months to develop before hatching, at which time larvae spend several days resting before becoming planktonic. It is during this time period that optimal spawning habitat, developing eggs or newly hatched larvae may become stranded by declining water levels in Kinbasket Reservoir. The fact that Burbot still exist in Kinbasket Reservoir implies that populations persist despite potential impacts from declining water levels; however, spawning success for a component of the population may be affected by operations in all or some years.

This study uses biotelemetry to determine biological characteristics, movement and depth preferences of Burbot during their suspected spawning period. Previous data on capture rates and logistical constraints limited the study area of Kinbasket Reservoir to the section between the Canoe Arm and Surprise Rapids. Burbot were captured by baited cod traps during the immediate post-spawning period of late April and early May, 2014 and 2015, shortly after ice-off and during the period of minimum reservoir elevation. Seven major areas of the reservoir were targeted for capture. Capture was conducted in 48 h soaks, in shallow areas (< 20 m) to minimize mortality to captured fish.

A total of 99 Burbot (mean size 660 +/- 115 mm; 1.5 +/- 0.67 kg) were caught in 7 days of trapping in 2015, yielding an overall CPUE of 0.64 fish/trapset (95% CI of 0.51-0.77 fish/trapset). CPUE was moderate compared to other lakes in British Columbia. Capture success varied between the seven capture areas targeted in the reservoir, indicating that Burbot abundance is not spatially uniform throughout the study area during their post-spawning period. Burbot size varied between capture locations. This suggests variation in age structure or size at age in different areas of the reservoir. Most Burbot captured were in post-spawning condition.

Fifty fish of a broad size range (0.84 – 3.96 kg) were surgically implanted in 2015 with combined acoustic-radio transmitters (CART) that transmit depth and temperature sensor data, for a total of 98 fish tagged for the study. These fish will be tracked year-round by fixed acoustic receivers from Spring/Summer 2015 to Spring 2016. Sixteen fixed acoustic receivers were redeployed in May 2015 and 14 new receivers were deployed in July 2015. Aerial radio tracking was discontinued due to poor recapture rates. Receivers were placed in specific areas to detect broad scale movements and in the vicinity of stream confluence areas that are suspected spawning areas. These receivers will record data

of Burbot biology and life history year-round and be used to determine movements towards spawning areas and depths used during the spawning season. Receivers will be downloaded in Spring 2016.

Mobile and fixed receiver tracking data collected from 2014 to 2015 indicated that there was no clear movement pattern towards a specific congregation location in the pre-spawning and early spawning season. While data from fixed acoustic receivers indicated variability in the depths occupied by Burbot and their mobility, patterns in shallower habitat (approximately <25 m) use during spawning season and deeper habitat use during fall/early winter were observed (approximately >25 m). Shallow habitat use during spawning season was corroborated by radio tracking data and observations of river habitat use was also made during this time. Data collected from fixed acoustic receivers also showed clear evidence of diel vertical migration (DVM) by Burbot.

Management Question	**Hypotheses**	**Status (2015; Year 2)**
What are some basic biological characteristics of Burbot populations in Kinbasket Reservoir (e.g., distribution, abundance, growth and age structure)?		Distribution and abundance of Kinbasket Burbot assessed in 2014 and 2015. To be further addressed in Year 3.
Does winter drawdown of Kinbasket Reservoir cause the dewatering of Burbot spawning habitat and affect spawning success?	H1: Winter drawdown of Kinbasket Reservoir causes dewatering of Burbot spawning habitat, which reduces egg survival and Burbot spawning success. H2: Winter drawdown of Kinbasket Reservoir causes dewatering of access to Burbot spawning habitat in some years.	To be addressed in Year 3.
Can modifications be made to the operation of Kinbasket Reservoir to protect or enhance spawning success of these Burbot populations?		To be addressed in Year 3.

ACKNOWLEDGEMENTS
We thank Guy Martel for review and discussion of methodology and safety programs for this project.

Jim Clarricoates, JoAnne Fisher, Katrina Caley, and Jaime Cristales provided technical field, logistics and administrative support for this project. Jose Galdamez provided support for mapping. Phil Harrison provided useful background information and advice on project methodology and Kinbasket Burbot capture and telemetry.

Last but not least, thank you to Phil Bradshaw at BC Hydro for management of this project.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

Background

Kinbasket Reservoir was created by the construction of Mica Dam in 1973, under the terms of the Columbia River Treaty. The purposes of the creation of this earthfill, high head dam and reservoir were for optimized, coordinated power generation between Columbia River mainstem dams in the US and Canada and for downstream flood control. The reservoir inundated 216 km of the length of the Columbia River between Mica and Donald, and is among the largest reservoirs in British Columbia, with a maximum surface area of 43,200 ha. Prior to dam construction, the majority of this habitat was free flowing, with the exception of a lacustrine portion known as Kinbasket Lake that was 13 km long and had a surface area of 2,250 ha (Prince, 2011). The reservoir can be coarsely segregated into two main reaches, with the Columbia and Canoe reaches meeting at the historic confluence of the Canoe and Columbia rivers, where the Columbia River turns southward approximately where Mica Dam is currently situated. The reaches of the reservoir are typically bounded by steep valleys and are narrow, with stretches becoming riverine at low pool. Three large lacustrine portions of the reservoir occur at the confluence of the Canoe and Columbia Reaches, at the historic location of Kinbasket Lake near the confluence with the Sullivan River, and at the confluence with the Bush River. Stream inputs are largely glacial, draining the high elevation northern tips of the Selkirk and Monashee mountains from the West, and the extensively glaciated West slopes of the Canadian Rockies from the East.

Operations of Mica dam result in extreme annual fluctuations of the reservoir levels. Kinbasket reservoir elevations may vary between a maximum of 754.38 m and a minimum 707.41 m, and may occasionally be brought up to a maximum elevation of 754.68m on application to the Comptroller of Water Rights if there is a high probability of spill. Normal operating level for the 2008-2012 period was from a mean maximum of 753.26 m and a minimum of 718.12 m, with a normal operating range of 35.14 m. Drawdown from full pool normally begins slowly in September, and draft rate increases through the winter, with a levelling off of drafting and normal low pool occurring in mid-late April. During the spring period, discharge from Mica dam decreases, which coincides with the normal spring freshet, which rapidly refills the reservoir through the spring and early summer.

Burbot (*Lota lota*) were identified by the Columbia River Water Use Plan Consultative Committee (WUP CC) as a key fish species of concern in Kinbasket Reservoir because of their importance to the sport fishery, because of the potential for links between reservoir operations and Burbot population productivity, and due to the dearth of information regarding Burbot biology in the reservoir (but see Harrison et al., 2013). The WUP CC hypothesized that the greatest potential impact of reservoir operations on Burbot populations may be the dewatering effect of winter drawdown on spawning success and egg survival in sites along the shoreline and in lower sections of tributaries. The WUP CC also had concerns that winter drawdown could affect Burbot spawning habitat in tributary streams of Kinbasket Reservoir. To address these concerns, the WUP CC recommended that a life history and habitat use assessment be undertaken in Kinbasket Reservoir to gain a better understanding of how the current operating regime might be affecting Burbot populations.

Burbot typically spawn between late January and April, with timing on major Columbia River system reservoirs (Duncan and Arrow) occurring in mid-February to early April (Arndt and Hutchinson, 2000; Bisset and Cope, 2002; Prince and Cope, 2008; Cope, 2011; Robichaud et al., 2013), either in lake habitats or low velocity stream habitats, and have an egg incubation period of 30-60 days (Taylor and McPhail, 2000; McPhail, 2007). After hatching, larvae spend several days resting on the bottom before becoming free-swimming and planktonic in the water column. It can be expected that the period of spawning and egg and early larval development occurs between February and May-June in Kinbasket Reservoir, which coincides with the period when reservoir water levels can decline by an average of 4.3 m/month before reaching low pool elevation (Figure 1).

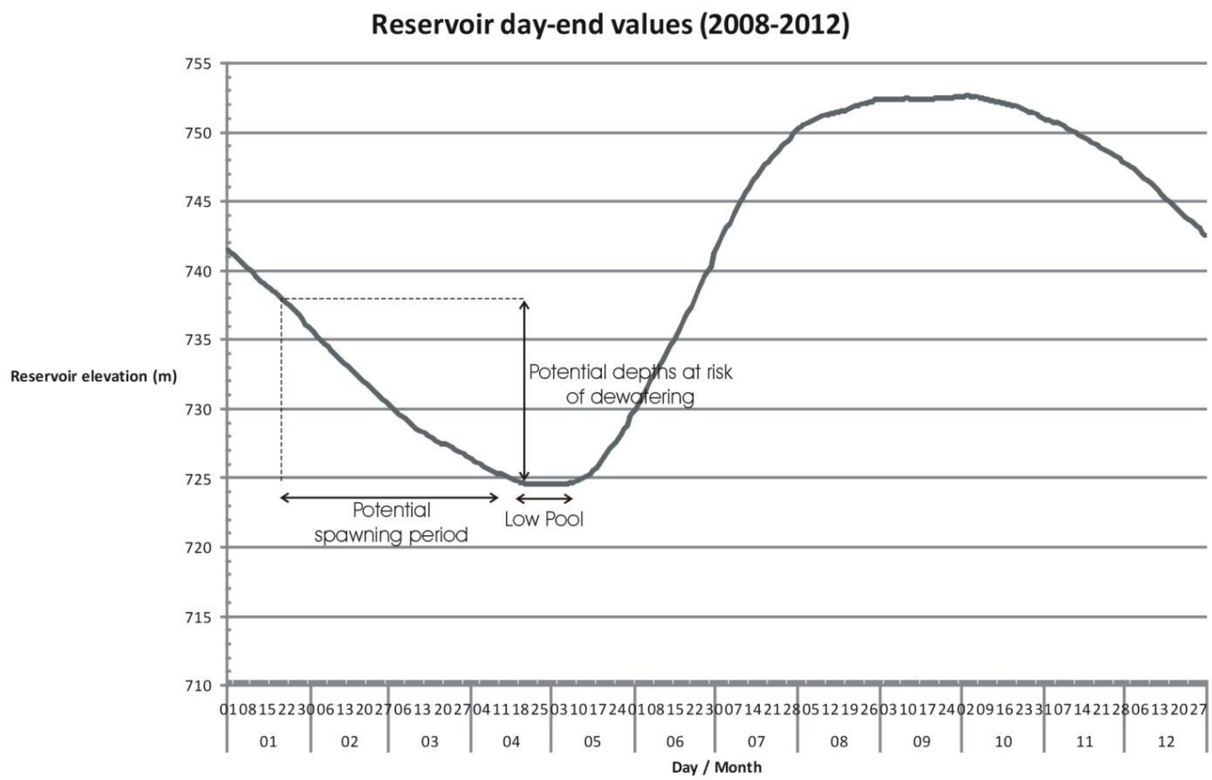


Figure 1: Potential depths used by Burbot during the spawning period that are at risk of dewatering in an average year of reservoir operation. Greater depths are at less risk for dewatering as the spawning season progresses. Line represents mean water elevation from 2008 to 2012.

The greatest potential impact of reservoir operations on Burbot populations may be the dewatering effect of winter drawdown on spawning success and egg survival in sites along the shoreline and in lower sections of tributaries. Burbot spawn in aggregations, often at night (McPhail, 2007), and vocalization appears to be a key behaviour that may aid Burbot in locating each other for spawning (Cott et al., 2014). In lakes and reservoirs, spawning may occur over near-shore shallows or over shallow offshore reefs and shoals (Ford et al., 1995; McPhail, 2007; Spence, 1999; Prince and Cope, 2008); however, deeper spawning (>20m) may also take place (Robichaud et al., 2013). In rivers and tributaries, Burbot spawn in low velocity areas in main channels and in side channels behind depositional bars (McPhail, 2007). In many cases, spawning in lakes is often associated with tributary confluences or upwelling; however microhabitat preferences for spawning appears to be general, as Burbot may select a range of substrate, habitat characteristics and depths to spawn (Ford et al., 1995; McPhail, 2007; Andrusak, 1998; Baxter et al., 2002; Spence and Neufeld, 2002; Prince and Cope, 2008; Cope, 2011). The depth at which spawning takes place, coupled with the timing of spawning until the period of maximum drawdown in April, dictates whether there is a risk of spawning failure due to reservoir operations (Figure 1).

Declining water levels may also interfere with Burbot spawning migration and spawning activity. In a radio telemetry study of adult Burbot in Duncan Reservoir, the extent of spawning migration into the upper Duncan River appeared to be influenced by reservoir water levels and related impacts on back-flooding and stream velocity (Spence and Neufeld, 2002; Cope 2011). As back flooding from Duncan Reservoir declined, Burbot tended to move downstream into areas with lower water velocities than the locations they had abandoned. Since stream spawning Burbot tend to spawn in low velocity stream habitats (McPhail, 2007), the Burbot may have been moving downstream to more suitable lower velocity spawning sites. Burbot are known to have low swimming endurance and biotelemetry results in the Kootenay River below Libby Dam suggest that spawning migrations of Burbot in the Kootenay River may be disrupted by high flows produced during hydropower production and flood control (Paragamian, 2000).

The operational impacts of Mica Dam depend on the life history strategy of resident Burbot populations. As there is no pre-dam life history information available for Burbot populations in this area, assessment of impacts must rely on estimation based on habitat features, other species and other Burbot populations. What is known is that there was habitat connectivity between the historic Kinbasket Lake and the upper Columbia watershed prior to dam construction and operation. The literature suggests that all three life history forms of Burbot (lacustrine, adfluvial, fluvial) often co-exist within the same system (McPhail, 2007) and this may have been the case for Burbot occupying the historic Kinbasket Lake and upper Columbia system that is now inundated by Kinbasket Reservoir. Adfluvial and lacustrine remnant life history forms may still be present, or the population may be supported by fluvial immigrants from upstream sources. The relative contributions or existence of any of these three life history forms to the current Kinbasket Burbot population is unknown.

While the life history and population status of Kinbasket Lake and the Columbia River Burbot before dam construction are largely unknown, recent studies have provided some insights into important habitats and distribution of remnant stocks (Prince, 2001; Harrison et al., 2013). Growth rate is highly variable, as within other populations (Cope, 2011). Burbot capture is relatively consistent and successful in the confluence, Bush pool and historic Kinbasket Lake areas of the reservoir, and near tributary confluences in the Sullivan, Bush and Wood arms and Hugh Allan Creek (Prince, 2001; Prince, 2011; Harrison et al., 2013). Most Burbot (~2/3 of fish captured in the confluence area between the Columbia and Canoe Reaches) appear to make limited seasonal movements, and diel vertical migration and seasonal shifts to shallower habitats in winter are common (Harrison et al., 2013). This suggests that there may be many, non-central spawning areas, and/or that fish may not spawn annually, a common observation for Burbot (Paragamian and Wakkinen, 2008), especially those in reservoirs (Dunnigan and Sinclair, 2008). For fish that did move out of the confluence area, there does not appear to be a central spawning area where fish move towards (Harrison, pers. comm.).

Management Questions

The management questions (MQs) associated with this monitoring program are (BC Hydro, 2007):

1) What are some basic biological characteristics of Burbot populations in Kinbasket Reservoir (e.g., distribution, abundance, growth and age structure)?

2) Does winter drawdown of Kinbasket Reservoir cause the dewatering of Burbot spawning habitat and affect spawning success?

3) Can modifications be made to the operation of Kinbasket Reservoir to protect or enhance spawning success of these Burbot populations?

The monitoring program will provide a quantitative baseline dataset to establish basic biological characteristics of the Burbot populations in Kinbasket Reservoir. It will provide information on habitat use, life history and rough estimates of abundance, and possible factors affecting Burbot productivity. Specifically, the assessment will address uncertainty regarding the extent to which Burbot are present in the drawdown zone during the spawning season, and if these areas are at risk for dewatering during the operational years of the study. A comprehensive drawdown risk assessment will be conducted in Year 3.

Management Hypotheses

The primary aim of this monitoring program is to provide baseline information on the Burbot population in Kinbasket Reservoir to better inform on the relationship between reservoir operations and recruitment. It is designed to specifically test the following hypotheses using assumptions of winter (January-April) habitat use being linked to spawning activity:

H1: Winter drawdown of Kinbasket Reservoir causes dewatering of Burbot spawning habitat, which reduces egg survival and Burbot spawning success.

H2: Winter drawdown of Kinbasket Reservoir causes dewatering of access to Burbot spawning habitat in some years.

Key Water Use Decision Affected

Implementation of the proposed monitoring program will provide information to support more informed decision making with respect to the need to balance storage in Kinbasket Reservoir with impacts on fish populations in the reservoir. Specifically, it will provide the information that is required to support future decisions around maintaining the current operating regime or modifying operations to protect reservoir Burbot populations.

METHODS

Overview, study objectives and limitations

The general approach of this study draws upon the designs of previous Water Use Planning Burbot life history and habitat use studies, particularly CLBMON-31 (Glova et al., 2009, 2010; Robichaud et al., 2011, 2012, 2013) and DDMON-11 (Cope; 2009, 2010, 2011), and refines them.

The study is designed to answer the management questions (MQs) outlined in the previous section. Unfortunately, the main drawbacks of work on Kinbasket reservoir are the size of the system, and inability to conduct on-reservoir work during the spawning season in February-March, which differs from the conditions of the previous two Water Use Planning studies on Arrow and Duncan Reservoirs.

The study is concentrated in a reduced area of the reservoir, between the Wood Arm and Surprise Rapids (Figure 2). This reduced area was chosen based on previous information of Burbot occurrence and logistical considerations for working from the only accessible boat launch near Mica Dam during the low pool period. During the Burbot spawning season, Kinbasket reservoir has unpredictable, dynamic ice conditions that make on-reservoir winter work unsafe. In addition, the remoteness of the reservoir requires extensive travel with limited safe access and contact points. Given these safety and logistical constraints, the following study design attempts to answer MQs 2 and 3 without working on-reservoir during the spawning season, and uses a combination of fixed receiver and mobile helicopter tracking. These methods attempt to infer whether fish are present and congregating in shallow drawdown habitats during the spawning season. This approach cannot confirm spawning activity, thus presence of aggregations of Burbot and movement to relatively shallow depths over multiple days during the potential spawning period will be treated as indicative of spawning activity when testing the management hypotheses outlined in the previous section.

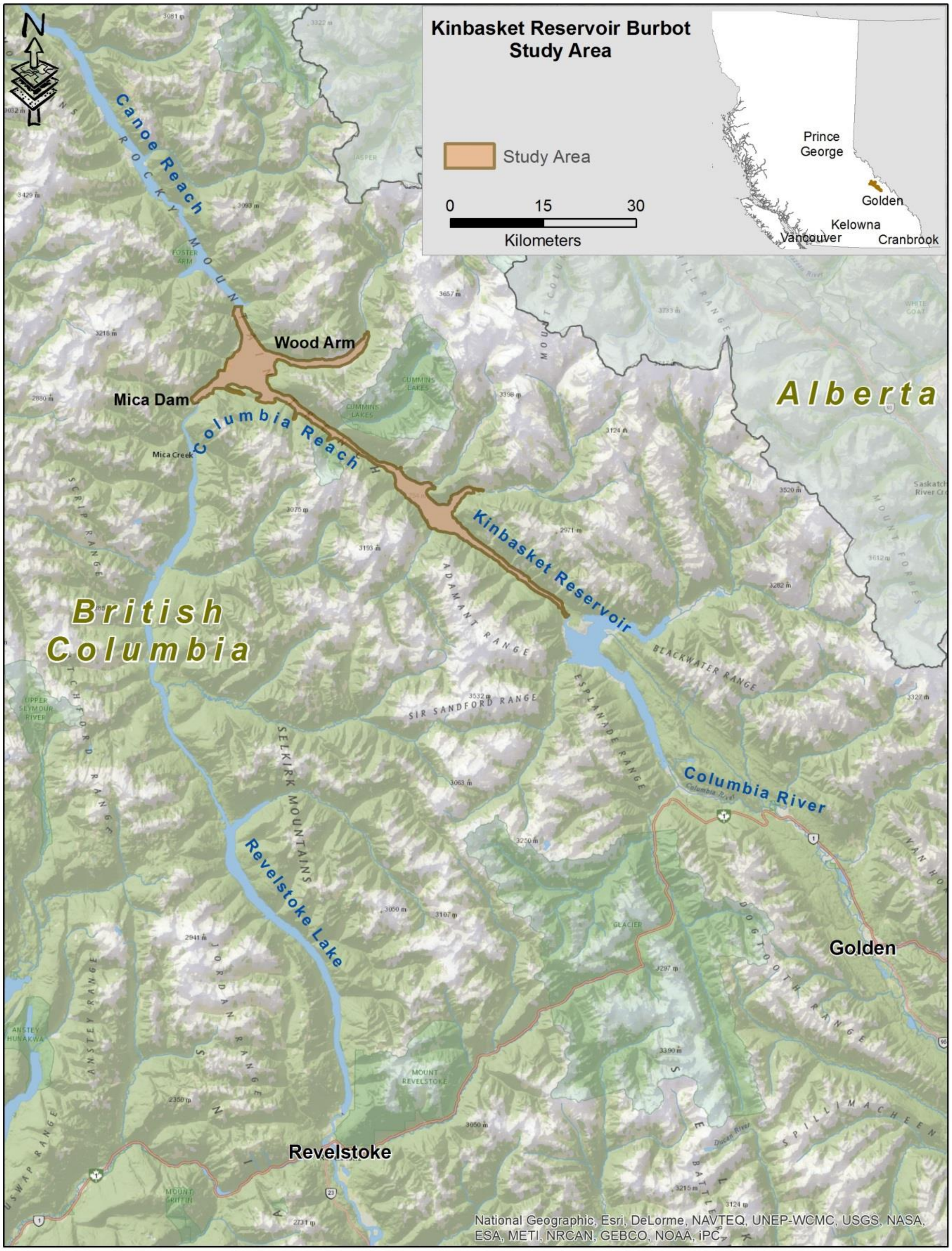


Figure 2: Study area within Kinbasket Reservoir

Burbot capture and tagging

Standardized capture techniques (i.e., time of year, depth, decompression methods and proper equipment) using baited cod traps have been developed and refined through many studies in the Kootenay region of British Columbia, and we applied these to minimize mortality and tag loss in captured fish. A spring capture time of year was chosen, as distribution shifts to shallower habitats, where the risk of barotrauma and mortality is lowest, while capture rates still remain high relative to other times of year (Bernard et al., 1993; Neufeld, 2006; Cope, 2009; Harrison et al., 2013). Capture during this time of year is further justified by minimizing stress that may interfere with spawning behaviour and maturation of adult fish (Cope, 2009), and provides nearly a full year of recovery before the critical tracking season during the spawning period. Further advantages of spring capture include isothermal, cool water column, thus minimizing temperature and decompression stress on fish brought up from depth (Harrison et al., 2013).

Trapping was conducted using cod traps baited with Chum salmon that were strategically placed in five reservoir areas where high Burbot bycatch was observed in a previous study that attempted to capture white sturgeon using setline techniques (Prince, 2009). The five areas sampled in 2014 were revisited (Wood Arm, Columbia Reach in vicinity of the Cummins River, in the vicinity of the confluence with the Kinbasket River, in the vicinity of the confluence with the Sullivan River and in the upstream portion of the Columbia Reach to Surprise Rapids). Two additional areas were sampled in 2015: in the confluence around the vicinity of Encampment Creek, and along the shoreline of the historic Kinbasket Lake. The Cummins River sampling area from 2014 was renamed “Columbia Reach North” and the Columbia Reach sampling area from 2014 was renamed “Columbia Reach South” (Figure 3). A variety of depths, between 5.8 and 18 m, were sampled and specific areas and depths were randomly selected for trapsets within the seven major sampling vicinities. Depths of over 20 m were avoided to minimize risk of barotrauma.

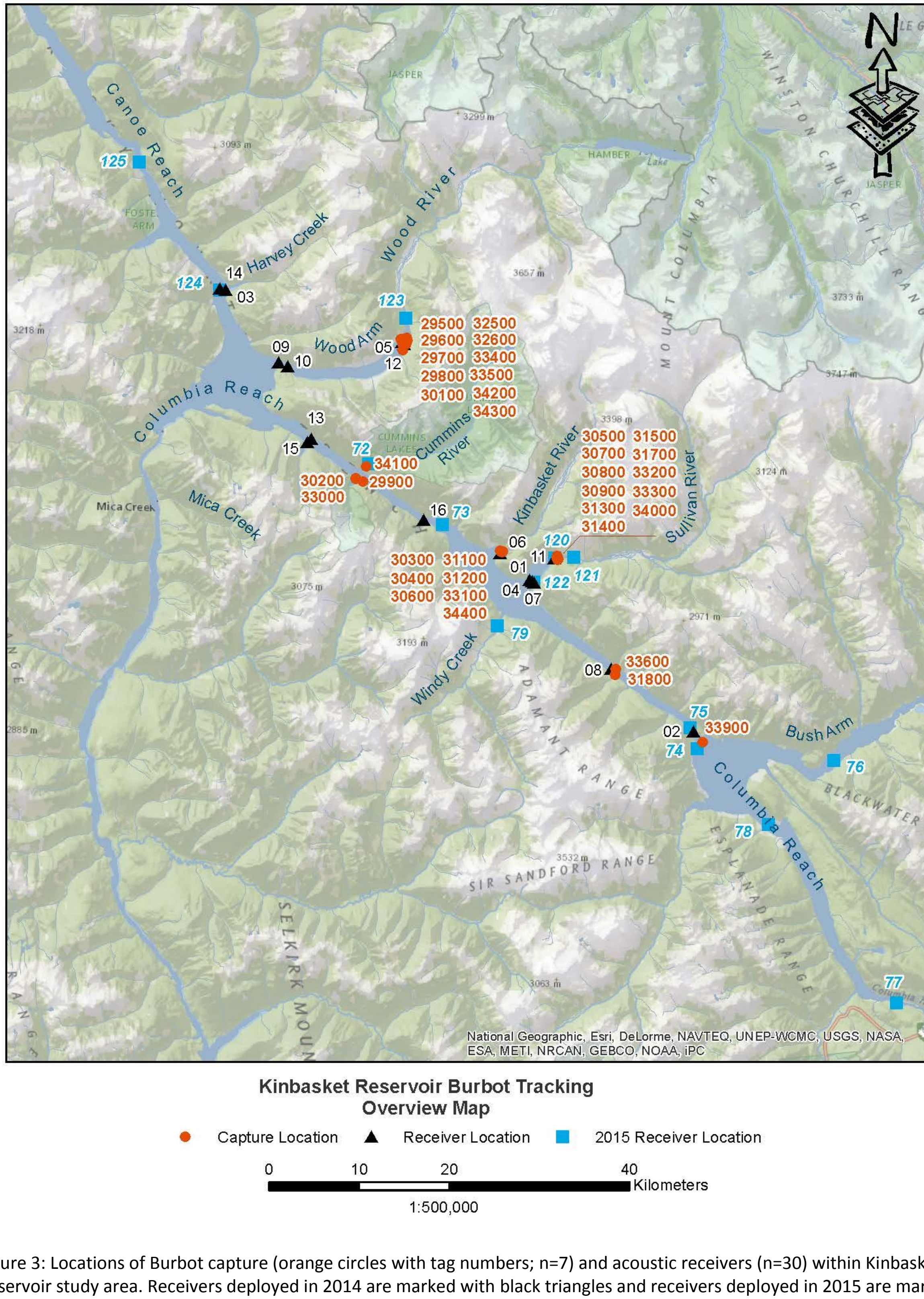


Figure 3: Locations of Burbot capture (orange circles with tag numbers; n=7) and acoustic receivers (n=30) within Kinbasket Reservoir study area. Receivers deployed in 2014 are marked with black triangles and receivers deployed in 2015 are marked with blue squares.

Abundance for Burbot is unlikely to be estimated in a robust manner from traditional capture-mark-recapture techniques given poor recapture rates in other studies (Neufeld, 2006; Prince, 2007; Cope, 2011), which bias population estimates high. The amount of trapping effort required for a robust assessment in this study, the large spatial coverage of Kinbasket Reservoir, and budgetary constraints that limit the effort that can be expended upon a randomized capture effort make a population estimate especially impractical in this system; therefore, we provide basic capture-per-unit-effort (CPUE) metrics as rough, relative estimates of abundance for MQ1 from a targeted sampling approach in much the same way as has been assessed in previous studies (Arndt and Baxter, 2006; Neufeld, 2006; Cope, 2010, 2011). Mean CPUE was calculated by taking the simple arithmetic mean of the number of Burbot caught, expressed in values of fish per 48 h trapset. Given that few fish enter traps during daylight and traps stop fishing after 48 hours, catches were not adjusted for the few hours' deviation in soak time (Cope, 2009).

Transmitters (Lotek CART11, 12 g in air, n = 14, Lotek CART16, 31 g in air, n = 34) were surgically implanted at the location of capture, according to the 2% tag-to-body weight ratio in water rule (Brown et al., 1999; Harrison et al., 2013). Transmitters had additional temperature and pressure sensors on them. Lotek CART11 tags were implanted in smaller fish and have an estimated battery life of 372 days; whereas CART16 tags can be implanted in larger fish and have an estimated life of 831 days. Transmitter data will be useful to determine whether Burbot are using depths that are at risk for dewatering during the spawning period, to the time of minimum reservoir elevation in the spring. Depth sensors are attached to the acoustic end of the tag, and read by acoustic receivers.

Sufficiently sized fish in good condition were selected and anaesthetized in a 60L bath of lake water, with a 100mg/L concentration of clove oil. Clove oil was first dissolved in ethanol before being added to water to ensure proper mixture of anaesthetic. Fish were transferred to surgery once they reached level four anaesthesia; total loss of movement and weak opercular motion (Cope, 2009). Times to anaesthesia, surgery and recovery of fish were recorded for quality assurance.

Fish were weighed and measured prior to surgery, and were transferred to a surgical table with a V-shaped cradle of soft netting (Figure 4). A crew member provided a continuous supply of oxygenated water to the fish by hydrating the gills throughout the procedure. A small incision was made 3 cm from the mid-ventral line and the anus, and a catheter was inserted through the incision to a point 3-4 cm posterior and dorsal to the incision. The antenna wire was fed through the catheter, which was pulled through the body wall, and the transmitter was simultaneously placed within the body cavity (Figure 5). The incision was then closed using independent and permanent monofilament sutures (4/0 Ethicon) and tissue adhesive applied. Fish were transferred to a 120 l live well supplied with medical grade oxygen (0.2 to 0.7 l/min.) and gentle flow delivered via a submersible pump (Figure 6). Burbot were typically allowed 60 minutes to fully recover (i.e., attainment of fear response) before being returned to depth in a decompression cage and released at the original point of capture.

Figure 4: Surgical setup for transmitter implantation.

Figure 5: Incision and antenna placement for burbot transmitter surgery.

Figure 6: Burbot in oxygenated recovery tank.

Mobile and fixed receiver tracking

This study is designed to detect year-round habitat use of Burbot and aspects of migratory life history (e.g., adfluvial movements; MQ1), as well as shallow habitat use during the spawning season (MQs 2 and 3). This will be assessed using a combined approach of data collection from mobile tracking radio frequencies of CART tags from a helicopter, and acoustic frequencies of the same CART tags from a series of fixed receivers placed throughout the study area. The study period for tagging and tracking will occur over two years. CART transmitters use a coded radio (Codes 1-26) frequency of 150.25 and 150.30 MHz for individual tag identification and an acoustic transmission of 76KHz. The radio burst rate is 5-6 seconds continuous; pressure and temperature sensors continuously transmit data on the acoustic transmission, which transmit every 60.5 s (CART16) or 100.5s (CART11) .

Multiple fixed acoustic receivers (*n* = 16) were deployed through 10 areas in the study area from June 2-5, 2014 (Figure 3). In order to increase coverage, some of these locations consisted of an array of multiple receivers. An advantage of the basin shape of a river valley reservoir is that constrictions in the valley may be “gated” with receiver arrays to track movement amongst areas (Gutowsky et al., 2013). Areas were gated at the study area limits at Surprise Rapids and the Canoe Reach. Additional receiver gates were placed within the study area at the Wood Arm outlet, Columbia Reach North outlet, Kinbasket Lake North Outlet, Sullivan Bay entrance and Kinbasket Lake South inlet. These gates will record valuable information on large scale movements within the reservoir to detect movement towards spawning locations during the spawning and pre-season period. Additional receivers were placed near the confluences with the Wood, Kinbasket and Sullivan Rivers, as these are known areas where Burbot concentrate during the post-spawn period in the spring. These receivers may be used to detect movements of Burbot and depths used during the spawning season.

Acoustic receivers used were Lotek WH3250E 76 KHz underwater hydrophone dataloggers (Figure 7), with an estimated receiving range of 750 m with a maximum depth range limit of 50 m. Receivers were generally placed within 400 m from shore, or, where an array of receivers was deployed, within 400 m from each other. These receivers will continuously record data throughout the study, receiving acoustic transmissions from CART tags. Receivers were anchored with sandbags, which were dropped to the bottom of the water column. Receivers were suspended approximately 1/3 of the way up from the bottom in the water column, attached to polypropylene floating line, which was floated to the surface with 2 high density foam buoys (6”x12”). Receivers were deployed when Kinbasket Reservoir elevations were ~750 m in 2015. Projected reservoir elevations for Spring 2016 are estimated to be ~713 m so limited slack line was added to receiver lines.

Acoustic receiver and transmitter range testing was conducted with the use of a digital rangefinder and a test transmitter. Radio receiver and transmitter range testing was completed in the Columbia Reach (clear water, cobble bottom) and the Wood River confluence (turbid water, silt bottom). Both tests revealed a vertical detection depth range of 12 m at breast height from the water surface.

Acoustic receiver retrieval was conducted from May 11-14, 2015. Due to high water levels, 11 of 16 receivers were retrieved and subsequently, only data from those receivers were used in review of range tests and analyses for this report. The remaining 5 receivers (#2, 7, 11, 14, and 16) will be retrieved in Spring 2016 and data will be incorporated in the Year 3 report.

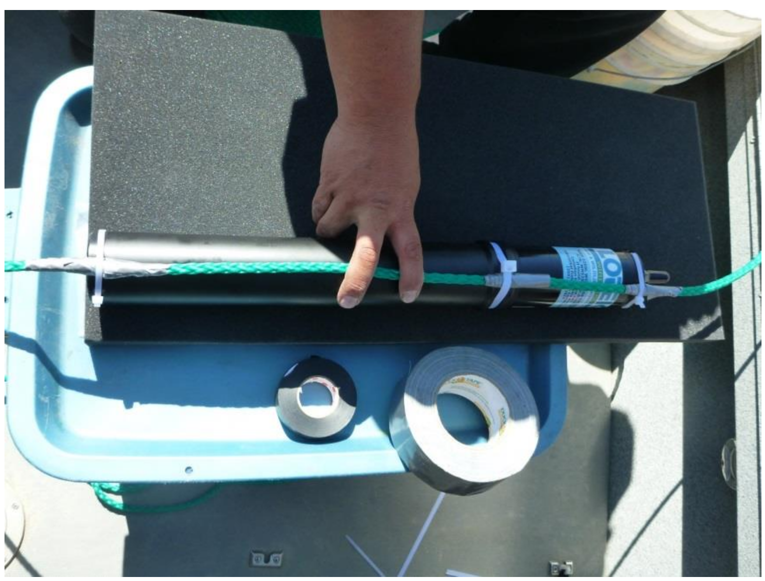


Figure 7: Receivers used in study, attached to floating line.

Radio tracking was conducted by 5 flights in a single engine helicopter, biweekly throughout the spawning season (February 17 – April 18, 2015). A Lotek SRX400 receiver with data logging abilities attached to dual antennas mounted externally on the aircraft was used. The detection limit for radio tracking was 10 m. The flight path consisted of flying as low as possible within safety limits (500' AGL) along the thalweg of the Columbia River from Columbia Lake to Surprise Rapids, and around the perimeter of Kinbasket Reservoir from Surprise Rapids, to the Canoe Arm. The Columbia River and tailrace of Mica Dam were also surveyed, from Mica Dam, downstream to the Mica townsite. In order to maximize the probability of detecting a radio tag, flights were conducted throughout the study area of Kinbasket reservoir at a speed of no greater than 60 knots. The helicopter was further slowed to 25 knots in areas of proximity to capture locations, since it was suspected that these areas would have a higher probability of Burbot presence. Radio tracking was also conducted opportunistically during the 2015 capture session and receiver re-/deployment.

Post-flight processing of tracking was conducted on downloaded receiver data. Invalid code logs and low power logs were filtered from the dataset. Tag position along the flight path was determined by taking the highest power entry logged for a specific tag. The clock in the receiver was synchronized with the time on a flight GPS log (position in the log was taken every second), so the time entry on each tag entry could be georeferenced to the helicopter position as the approximate location of the fish.

Tag mortalities were assessed by two means. Firstly, the temperature sensor data from receiver logs were reviewed to determine if a sensor was likely in air rather than water. Maximum air temperatures were downloaded from nearby Environment Canada weather stations (Mica Dam, Golden and the Goldstream River) on the same day of each flight (data not shown). The flight conducted on April 18 had abnormally high air temperatures (~15 °C). If a tag had a correspondingly high air temperature readings for this date (>15 °C), then it was considered to be out of the water and hence a mortality. Secondly, ground tracking was conducted opportunistically during the Year 2 capture and receiver deployment sessions. Tag mortalities could be assessed during these sessions.

Statistical analysis

Burbot distribution and biological attributes were assessed by statistically examining the association between Burbot capture (binary response; 0 vs. 1) and several predictor variables (e.g., depth, distance from confluence; see below). Statistics were run in the program JMP® 8.0.

Burbot CPUE is commonly expressed in the number of fish caught per trapset or per unit of time. In year 1 of the study, the distribution of CPUE was examined and found to be highly skewed due to the rarity of multiple captures in a single trap (Figure 8) and high proportion of zero captures. Although it was reported, CPUE was not used for statistical tests (Warnock et al., 2014). In the current analysis, the appropriateness of CPUE was revisited as the primary response variable for statistical tests. Calculation of soak time (*S*) revealed some variation in soak time from the idealized 48 hour trapset, so CPUE was expressed both in per trapset and per trap day (/24 h) standardized metrics. CPUE per trap day is calculated as:

$$CPUE_{day} = \frac{n_{burbot}}{S/24}$$

For the whole 2 year dataset, Burbot CPUE was highly skewed using both per trapset and per trap day metrics (Figure 9). Both arcsine-square root and log transformations did not result in appropriate distributions of residuals for further parametric statistical tests (data not shown) using either CPUE estimate as the response variable.

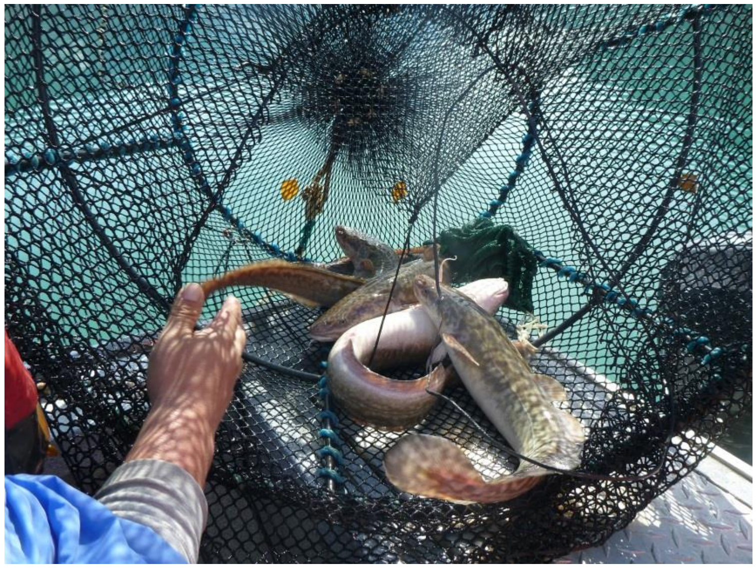


Figure 8: Multiple fish captures in a trapset such as above were relatively rare.

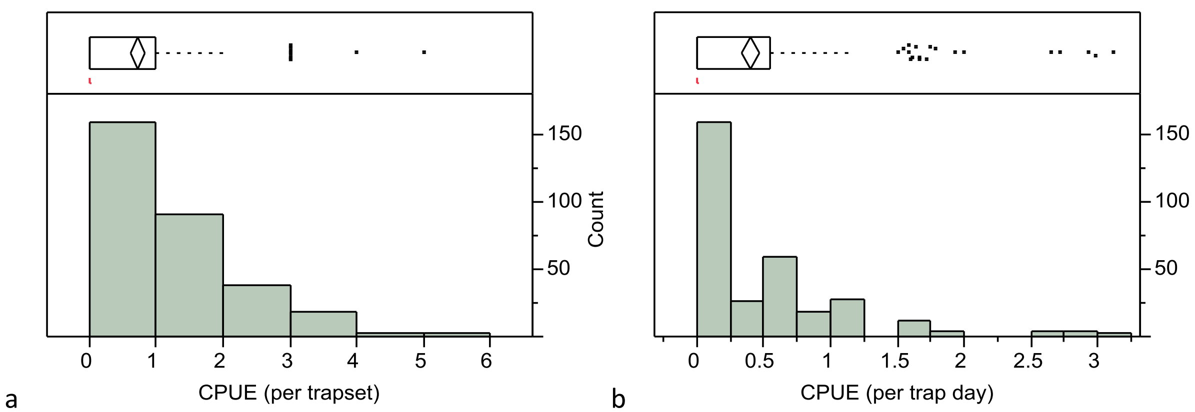


Figure 9: Distribution (histogram and box plot) of CPUE for 303 trapping events in Kinbasket Reservoir in 2014 and 2015 (data pooled), expressed as a) per trapset (CPUEset), or b) per standardized 24 hour trap day (CPUEday). Boxes represent interquartile range, diamonds represent the sample mean and 95% confidence interval, while the middle line in the box is the median sample value. Whiskers represent observations outside of the interquartile range, with outlier data points. The red line indicates the densest 50% of the observations.

Burbot catches were analyzed using Burbot capture as a binary response variable, due to the reasons outlined above of CPUE not being suitable for parametric statistical tests for strong violations of normality assumption. A global general logistic regression model was built, with the intention of determining the relative importance and significance of a suite of variables (year of sampling, reservoir area, distance to nearest confluence, depth) on Burbot capture success. Unfortunately, the fit of the global logistic model was poor, indicating little support for this method of analysis (Chi square goodness of fit; χ^2_{253} = 325.43, *P* = 0.0014). Analyses in year one of the study (Warnock et al., 2014) revealed no relationship between Burbot capture and depth or distance to the nearest confluence, but a significant different in capture success amongst reservoir sampling areas. In the current analysis, we repeat the analysis of the first year of study to determine if capture success varied between reservoir sampling areas in 2015 and in both years of the study. Overall capture success between the two years of study was compared by conducting a Fisher's Exact test on areas of the reservoir that were revisited.

Additional statistical tests were used to determine the effect of variability in soak time on Burbot capture over the two years of study. We did this by first examining the mean soak time, compared to the idealized 48 hour soak time with a t-test. A significant deviation of the observed mean soak time from the idealized 48 hours and deviation would suggest that trap data in this study is not directly comparable to studies in other lakes where 48 h trapsets are employed. We also examined the effect of soak time on $CPUE_{/day}$ for traps that had at least one Burbot by linear regression. Finally, we examined whether the primary binary response variable (Burbot capture success) was dependent on soak time by logistic regression.

A general linear model was constructed to determine whether year of sampling, reservoir sampling area or depth explained variation in Burbot size.

RESULTS

Burbot capture and tagging

Capture was conducted from April 28 to May 10, 2015 with 154-48 h trapsets. Ice-off occurred during the first week of sampling. Ice was sparsely distributed throughout the reservoir during the capture season, thus trapping occurred immediately after ice-off.

Burbot capture summary statistics for the whole study are available in Table 1 and Table 2. Detailed capture data for 2015 can be found in the Appendix 1. In Year 2 of the study, 99 Burbot were caught in 154 trapsets across the 7 sampling areas of the reservoir from April 28 to May 10, 2015. Fifty of these Burbot were surgically implanted with CART tags (see methods). Only one of the 48 Burbot that were tagged in 2014 was recaptured in 2015. This fish (acoustic tag code 31400) was recaptured in the same location as in 2014. Two fish were captured that had acoustic tags surgically implanted in either 2010 or 2011 from a previous study in Kinbasket Reservoir (Harrison et al., 2013). Tagged fish size ranged from 0.84 kg (588 mm) to 3.96 kg (939 mm). No mortalities occurred during the sampling program, and fish surgery was minimally invasive, with quick surgery and recovery times (Appendix 1). Bycatch was minimal, but higher than in 2014, consisting of 29 Mottled (*Cottus bairdi*) and/or Slimy Sculpin (*Cottus cognatus*), 13 Northern Pikeminnow (*Ptychocheilus oregonensis*), 2 Peamouth Chub (*Mylocheilus caurinus*), 2 Redside Shiners (*Richardsonius balteatus*), 1 Rainbow Trout (*Oncorhynchus mykiss*) and 4 Bull trout (*Salvelinus confluentus*). Several sculpins were exceptionally large (Figure 11).

Table 1: Summary statistics of Burbot capture data across all sampling areas of Kinbasket Reservoir for the study.

Reservoir area	Year	N trap-sets	N trap-sets with BB	N BB caught	N BB tagged	Mean $CPUE_{set}$ (fish/ trapset)	S.D. $CPUE_{set}$ (fish/ trapset)	95% CI $CPUE_{set}$ (fish/ trapset)	Mean $CPUE_{day}$ (fish/ 24 h)	S.D. $CPUE_{day}$ (fish/ 24 h)	95% CI $CPUE_{day}$ (fish/ 24 h)
Columbia Reach South	2014	29	13	19	11	0.66	0.86	0.33-0.98	0.34	0.45	0.17-0.51
Columbia Reach North	2014	20	6	11	5	0.55	0.94	0.11-0.99	0.30	0.52	0.05-0.54
Kinbasket River	2014	30	7	11	8	0.37	0.76	0.08-0.65	0.20	0.42	0.04-0.36
Sullivan River	2014	23	16	36	13	1.56	1.44	0.94-2.19	0.89	0.90	0.50-1.28
Wood Arm	2014	47	32	47	11	0.93	0.93	0.14-0.93	0.61	0.69	0.40-0.81
Whole study area	2014	149	74	124	48	0.83	1.05	0.66-1.00	0.48	0.66	0.37-0.58
Columbia Reach South	2015	20	12	15	7	0.75	0.79	0.38-1.11	0.38	0.40	0.19-0.56
Columbia Reach North	2015	12	6	9	1	0.75	0.97	0.13-1.36	0.40	0.51	0.07-0.73
Confluence	2015	7	4	5	3	0.71	0.76	0.02-1.41	0.39	0.41	0.01-0.77
Kinbasket River	2015	22	5	6	6	0.27	0.55	0.03-0.52	0.12	0.23	0.016-0.22
Old Kinbasket Lake	2015	25	10	13	5	0.52	0.71	0.23-0.81	0.27	0.37	0.11-0.42
Sullivan River	2015	47	20	27	15	0.57	0.77	0.35-0.80	0.30	0.41	0.18-0.42
Wood Arm	2015	21	14	24	13	1.1	1.01	0.68-1.60	0.61	0.69	0.30-0.92
Whole study area	2015	154	71	99	50	0.64	0.81	0.51-0.77	0.33	0.45	0.26-0.40
Whole study area	All years	303	145	223	98	0.74	0.94	0.63-0.84	0.4	0.57	0.34-0.47

Table 2: Summary statistics of Burbot capture and individual fish data across all sampling areas of Kinbasket Reservoir for the entire study.

Reservoir area	Year	N	Depth range (m)	Mean depth (m)	S.D. depth (m)	Mean length (mm)	S.D. length (mm)	Mean weight (kg)	S.D. weight (kg)
Columbia Reach South	2014	11	5.6-14.4	10	2.6	720	134	2	0.85
Columbia Reach North	2014	5	9.2-16.5	12.6	1.7	642	126	1.5	0.9
Kinbasket River	2014	8	3.5-14.6	10.2	2.8	674	108	1.6	1
Sullivan River	2014	13	2.2-14.1	7.6	3.6	675	72	1.7	0.44
Wood Arm	2014	11	2.6-15.4	8	3.3	625	103	1.4	0.47
Whole study area	2014	48	2.2-16.5	9.4	3.4	663	106	1.6	0.71
Columbia Reach South	2015	7	10.3-14.8	12.8	1.5	658	133	1.6	0.87
Columbia Reach North	2015	1	9.3-13.7	12.1	1.9	578	82	1.1	0.4
Confluence	2015	3	9.0-10.9	9.9	0.9	568	105	1	0.43
Kinbasket River	2015	6	8.5-18.0	14.7	3.3	774	103	2.2	0.65
Old Kinbasket Lake	2015	5	10.5-14.6	12.4	1.1	650	95	1.4	0.56
Sullivan River	2015	16	4.3-14.7	11.7	2.9	680	121	1.6	0.74
Wood Arm	2015	13	9.1-16.1	12.1	2	667	96	1.5	0.44
Whole study area	2015	51	4.3-18.0	12.2	2.3	660	115	1.5	0.67
Whole study area	All years	99	2.2-18.0	10.3	3.3	663	107	1.6	0.68

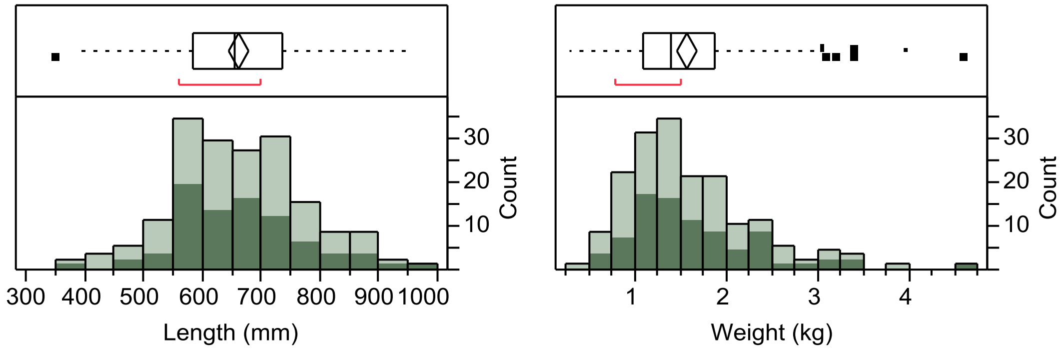


Figure 10: Size (length and weight) distributions and box plots of Burbot (n=175) caught and measured in Kinbasket Reservoir. Dark shaded histogram bar sections are from 2014 data and light shaded sections are from 2015 data. Boxes represent interquartile range, diamonds represent the sample mean and 95% confidence interval, while the middle line in the box is the median sample value. Whiskers represent observations outside of the interquartile range, with outlier data points. The red line indicates the shortest half, which is the densest 50% of the observations.

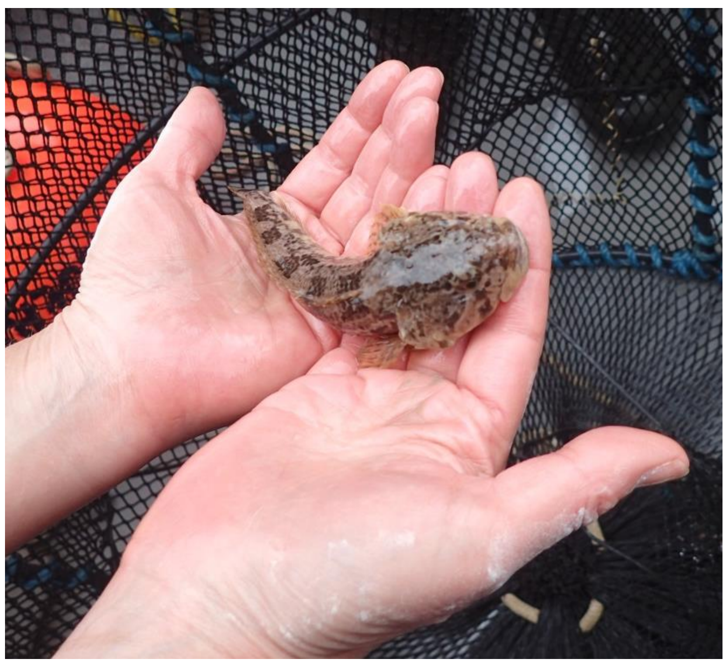


Figure 11: Large sculpin (*Cottus* sp.) bycatch in cod traps.

Two ripe (flowing) males were caught, one in the mouth of Encampment Creek, and the other at the Wood Arm. A single ripe female was caught at the mouth of the Sullivan River. As with capture data in 2014, many fish caught in 2015 had slack bodies, indicating post spawn period.

Burbot capture success was not different between the first and second years of the study in sampling areas that were visited in both years (Fisher's Exact Test; P=0.71, n = 271, df = 1). Burbot capture success did not vary by reservoir area in 2015 (Figure 12), but did vary overall when combining data from the two years of study (Figure 13).

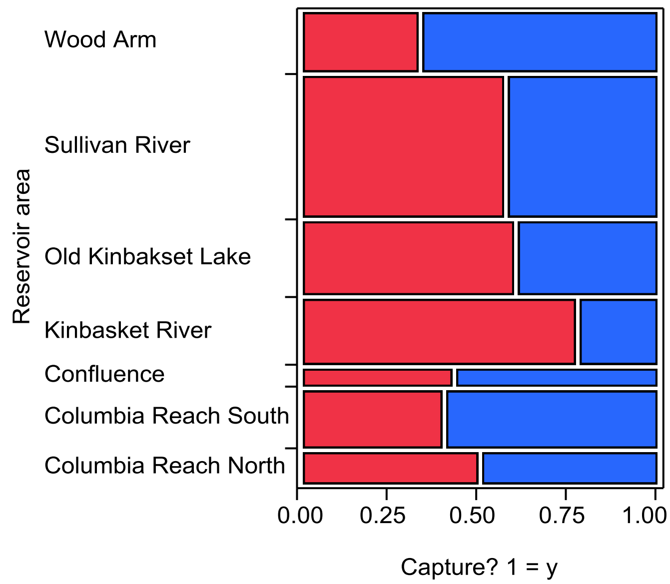


Figure 12: Mosaic plot of Burbot capture success in different areas of the Reservoir for 2015. Blue bars represent the proportion of traps set in a location that captured Burbot while red bars represent the proportion of traps set in a location that did not capture Burbot; the height of the bar corresponds to the total number of sets for the trapping area. Burbot capture did not differ between areas of the reservoir ($\chi 2$ = 11.0 P = 0.089, n = 154, df = 6).

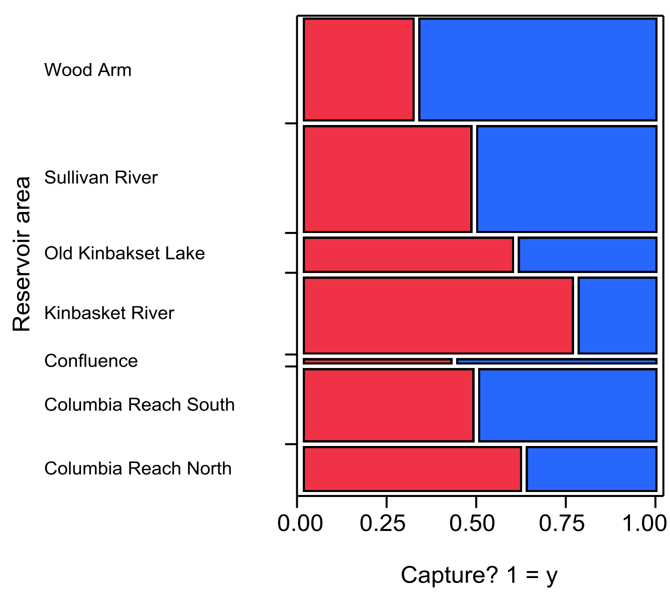


Figure 13: Mosaic plot of Burbot capture success in different areas of the Reservoir, combining data from 2014 and 2015. Blue bars represent the proportion of traps set in a location that captured Burbot while red bars represent the proportion of traps set in a location that did not capture Burbot; the height of the bar corresponds to the total number of sets for the trapping area. Burbot capture differed among areas of the reservoir ($\chi 2$ = 26.26 P = 0.0002, n = 303, df = 6).

Soak time varied throughout the entire study, but most soak times were close to the target 48 h trapset length (Figure 14), and the mean soak time (47.5 h) was not significantly different than the idealized 48 h length (one sample t-test; t_{302}= -0.71; p=0.48). Soak time did not vary by reservoir area (ANOVA; $F_{6, 296}$ = 1.22, P = 0.30). Soak time was significantly correlated with $CPUE_{day}$ for capture events where at least one Burbot was present in the trap (Figure 15); the negative slope of the relationship suggested that $CPUE_{day}$ declines with increasing soak times. In contrast, the probability of capturing at least one Burbot was not correlated with soak time (Logistic Regression; $\chi^2 = 1.08$, $P = 0.30$).

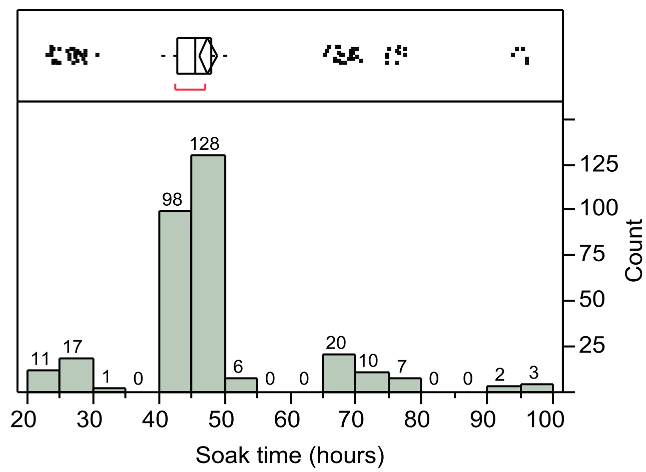


Figure 14: Distribution (histogram and box plot) of soak times for 303 trapping events in Kinbasket Reservoir during the study period. Numbers above histogram bars represent the total count for the bin. Boxes represent interquartile range, diamonds represent the sample mean and 95% confidence interval, while the middle line in the box is the median sample value. Whiskers represent observations outside of the interquartile range, with outlier data points. The red line indicates the shortest half, which is the densest 50% of the observations.

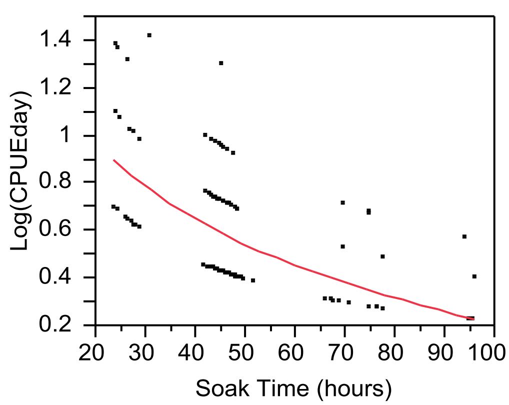


Figure 15: Relationship between $CPUE_{day}$ and soak time ($R^2 = 0.31$) for traps that successfully captured at least one Burbot. Regression (red line; Log $CPUE_{day} = 2.41 - 0.477$*Log soak time) was significant ($F_{1,143} = 64.6$, $P < 0.0001$).

A general linear model was constructed to predict log-transformed Burbot size (weight) using covariates of depth, reservoir area, year and depth*year and depth*reservoir area interaction terms, since depths sampled in 2015 were deeper than those sampled in 2014 (2-tailed t-test; $t_{205}=7.8$; $P < 0.0001$), and depths sampled tended to vary among sampling areas. The global model revealed a weak but significant relationship ($R^2 = 0.17$; $F_{15,158} = 2.21$; $P = 0.008$). Interaction terms were not significant and removed from further analysis. Further effect tests revealed a difference in fish size among years ($P = 0.046$) and reservoir sampling area ($P = 0.017$), but depth was not significant predictor of Burbot size ($P = 0.10$).

Mobile and fixed receiver tracking

This report summarizes information collected from Burbot captured in Spring 2014/2015 and tracking information collected from fixed (11 of 16 recovered that were deployed in 2014) and mobile receivers (flights conducted 2015).

Fixed acoustic tracking

There was a month-long gap in monitoring information between the time of tagging and receiver deployment (May 8 to June 1, 2014). A second period of data gap was discovered when receiver data download indicated that the battery of receivers did not last the full length of the intended monitoring period of one year. Table 3 presents the start and end dates of data recording. Monitoring for Receiver #6 ended as early as Nov. 4, 2014, while Receiver 8, lasted until Apr. 3, 2015. Unfortunately, the majority of batteries failed during the critical spawning period (January to April). Receivers were reprogrammed to save battery life when they were redeployed for monitoring in 2015.

Table 3: Summary of monitoring period of fixed acoustic receivers installed in Kinbasket Reservoir. Data were downloaded May 11-12, 2015.

Receiver ID	Start of Monitoring	End of Monitoring	Number of Detections
1	03-Jun-14	06-Feb-15	4649
3	02-Jun-14	03-Mar-15	105
4	03-Jun-14	16-Feb-15	6202
5	05-Jun-14	30-Mar-15	49071
6	03-Jun-14	04-Nov-14	33677
8	04-Jun-14	03-Apr-15	3394
9	04-Jun-14	16-Feb-15	630
10	05-Jun-14	26-Mar-15	1238
12	05-Jun-14	12-Feb-15	66858
13	02-Jun-14	03-Feb-15	1509
15	02-Jun-14	05-Feb-15	1231

Range tests conducted after receiver installation with a test tag indicated detection efficiency was high. Receivers detected the test tags during all drifts conducted between 100 and 750 m from receivers at a range of depths. Receivers also detected near-by receivers in narrowings where the reservoir was gated, indicating that these areas had excellent coverage to detect movement of burbot between reservoir areas.

Of 48 Burbot tagged in 2014, 39 were detected by acoustic receivers. Appendix 2 presents the movement of tagged Burbot through Kinbasket Reservoir as detected by the 11 receivers, as well as radio tracking. Table 4 summarizes depth statistics and acoustic receivers that detected each Burbot.

Table 4: Summary of acoustic receiver detection and depth statistics for Burbot (n = 39) in Kinbasket Reservoir.

Acoustic Code	Radio Code	Frequency	Length (mm)	Weight (kg)	Capture Location	Receivers	Mean Depth (m)	SD Depth (m)	Min Depth (m)	Max Depth (m)
29500	1	150.25	742	1.6	Wood Arm	5, 6, 12	24.4	6.67	3	41
29600	2	150.25	715	2.0	Wood Arm	1, 3, 4, 5, 8, 9, 10, 12, 13, 15	21.1	10.84	4	49
29700	3	150.25	705	1.7	Wood Arm	5, 12	21.4	4.27	11	29
29800	4	150.25	770	2.4	Wood Arm	1, 3, 4, 5, 8, 9, 10, 12, 13, 15	21.1	8.34	3	49
29900	5	150.25	904	3.4	Goosegrass Creek (across from Cummins River)	5, 9, 10, 12, 13, 15	17.6	5.32	0	32
30000	6	150.25	810	2.4	Surprise Rapids	4	27.0		27	27
30100	7	150.25	795	2.5	Wood Arm	5, 12	21.4	7.59	6	40
30200	8	150.25	642	1.5	Goosegrass Creek (across from Cummins River)	13, 15	9.1	5.53	2	39
30300	9	150.25	720	1.8	Kinbasket River	1, 4	13.2	1.12	12	17
30400	10	150.25	668	1.6	Kinbasket River	1, 4, 6	13.0	2.33	7	24
30500	11	150.25	735	2.0	Sullivan River	1, 4, 15	23.8	4.51	8	49
30600	12	150.25	655	1.5	Kinbasket River	1, 4, 5, 6, 12	16.9	7.16	0	49
30700	13	150.25	742	1.8	Sullivan River	1, 4, 6	18.1	2.39	4	24
30800	14	150.25	695	1.8	Sullivan River	1, 4, 6	16.8	1.58	10	20
30900	15	150.25	768	2.4	Sullivan River	1, 4, 8	36.9	9.43	17	49
31100	17	150.25	950	4.6	Kinbasket River	1, 4, 6	17.8	6.70	0	43
31200	18	150.25	710	1.9	Kinbasket River	1, 4, 6	17.5	6.74	1	45
31300	19	150.25	731	2.1	Sullivan River	1, 4, 6	26.2	13.01	4	49
31400	20	150.25	744	2.1	Sullivan River	1, 4, 8	23.2	6.93	8	49
31500	21	150.25	678	1.8	Sullivan River	1, 4, 8, 13, 15	19.5	5.21	4	39
31700	23	150.25	674	1.6	Sullivan River	8, 13, 15	13.6	1.70	9	19
31800	24	150.25	692	1.5	Double Eddy Creek (downstream from Surprise	8	48.7	1.44	40	49

					Rapids)					
32500	5	150.3	747	1.8	Wood Arm	5, 10, 12	19.7	4.49	3	36
32600	6	150.3	660	1.5	Wood Arm	5, 9, 10, 12	15.5	3.86	4	39
33000	10	150.3	810	2.7	Goosegrass Creek (across from Cummins River)	1, 4, 6, 8, 13, 15	26.2	13.85	0	49
33100	11	150.3		1.1	Kinbasket River	6	16.9	3.50	6	25
33200	12	150.3	647	1.4	Sullivan River	1, 4, 6	22.8	4.34	17	36
33300	13	150.3	653	1.3	Sullivan River	1, 4, 6	21.1	6.26	9	49
33400	14	150.3	570	1.0	Wood Arm	5, 6, 9, 10, 12	21.3	10.28	6	49
33500	15	150.3	656	1.2	Wood Arm	1, 4, 8, 9, 10, 13, 15	20.9	7.95	10	49
33600	16	150.3	574	1.1	Double Eddy Creek (downstream from Surprise Rapids)	8	29.5	5.99	14	49
33900	19	150.3	620	1.3	Surprise Rapids	8	30.3	3.94	25	45
34000	20	150.3	665	1.4	Sullivan River	1, 4	16.9	4.29	9	23
34100	21	150.3	685	1.3	Cummins River	13, 15	14.6	9.37	0	34
34200	22	150.3	683	1.4	Wood Arm	3, 5, 9, 12	18.2	5.87	5	30
34300	23	150.3	642	1.4	Wood Arm	5, 12	19.0	5.14	8	37
34400	24	150.3	592	1.0	Kinbasket River	6	16.6	6.79	0	47
34500	25	150.3	592	0.9	Cummins River	15	26.0		26	26
34600	1	150.3	723	1.9	Sullivan River	6	41.0		41	41

Figure 16 displays the distribution of depths occupied by tagged Burbot throughout the Kinbasket Reservoir. Mean depth was 20.5 ±7.88 m while most Burbot were distributed in the depth range of 15.0 to 25.0 m.

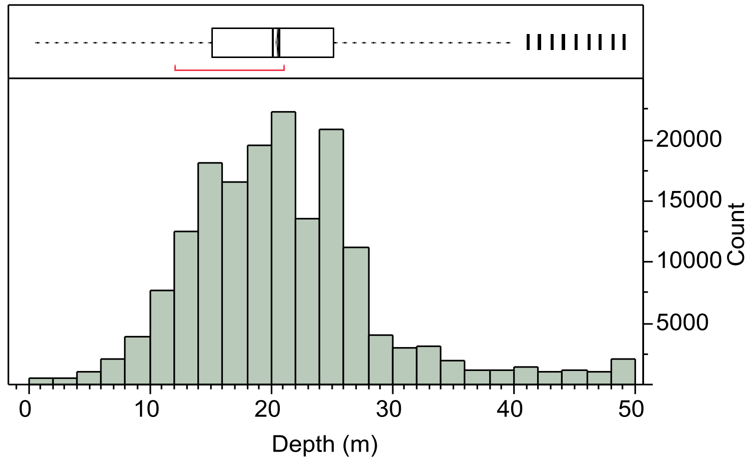
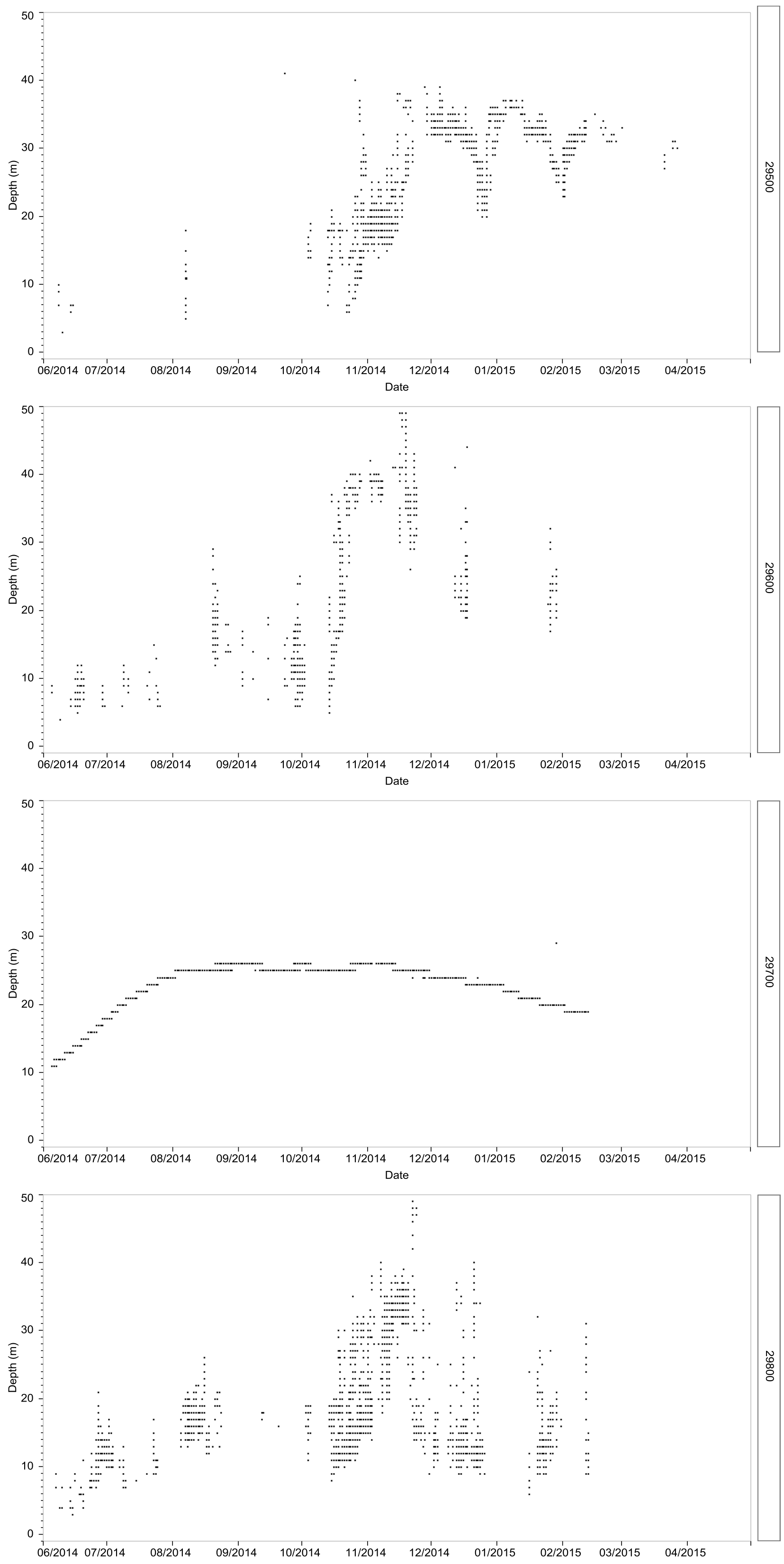


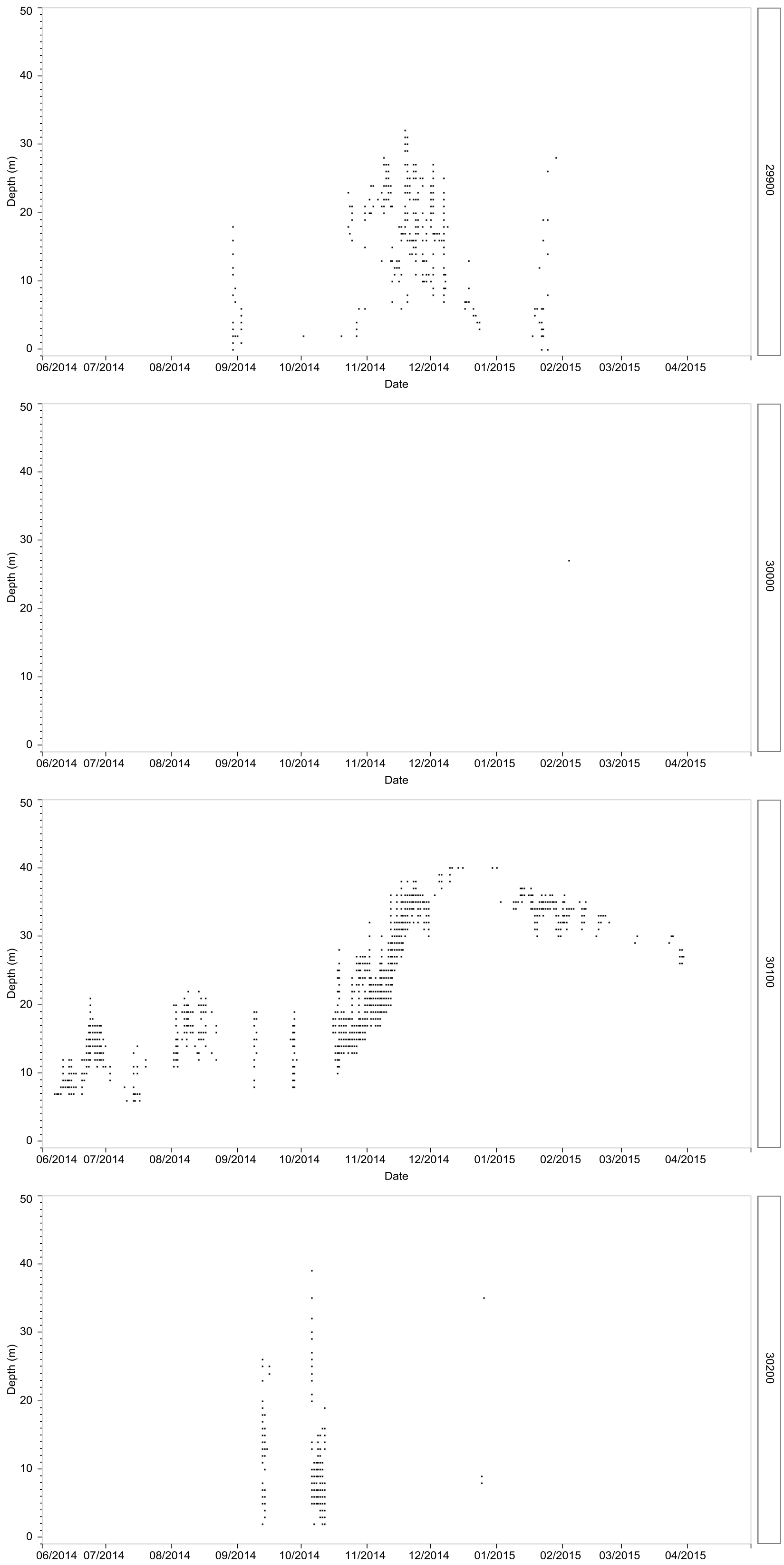
Figure 16: Distribution (histogram and box plot) of depth (m) for Burbot detected by acoustic tracking (n = 39) in Kinbasket Reservoir during Year 1 (2014-2015). Boxes represent interquartile range, diamonds represent the sample mean and 95% confidence interval, while the middle line in the box is the median sample value. Whiskers represent observations outside of the interquartile range, with outlier data points. The red line indicates the densest 50% of the observations.

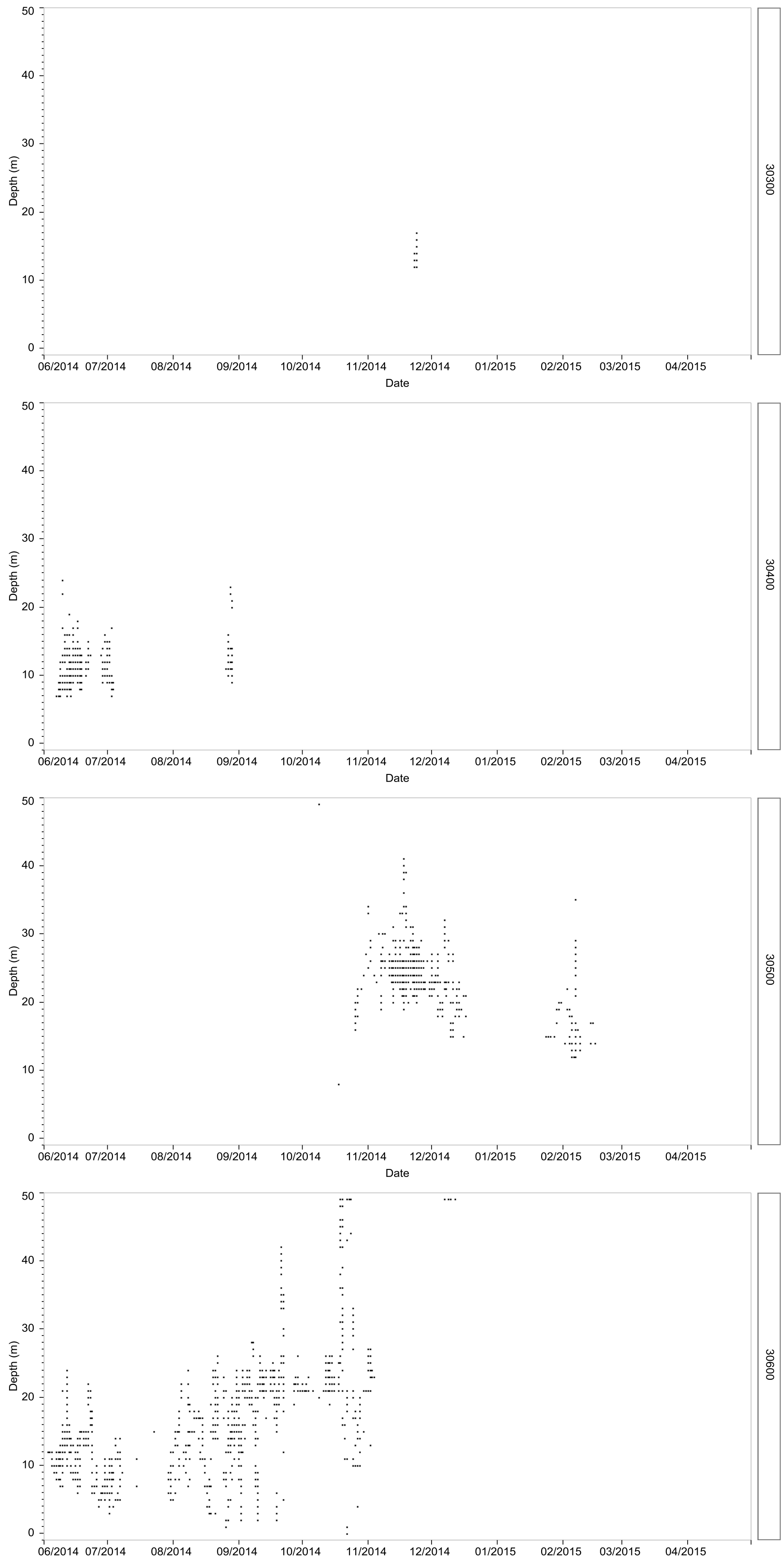
Most movement detections occurred near the location of capture (Appendix 2) with most detections occurring at receivers 5 (29%) and 12 (40%) in Wood Arm, as well as receiver 6 (20%) at the mouth of Kinbasket River. These locations also correspond to the locations of capture of 46% of the detected Burbot. Although some Burbot remained close to their location of capture, indicating sedentary behaviour, others were more active and exhibited movement throughout the study area (i.e., Burbot with acoustic codes 29500, 29600, 29800, 29900, 30600, 31500, 31700, 33000, 33400, 33500, 34200). Additionally, some Burbot (i.e., 29500, 30500, 30600) passed receivers without detection, suggesting that they either passed at depths out of the range of receivers or too quickly for receivers to detect them.

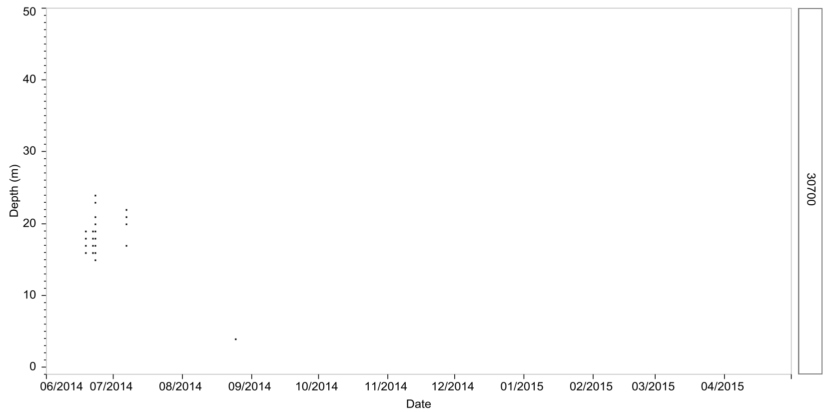
Figure 17 presents depth profiles of each fish over the monitoring period. The depth profiles illustrate the variability in movements among Burbot, with individuals occupying a range of depths. However, some general trends are apparent such as movement from shallow to deeper areas from June to December and subsequent movement to shallower depths from January to April. Diel vertical migration (DVM) is also illustrated by the vertical pattern of multiple points within a day (Figure 17). More detail of DVM is provided when focusing on the depth movement of Burbot with acoustic code 29800 over the course of a day (Figure 18). Some individuals appeared to move into areas deeper than the receiver range limit of 50 m, as illustrated by numerous data points along the 50 m mark (i.e., Burbot with acoustic codes 30900, 31300, 31800, 33400, 33500, 33600; Figure 19). The Burbot with acoustic code 31800 occupied particularly deep areas (40 - 49 m) for most of the monitoring period until Dec. 19, 2014.

Detections of the Burbot with acoustic code 29700 suggest that the individual was either dead or had expelled the tag given the pattern of detections at the same depth over a number of days with changes in depth likely corresponding with changes in reservoir elevations.

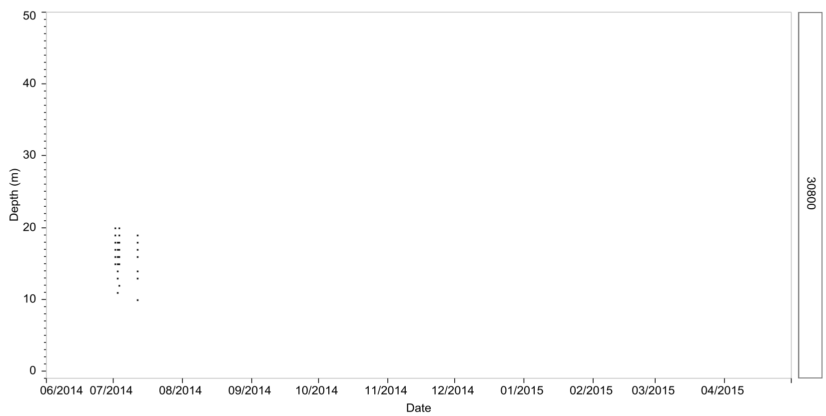

Depth (m)
0
10
20
30
40
50
06/2014 07/2014 08/2014 09/2014 10/2014 11/2014 12/2014 01/2015 02/2015 03/2015 04/2015
Date
29500
29600
29700
29800


Depth (m)
Date
06/2014 07/2014 08/2014 09/2014 10/2014 11/2014 12/2014 01/2015 02/2015 03/2015 04/2015
0
10
20
30
40
50
29900
30000
30100
30200

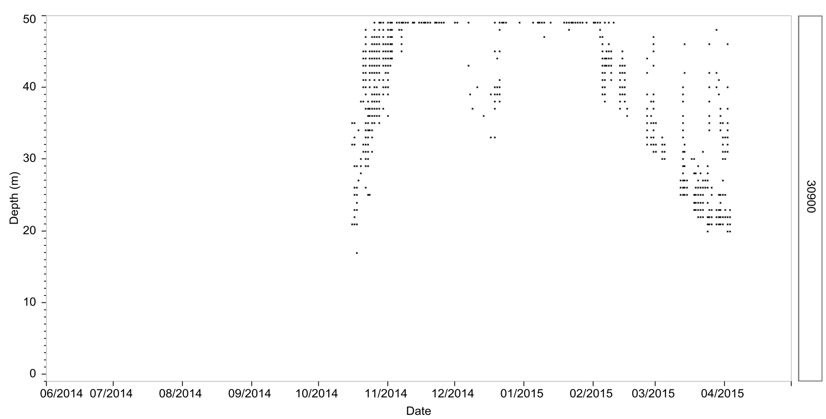

30300
30400
30500
30600
Depth (m)
Date
06/2014
07/2014
08/2014
09/2014
10/2014
11/2014
12/2014
01/2015
02/2015
03/2015
04/2015



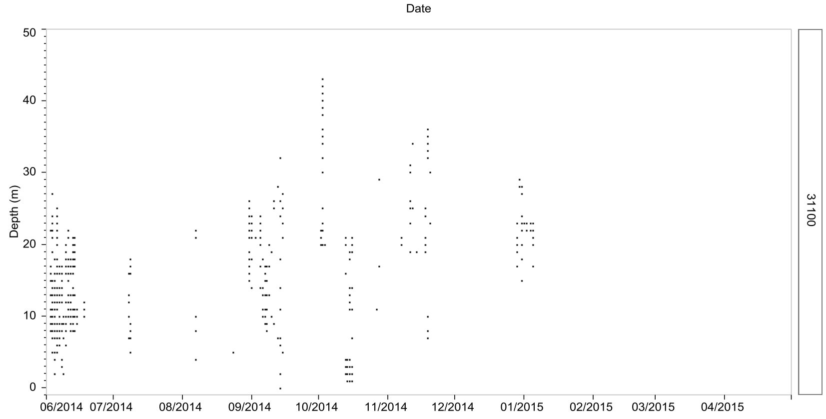
Depth (m)
Date
06/2014 07/2014 08/2014 09/2014 10/2014 11/2014 12/2014 01/2015 02/2015 03/2015 04/2015
30700



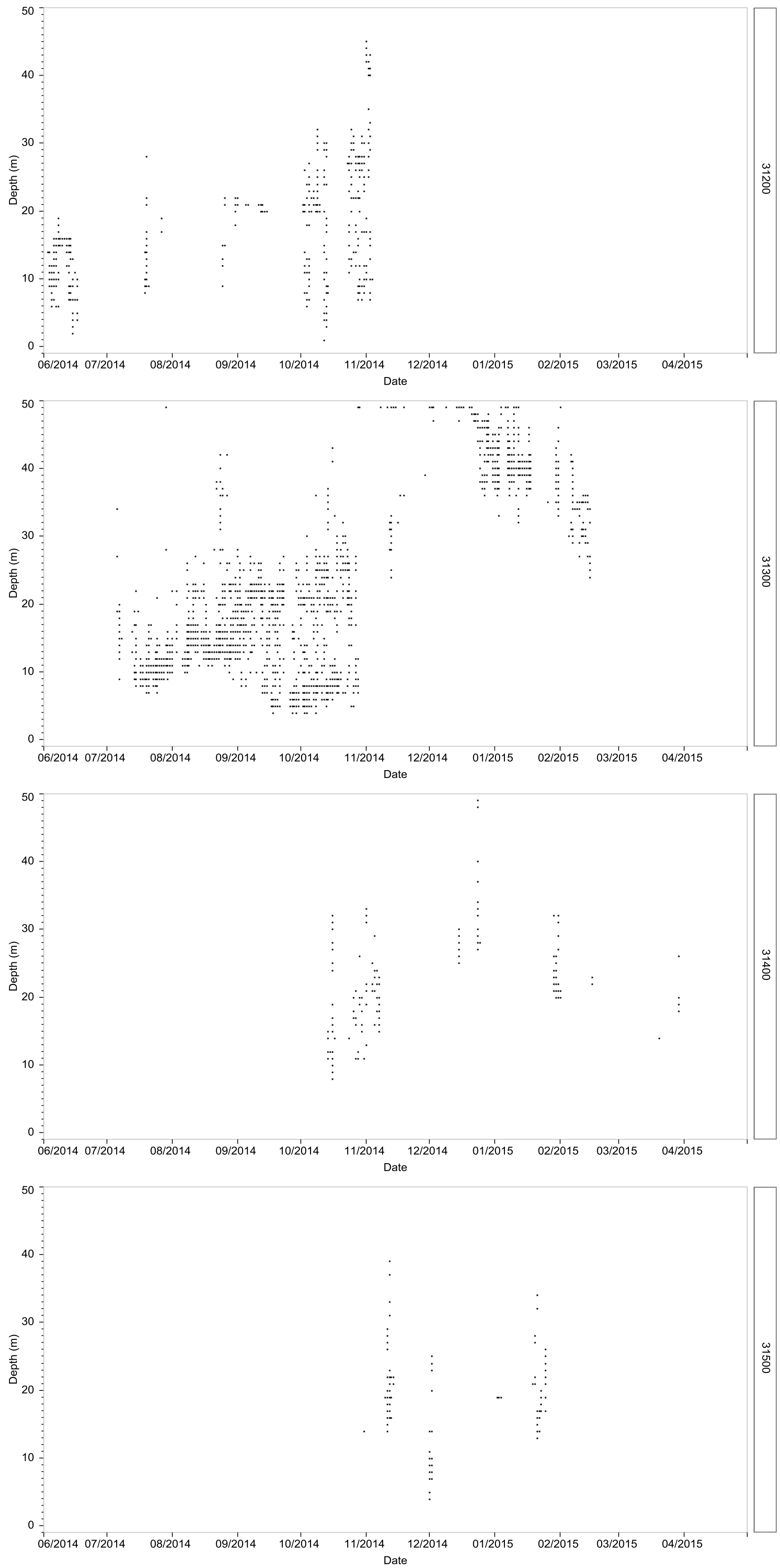
Depth (m)
Date
06/2014 07/2014 08/2014 09/2014 10/2014 11/2014 12/2014 01/2015 02/2015 03/2015 04/2015
30800

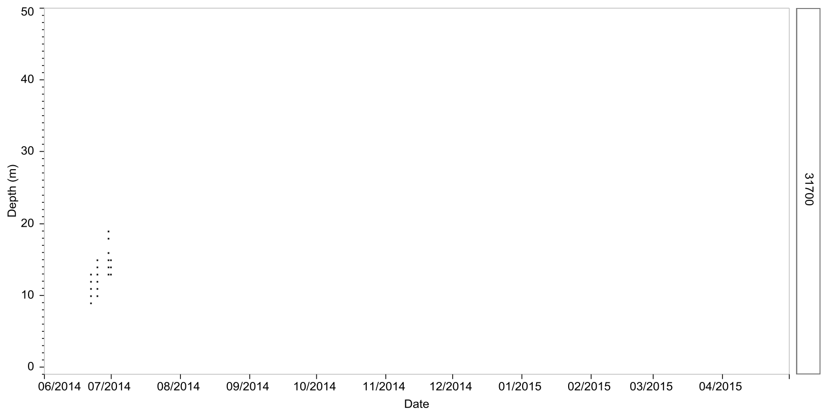


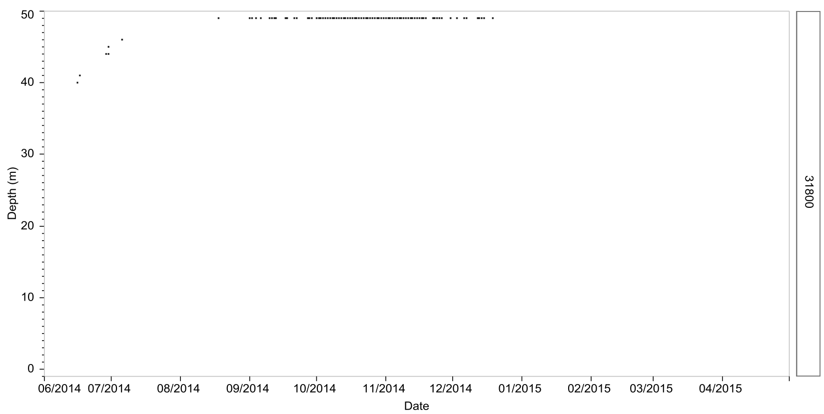
Depth (m)
Date
06/2014 07/2014 08/2014 09/2014 10/2014 11/2014 12/2014 01/2015 02/2015 03/2015 04/2015
30900

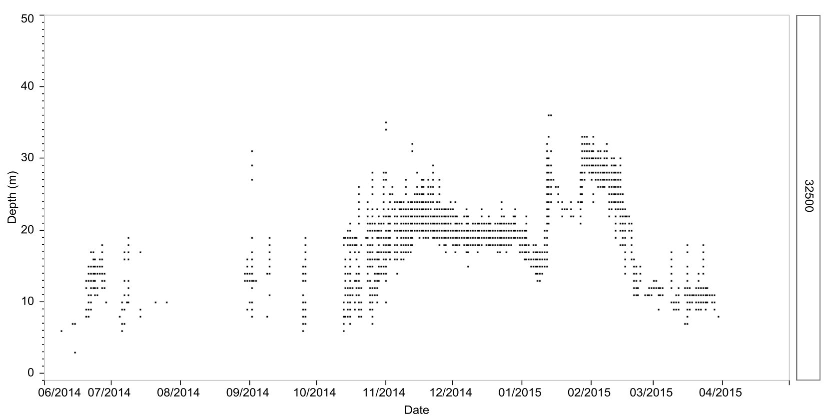


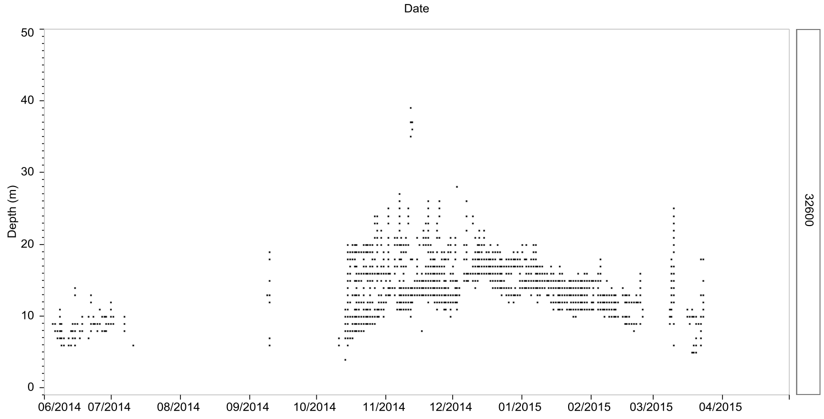
Depth (m)
Date
06/2014 07/2014 08/2014 09/2014 10/2014 11/2014 12/2014 01/2015 02/2015 03/2015 04/2015
31100

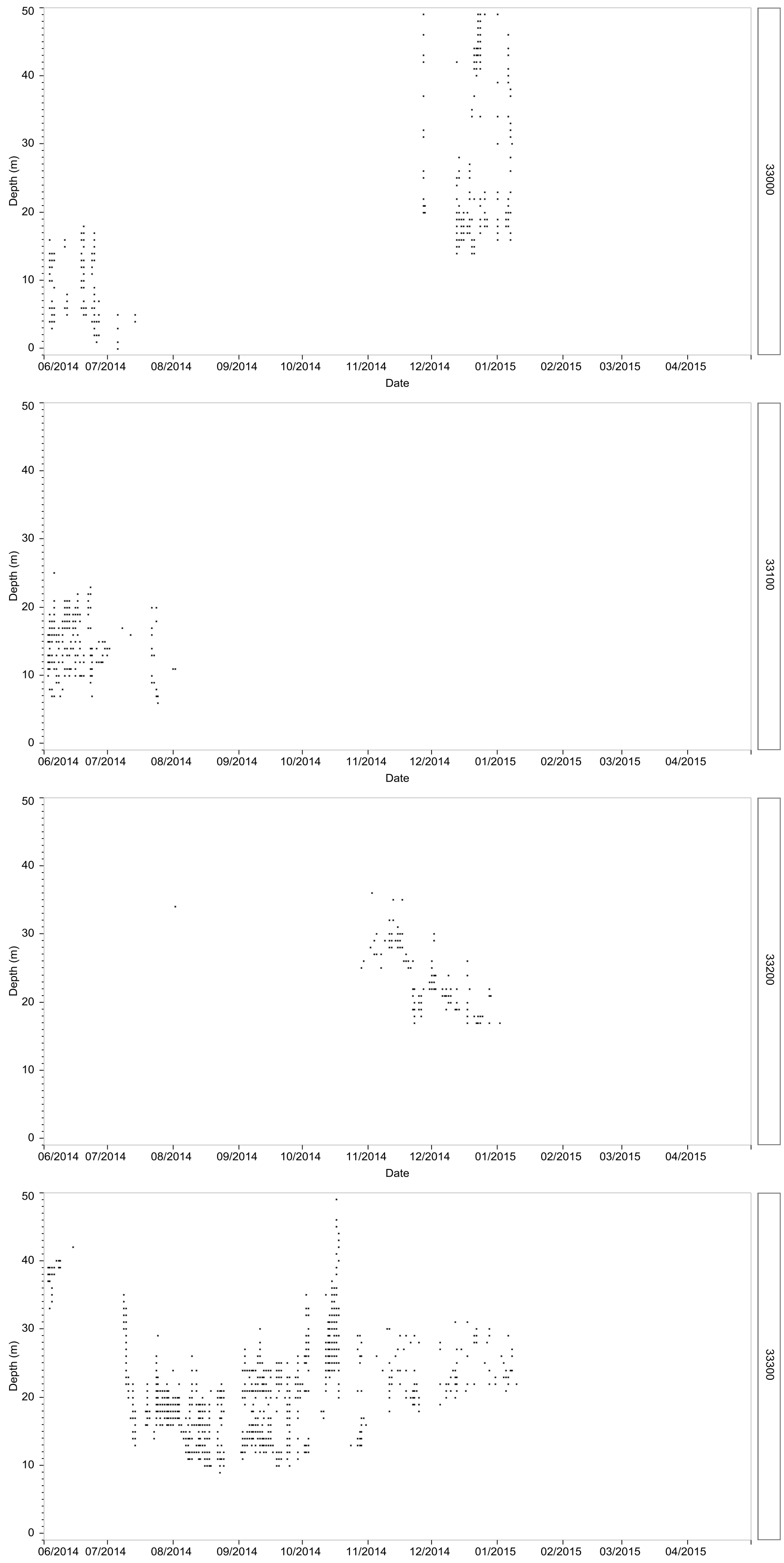

31200
31300
31400
31500
Depth (m)
0
10
20
30
40
50
Date
06/2014 07/2014 08/2014 09/2014 10/2014 11/2014 12/2014 01/2015 02/2015 03/2015 04/2015

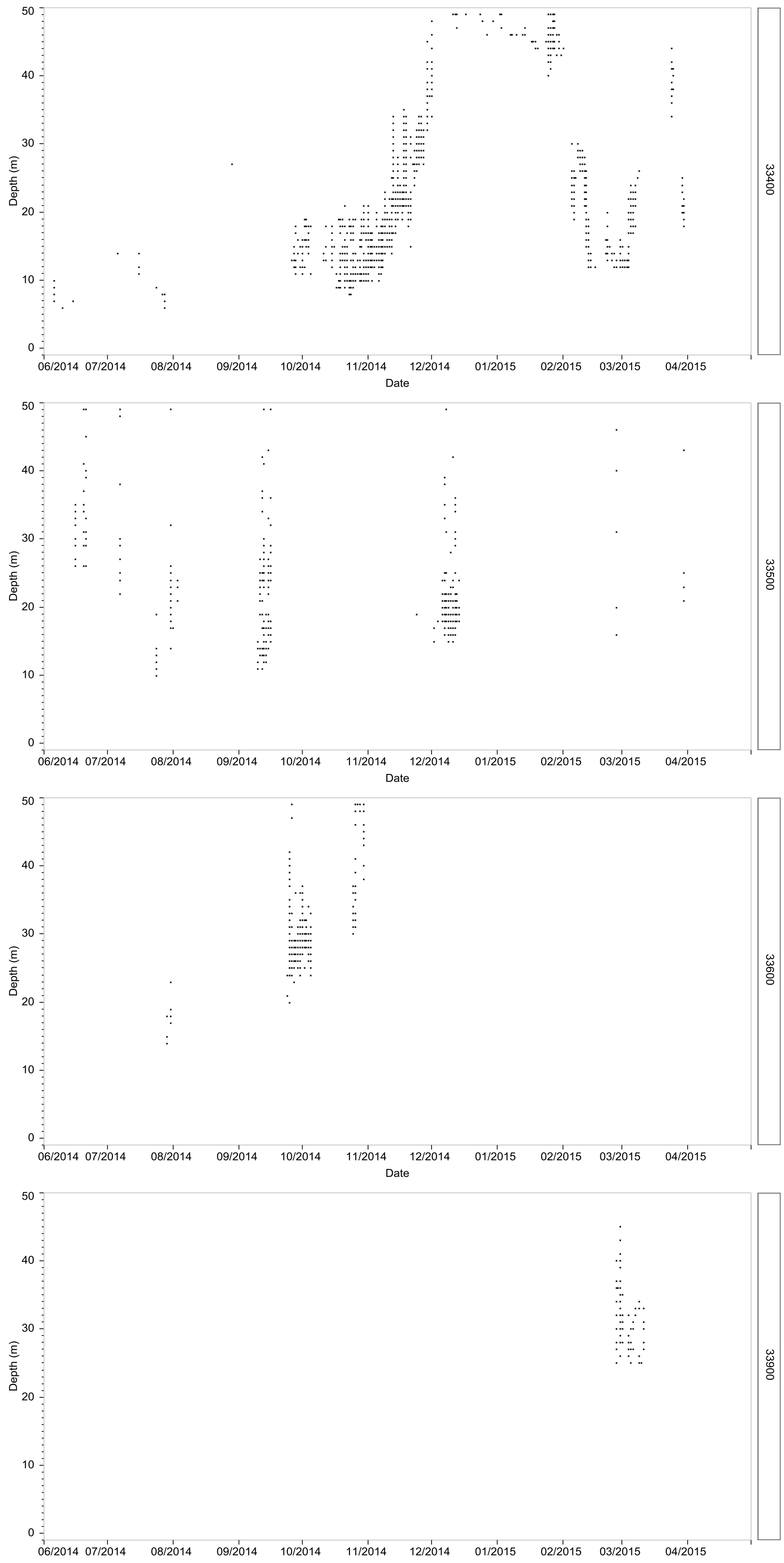

50
40
30
20
10
0
Depth (m)
06/2014 07/2014 08/2014 09/2014 10/2014 11/2014 12/2014 01/2015 02/2015 03/2015 04/2015
Date
31700

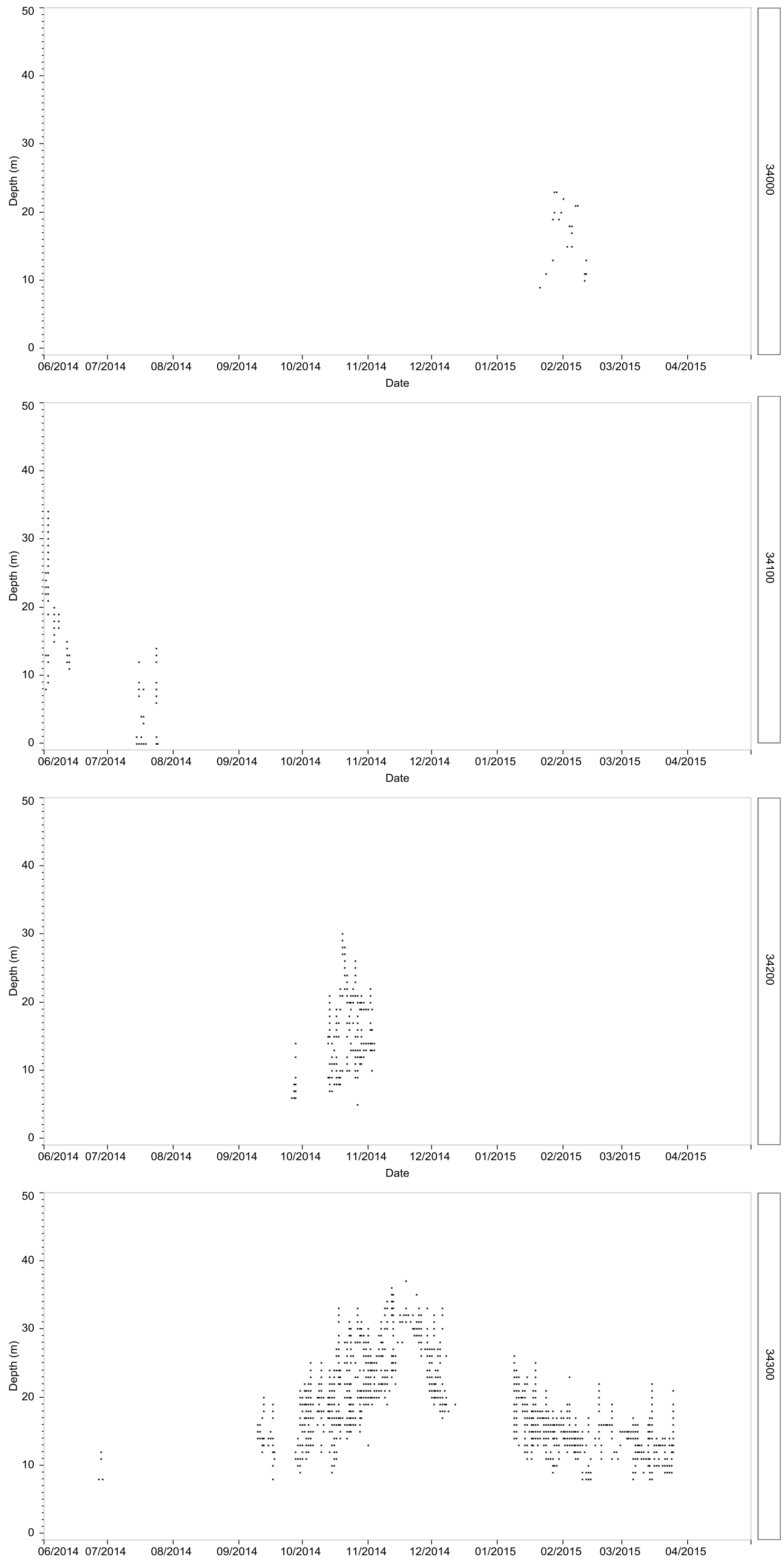

50
40
30
20
10
0
Depth (m)
06/2014 07/2014 08/2014 09/2014 10/2014 11/2014 12/2014 01/2015 02/2015 03/2015 04/2015
Date
31800


50
40
30
20
10
0
Depth (m)
06/2014 07/2014 08/2014 09/2014 10/2014 11/2014 12/2014 01/2015 02/2015 03/2015 04/2015
Date
32500


50
40
30
20
10
0
Depth (m)
06/2014 07/2014 08/2014 09/2014 10/2014 11/2014 12/2014 01/2015 02/2015 03/2015 04/2015
Date
32600


Depth (m)
Date
06/2014 07/2014 08/2014 09/2014 10/2014 11/2014 12/2014 01/2015 02/2015 03/2015 04/2015
33000
33100
33200
33300


Depth (m)
Date
06/2014 07/2014 08/2014 09/2014 10/2014 11/2014 12/2014 01/2015 02/2015 03/2015 04/2015
33400
33500
33600
33900


Depth (m)
Date
06/2014 07/2014 08/2014 09/2014 10/2014 11/2014 12/2014 01/2015 02/2015 03/2015 04/2015
34000
34100
34200
34300

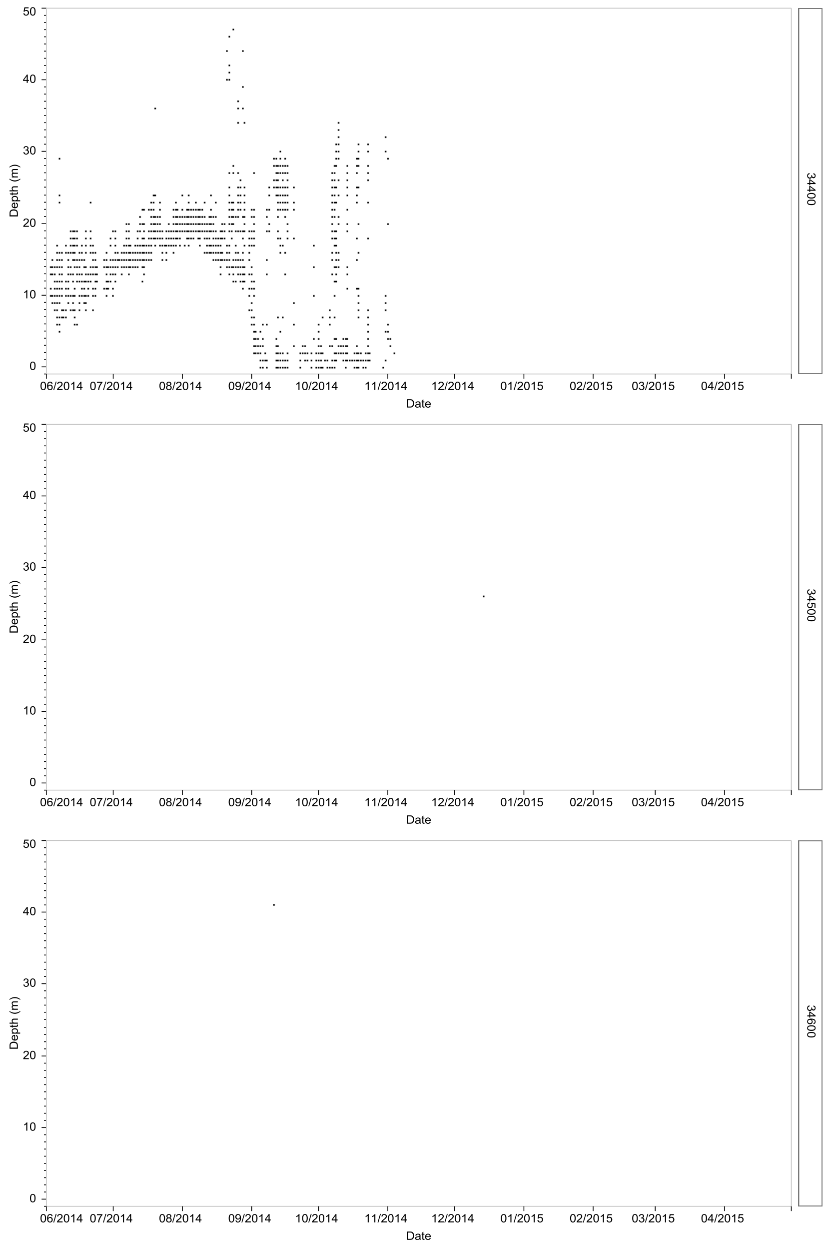


Figure 17: Mean daily depths of each Burbot during the monitoring period (June 2014 to March 2015) in Kinbasket Reservoir.

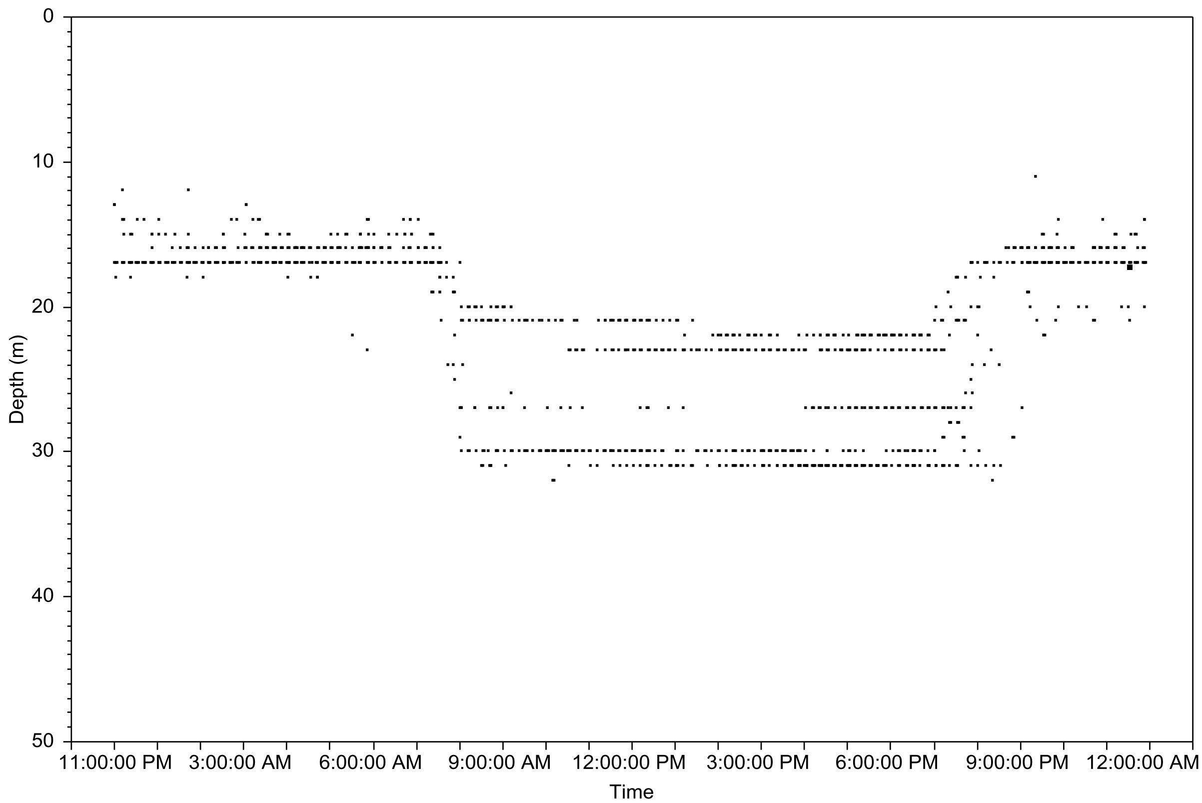


Figure 18: Detail of depth movement by Burbot with acoustic code 29800 over 24 hours (Oct. 26, 2014).

There were significant differences in depths occupied by Burbot throughout the monitoring period (June 2014 to March 2015; Figure 19; ANOVA: $F_{10, 198} = 3.86$, $p < 0.0001$). Tukey post-hoc tests indicated that depths during November (mean ± SE = 25.36 ± 1.962 m) and December (mean ± SE = 27.77 ± 2.042 m) were significantly greater than depths during June (mean ± SE = 15.52 ± 2.133 m; p< 0.05 and p< 0.0005, respectively) and July (mean ± SE = 14.45 ± 2.086 m; p<0.01 and p<0.005, respectively). As well, July depths were significantly greater than depths during January (mean ± SE = 24.55 ± 2.237 m; p< 0.05). These trends are consistent with movement from shallow areas at the end of the spawning period to deeper areas during fall-winter and subsequent movement to shallow areas during the next spawning period. There was a lack of data from November 2014 to April 2015 due to battery failure.

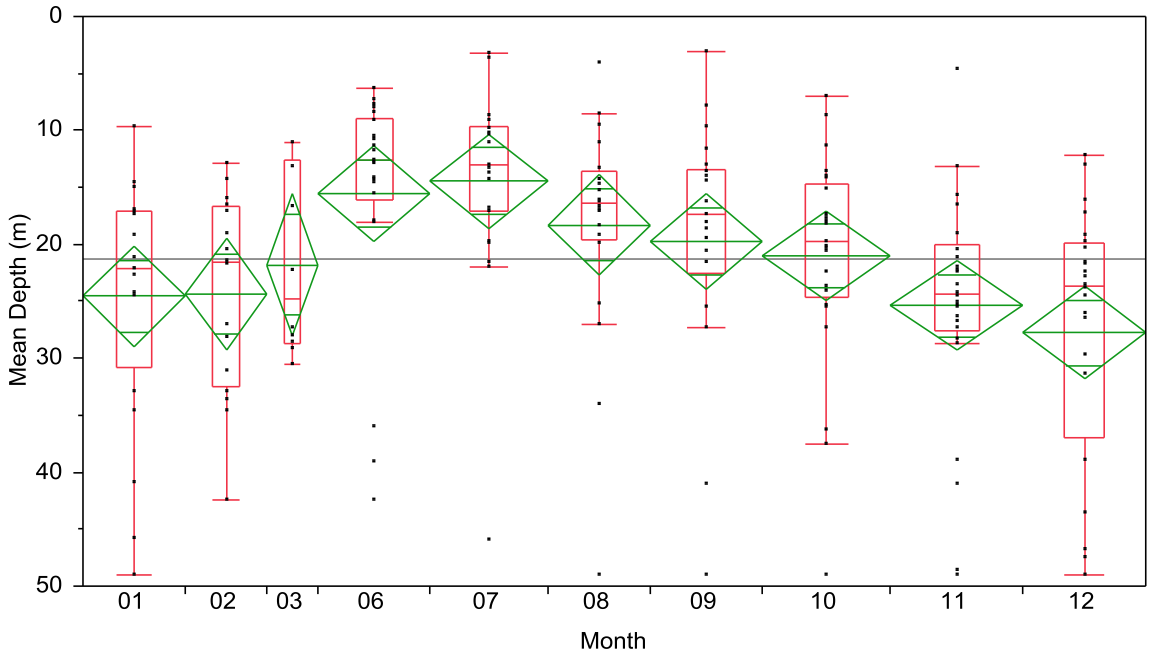


Figure 19: Mean daily depth (m) of all Burbot detected for each month of the year. Boxes represent interquartile range with the middle line representing the median sample value. Diamonds represent the 95% confidence interval with the middle line representing the mean. Whiskers represent observations outside of the interquartile range, with outlier data points. Data from June ('06') 2014 to March ('03') 2015.

Mobile tracking

Mobile tracking flights by helicopter were conducted on Feb.2, Mar. 6, 22, Apr. 2, 18, 2015. The flight path for mobile tracking is illustrated in Figure 20. Additional tracking by mobile receiver were conducted opportunistically during Burbot capture and receiver re-/deployment events. A total of seventeen Burbot were tracked by radio of which 4 Burbot have been confirmed or suspected to be dead (see 'Burbot Mortality' section). The 13 live Burbot tracked by radio did not meet an imposed quota of 15 Burbot detections to continue radio tracking methods in 2016. Hence, an alternative methodology was initiated to concentrate more effort on fixed acoustic array tracking and discontinue radio tracking. Fourteen additional receivers were deployed from July 21 -25, 2015 to collect tracking data for 2015-2016 that will be incorporated into the Year 3 report.

The locations of the Burbot detected by radio tracking are presented in Flight path included Columbia River from headwaters at Columbia Lake to Kinbasket Reservoir.

Table 5 and Appendix 2. The highest number of Burbot detected by radio tracking was on March 22, 2015 (n=12), indicating the possible peak time of the shallow habitat use. Interestingly, although the radio tracking flight path included the entire Columbia River from the headwaters at Columbia Lake, we did not detect any fish at the Columbia Reach towards Golden, or at the main confluence areas of the reservoir (see 'Discussion and Recommendations' section). Appendix 3 presents the temperature data for radio tracked Burbot. Appendix 4 presents the depth data for radio tracked Burbot.

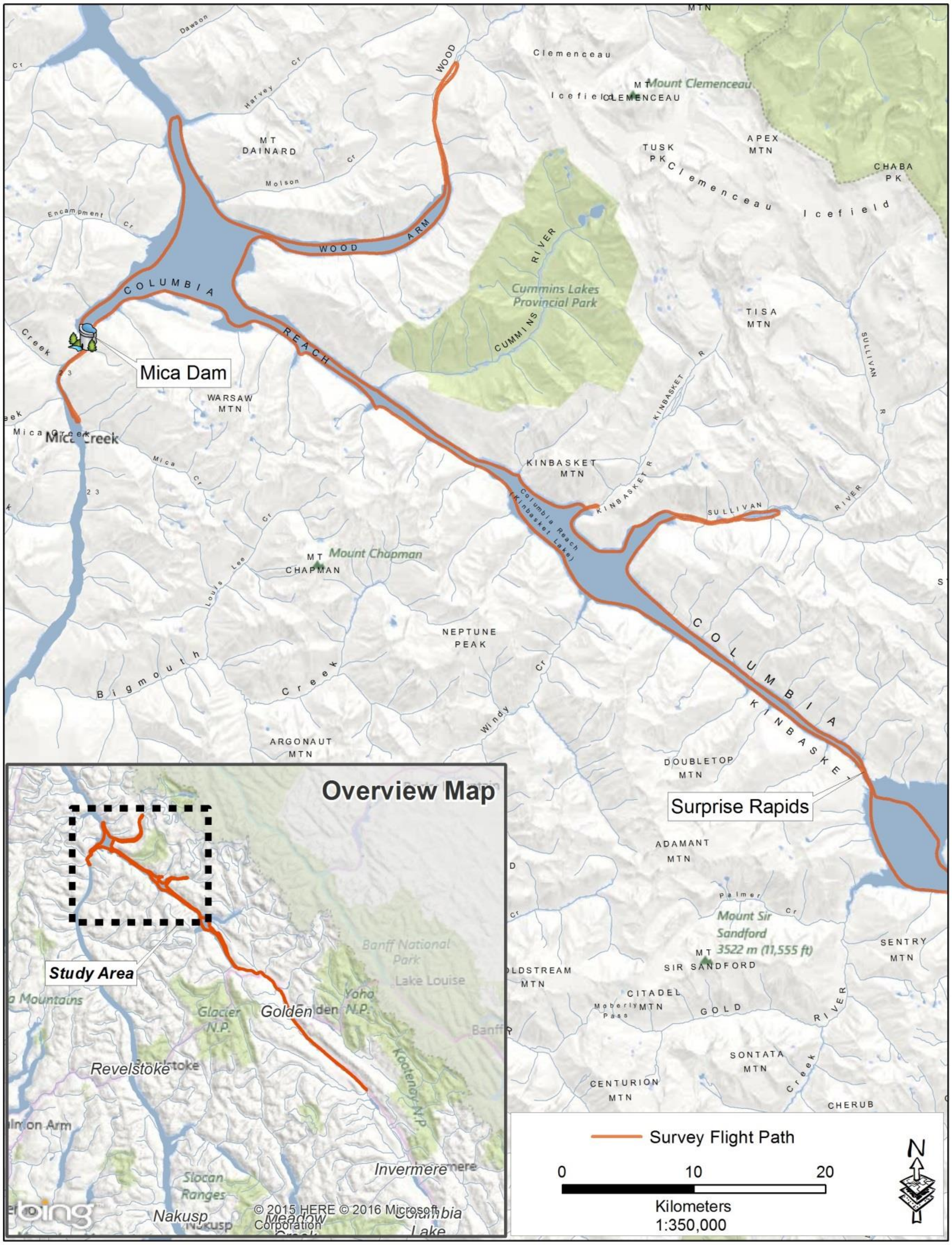


Figure 20: Mobile tracking flight path for study. Flight path included Columbia River from headwaters at Columbia Lake to Kinbasket Reservoir.

Table 5: Summary of locations of Burbot detected by radio tracking in Kinbasket Reservoir in 2015.

Date	n Burbot	Acoustic Codes	Radio Codes	Channel	Frequency	Location
02-Feb-15	4	30400	10	1	150.25	Kinbasket River
		30700	13	1	150.25	Kinbasket River
		33100	11	2	150.3	Kinbasket River
		34100	21	2	150.3	Bobcat Creek
06-Mar-15	9	30400	10	1	150.25	Kinbasket River
		30700	13	1	150.25	Kinbasket River
		31000	16	1	150.25	Sullivan River
		31600	22	1	150.25	Sullivan River
		31700	23	1	150.25	Cummins River
		32200	2	2	150.3	Smith Creek
		32400	4	2	150.3	U/s Surprise Rapids
		33100	11	2	150.3	Kinbasket River
		34100	21	2	150.3	Bobcat Creek
22-Mar-15	12	30200	8	1	150.25	Kinbasket River
		30400	10	1	150.25	Kinbasket River
		30700	13	1	150.25	Kinbasket River
		31000	16	1	150.25	Sullivan River
		31500	21	1	150.25	Entrained at Mica
		31600	22	1	150.25	Sullivan River
		31700	23	1	150.25	Cummins River
		32200	2	2	150.3	Smith Creek
		32400	4	2	150.3	U/s Surprise Rapids
		33100	11	2	150.3	Kinbasket River
		34000	20	2	150.3	Sullivan River
		34100	21	2	150.3	Bobcat Creek
02-Apr-15	9	30400	10	1	150.25	Kinbasket River
		30700	13	1	150.25	Kinbasket River
		31000	16	1	150.25	Sullivan River
		31500	21	1	150.25	Entrained at Mica
		31600	22	1	150.25	Sullivan River
		32200	2	2	150.3	Smith Creek
		32400	4	2	150.3	U/s Surprise Rapids
		33100	11	2	150.3	Kinbasket River
		34100	21	2	150.3	Bobcat Creek
18-Apr-15	9	30400	10	1	150.25	Kinbasket River
		31000	16	1	150.25	Sullivan River
		31500	21	1	150.25	Entrained at Mica
		31600	22	1	150.25	Sullivan River
		31700	23	1	150.25	Cummins River
		32200	2	2	150.3	Smith Creek
		32400	4	2	150.3	U/s Surprise Rapids
		33100	11	2	150.3	Kinbasket River
		34100	21	2	150.3	Bobcat Creek

Four Burbot exhibited adfluvial movements, mainly in the Sullivan River (Table 6). Twelve Burbot were detected at depths < 10 m suggesting that they were using shallow habitats during the suspected spawning period.

Table 6: Summary of locations of Burbot detected by radio tracking in shallow habitats of Kinbasket Reservoir and/or occurred at < 10 m depth.

Acoustic Code	Radio Code	Channel	Frequency	Location of adfluvial movement	Detected at < 10 m depth
30400	10	1	150.25		✓
30700	13	1	150.25		✓
30800	14	1	150.25		✓

31000	16	1	150.25	Sullivan River	✓
31400	20	1	150.25		✓
31600	22	1	150.25	Sullivan River	✓
31700	23	1	150.25	Cummins River	✓
32200	2	2	150.3		✓
32400	4	2	150.3		✓
32800	8	2	150.3		✓
33100	11	2	150.3		✓
34000	20	2	150.3	Sullivan River	✓

Figure 21 displays the distribution of depths occupied by Burbot detected by radio tracking throughout the Kinbasket Reservoir. Data from acoustic tag 34100 was excluded due to outlier data that indicated a faulty sensor. Mean depth was 0.75 ±2.53 m while most Burbot were distributed in the depth range of 0 to 1 m (88%). It should be noted that detection efficiency of these radio tags is poor if fish occupy depths below 10 m. Within this depth limit, radio tags were equally likely to be detected provided water quality and substrate conditions were favourable. Burbot located in areas with high turbidity or hiding in boulder/cobble substrate may not have been detected.

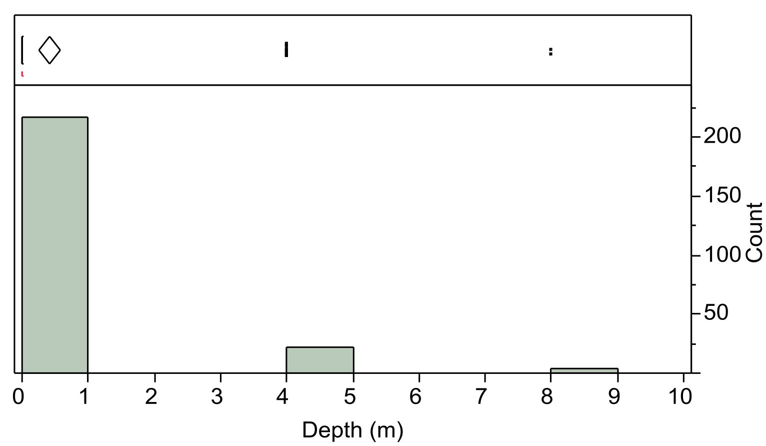


Figure 21: Distribution (histogram and box plot) of depth (m) for Burbot detected by radio tracking (n = 13) in Kinbasket Reservoir (February 17 – April 18, 2015). Boxes represent interquartile range, diamonds represent the sample mean and 95% confidence interval, while the middle line in the box is the median sample value. Whiskers represent observations outside of the interquartile range, with outlier data points. The red line indicates the densest 50% of the observations.

Burbot Mortality

Five Burbot were either suspected (n=3) or confirmed dead (n=2) by the end of the second year of study (Table 7). The Burbot with acoustic tag 32800 was found by a trapper who found the tag on a rock ledge 1m above the water level on Aug. 23, 2015. Teeth marks (possibly from an otter) on the broken tag indicated that the Burbot had died from predation. The Burbot with acoustic tag 30800 died from harvesting on Jul. 30, 2014 by a fisherman who returned the tag.

Table 7: Summary of tagged Burbot mortality in Kinbasket Reservoir.

Acoustic Code	Tag Year	Location tagged	Date mortality determined	Location of mortality	UTM E	UTM N	Cause of mortality	Method used to determine mortality	Mortality Confirmed?
29700	2014	Wood Arm	5-Jun-14	Wood Arm	419541	5780798	Unknown	Depth data	No
30800	2014	Kinbasket River confluence	30-Jul-14	Kinbasket River confluence			Angler harvest	Angler return of tag	Yes
31500	2014	Sullivan River confluence	22-Mar-15	Mica Dam tailrace	390817	5767174	Entrainment	Sensor data from aerial tracking	No
32400	2014	Columbia Reach south	18-Apr-15	Columbia Reach south; surprise rapids	453133	5735739	Unknown	Sensor data from aerial tracking	No
32800	2015	Kinbasket River confluence	23-Aug-15	Kinbasket River confluence	431480	5757714	Predator	Tag found with teeth marks	Yes

DISCUSSION AND RECOMMENDATIONS

Burbot Capture, biological characteristics and tagging

Burbot capture success varied amongst sampling areas in Kinbasket Reservoir. This implies that Burbot are not evenly distributed throughout the reservoir, a common observation in other lakes (Cope 2011; Robichaud et al., 2012). Over the two years of study, the Wood Arm had the highest catch and the Kinbasket River confluence the lowest catch. New reservoir areas sampled in Year 2 of the study, particularly those focused around the perimeter of historic Kinbasket Lake, did not have different capture rates than the majority of other sampling areas. This area was suspected to have higher capture rates prior to undertaking the study because of the potential for persistence of an historic lacustrine morph that may have been present prior to the construction of Mica Dam (Warnock et al., 2014).

For the whole study area, Kinbasket Reservoir appeared to have moderate trap CPUE relative to other lakes that have been studied in British Columbia (Table 8). It is important to note that sampling effort was not randomized spatially or by depth, thus CPUE estimates may be skewed by specific depth strata and/or intensive sampling of specific reservoir areas. It is also important to note that the study area was 43% of the total area of the reservoir, thus the estimate should not be a reflection of the reservoir as a whole. Other possible confounding factors that may affect capture success amongst studies includes soak time (gear saturation), bait type and quality, trap placement, study design and effort, season, crew experience, depth and trap type used (Prince 2007). Thus, extreme caution is recommended when comparing CPUE estimates among lakes or studies. Randomized grid trap placement, stratified both spatially and by depth is the most preferable for standardized design for evaluating relative abundance, as spatial and depth bias is minimized. Effort must be scaled to the size of the system, as high error may result in large lakes if a sufficient effort cannot be expended on trapping for a sufficient spatial coverage.

Table 8: Literature review of Burbot relative abundance; rows are presented ranked from lowest catch rates to highest. Rows presenting data from this study are highlighted. NR = not reported.

Lake	Year	N trapsets	sampling design	trapset soak time range (h)	mean soak time (h)	trap type	Time of year	depth range (m)	mean depth (m)	Mean $CPUE_{set}$ (fish/trapset)	Reference
Koocanusa Reservoir (MT)	2013	216	targeted	47.3-48	~48	hoop trap	Winter	NR	NR	0.10	Dunnigan et al., 2014
Windermere Lake	2006	60	randomized grid	NR	~48	cod trap	Fall	0-6	3	0.12	Prince 2007
Duncan Reservoir	2010	361	randomized grid, perimeter	NR	~48	cod trap	Spring	1.2-30	20.5	0.13	Cope 2010
Duncan Reservoir	2011	340	randomized grid & targeted	NR	~48	cod trap	Spring	1.8-30	18.6	0.14	Cope 2011
Columbia Lake	2001	128	spatially systematic	NR	~24	cod trap	Spring	NR	NR	0.15	Bisset et al., 2002
Duncan Reservoir	2010	89	targeted	NR	~48	cod trap	Spring	1.2-30	20.5	0.16	Cope 2010
Kootenay Lake	2015	38	targeted	50-93	74	cod trap	Spring	10.0-24.2	18.5	0.18	Stephenson & Evans 2015
Koocanusa Reservoir (BC)	2013	38	targeted	44.4-48.9	~48	cod trap	Winter	1.8-15.7	6.1	0.21	Robinson 2013
Duncan Reservoir	2005	85	randomized, perimeter	45-50	NR	cod trap	Fall	15.0-33	24.4	0.22	Neufeld 2006
Duncan Reservoir	2009	212	randomized grid, perimeter	NR	~48	cod trap	Spring	1.5-30.6	15.2	0.22	Cope 2009
Columbia Lake	2001	138	targeted	NR	~24	cod trap	Fall	NR	NR	0.28	Bisset et al., 2002
Birch Lake	2002	50	targeted	18.8-26.7	~24	cod trap	Fall	3.5-28	15.4	0.30	Redekopp et al., 2003
Lac Des Roches	2002	74	targeted	19.3-33.1	~24	cod trap	Fall	6.0-29	16.1	0.32	Redekopp et al., 2003
Duncan Reservoir	1999	88	convenience	NR	53.4	cod trap	Fall	5.0-30	NR	0.33	Spence & Neufeld 2002
Duncan Reservoir	2006	192	randomized, perimeter	19-74	NR	cod trap	Spring	2.0-79	22.3	0.41	Neufeld 2006
Duncan Reservoir	2009	127	targeted	NR	~48	cod trap	Spring	1.5-30.6	15.2	0.41	Cope 2009
Moyie Lakes	2014	46	targeted	0.9-33.3	NR	cod trap	Fall	3.0-7.0	NR	0.50	Stephenson & Evans 2015
Columbia Lake	2006	40	randomized grid	NR	~48	cod trap	Fall	0-5	3	0.58	Prince 2007
Kinbasket Reservoir	2015	154	targeted	23.2-96.2	49.9	cod trap	Spring	4.3-18.0	12.2	0.64	this study
St. Mary Lake	2005	11	randomized grid	NR	~48	cod trap	Fall	0-21	8	0.64	Prince 2007
Duncan Reservoir	2005	282	randomized, perimeter	45-50	NR	cod trap	Spring	10.0-45	23.2	0.78	Neufeld 2006
Kinbasket Reservoir	2014	149	targeted	23.6-77.4	45	cod trap	Spring	2.2-16.5	9.4	0.83	this study
Arrow Lakes	2008	64	targeted	14.4-74.4	33.6	cod trap	Fall	NR	NR	0.86	Glova et al., 2009
Moyie Lakes	2006	45	randomized grid	NR	~48	hoop trap	Fall	NR	NR	1.16	Prince 2007
Arrow Lakes	2010	124	spatially stratified	24-74	48*	cod trap	Fall	3.0-16	NR	1.16	Robichaud et al., 2011
Arrow Lakes	2008	51	spatially stratified	21.6-76.8	52.8	cod trap	Fall	NR	NR	1.33	Glova et al., 2009
Arrow Lakes	2011	125	spatially stratified	46-72	48*	cod trap	Fall	NR	NR	1.35	Robichaud et al., 2012
Arrow Lakes	2009	143	spatially stratified	23-90.7	72.7*	cod trap	Fall	NR	NR	1.43	Glova et al., 2010
Moyie Lakes	2006	154	randomized grid	NR	~48	cod trap	Spring	NR	NR	2.01	Prince 2007
Moyie Lakes	2006	48	randomized grid	NR	~48	cod trap	Fall	NR	NR	2.08	Prince 2007
Moyie Lakes	2005	30	targeted	NR	~48	cod trap	Fall	NR	NR	4.17	Prince 2007
Arrow Lakes	2003	43	targeted	4.8-50	20.9	cod trap	Fall	10.0-31	21.4	4.60	Arndt and Baxter 2006
Arrow Lakes	2006	17	targeted	NR	NR	cod trap	Fall	16.8-29.7	23.5	7.29	Neufeld 2006
Arrow Lakes	2004	15	targeted	17.9-22.5	20.3	cod trap	Fall	18.5-30	24.8	8.50	Arndt and Baxter 2006

*median reported

The negative relationship between $CPUE_{day}$ and soak time implies that increasing soak time will bias estimates of $CPUE_{day}$ low. The reasons for this are unknown, but may be due to gear saturation, whereby a successful capture event reduces the probability of a subsequent capture event. Traps may become saturated for a variety of reasons, including discouragement of entering the trap if fish are already present or decreased quantity/quality of bait over time. Saturation may also occur if the gear samples a small fishing area rapidly and no fish recruit into the fishing area over the length of the soak. This suggests that $CPUE_{day}$ is sensitive to soak time, and that standardized trapset length is necessary if $CPUE_{day}$ is to be used as a metric for comparison purposes or indexing. Alternatively, a minimum trapset soak time may be employed, using capture as a binary response variable, or CPUE should preferentially be reported as $CPUE_{set}$. The two years of capture data suggested that capture success was insensitive to soak time (i.e., longer soak times do not result in higher probability of Burbot capture). This supports the use of Burbot capture success as a binary response variable if comparing relative abundance of Burbot in Kinbasket Reservoir, providing traps are set for a minimum of 24 hours.

Burbot size was weakly correlated with the year of sampling (Burbot were larger in Year 1 than Year 2) and with reservoir area, when controlling for depth in a linear model. Using 2014 data alone, we found that Burbot size was weakly, but positively associated with increasing sampling depth (Warnock et al., 2014). Greater depths were sampled in 2015, and the trend was no longer significant when this data was included. The variation in Burbot size in different areas of the reservoir may suggest different age structures or size at age in some areas than others. This might be expected if Burbot exploitation by anglers is spatially unequal or if density dependent growth is variable. The latter may occur if Burbot density or reservoir productivity is spatially variable.

Qualitative observations of habitat at capture locations indicate that Burbot were captured in a variety of habitats. This supports the observation that Burbot are benthic, but specific microhabitat preferences of adults for substrate are not necessarily specialized (McPhail 2007).

Burbot spawning occurs during winter months in most populations (McPhail 2007). Our assumption of spawn period from February to April in Kinbasket is likely valid and spawn timing is probably similar to that in the nearby and southern Arrow Lakes Reservoir where spawning occurs over a protracted period, beginning in late February or early March and continuing to the end of March or early April (Robichaud et al., 2013). Over the two years of trapping in early spring in Kinbasket Reservoir, several fish were observed in spawning condition, and many were in post-spawn condition. This implies that spawning either peaks late in winter in Kinbasket Reservoir, or is protracted through the winter period, ending around the time of sampling in late April-early May.

Mobile and fixed receiver tracking

While there was a lack of monitoring data during the 2015 spawning period (likely from January to April) due to fixed receiver battery failure and poor detection of Burbot by radio tracking, clear seasonal patterns in movement could be characterized by fixed and mobile tracking information. While data from fixed acoustic receivers indicated that there was variability in the depths occupied by Burbot and their mobility, most tagged Burbot moved from relatively shallow areas in June to deeper areas in December and again into shallower areas from January to April (Figure 17 and Figure 19). The movement into shallower areas is associated with the timing of spawning season, as demonstrated by Harrison et al., (2013). Radio tracking throughout the spawning season indicated that Burbot use shallow water habitat during these months in the reservoir and the greatest number of detections occurred during March 22, 2015. There were also several observations of river habitat occupation from radio tracking data during this time period (Table 6 and Figure 21). These fish were detected at the Sullivan River and did not make extensive movements (<2 km) upriver. This could be indicative of a limited segment of the population that engages in an adfluvial life history, undertaking limited movements up large spawning tributaries close to the study area.

Aerial tracking was conducted over the entire length of the Columbia River from the headwaters at Columbia Lake and no burbot were detected upstream, or anywhere else outside of the study area, except for a single entrainment event. Although these patterns of detection could not be corroborated by acoustic tracking, the lack of burbot detections upstream of Kinbasket Reservoir during the aerial tracking period suggests that this area is not preferred habitat for Burbot during this time, likely due to lack of spawning habitat. Conversely, Burbot may have been occupying depths out of range for radio tracking in these areas.

The occurrence of Burbot in shallow areas in June suggests that burbot may remain in shallow areas during the post-spawn period (also reported by Harrison et al., 2013), though we did not deploy receivers immediately after tagging so depth use during the immediate post-spawn season is unknown. Incorporation of data from 2015-2016 will provide further elucidation of the distribution, migratory behaviour, and depth use during the spawning season. Information on the depths occupied by Burbot will be used to determine if these depths are at risk of dewatering with reservoir operations in future years of the study.

Data collected from fixed acoustic receivers also showed clear DVM in some Burbot (Figure 17 and Figure 18). DVM has previously been demonstrated in adult Burbot from Kinbasket Reservoir (Harrison et al., 2013; Martins et al., 2013). The function of DVM has been attributed to a trade-off among bioenergetics advantage (i.e., fitness gains from foraging in warmer water at night and digesting in cooler, deeper waters in the day), foraging opportunity (i.e., migration aligned with prey movement), and predation threat (i.e., avoidance of predators by smaller individuals within gape size limits) (Harrison et al., 2013).

One Burbot was tracked by radio receiver in the tailrace of Mica dam (Acoustic Code: 31500; Table 7). It was tagged >20 km from the dam (Appendix 1 and 2). Although the timing of entrainment cannot be confirmed with receiver data, the date of first observation in the Mica tailrace occurred in Spring 2015. Our ability to detect entrainment was constrained because there were only five radio tracking sessions during the winter months. A more thorough investigation of burbot entrainment was conducted as part of the BC Hydro Fish Entrainment Strategy Action Plan for Mica Dam (Martins et al., 2013). Although use of the Mica forebay and entrainment rates were reported to be low, Burbot were more likely to be entrained in the fall (Martins et al., 2013).

We recommend that field studies of tagged Burbot continue into 2016-2017 given the opportunity for further data collection with the remaining battery life in CART tags and the fact that most fixed acoustic receivers lost power before or during the spawning season in 2015.

REFERENCES

Andrusak, H., 1998. Investigation of burbot in Kootenay Lake. prepared for B. C. M. o. Environment. Victoria, B.C., pp. 22

Arndt, S., and J. Baxter, 2006. Status of burbot (Lota lota) in Arrow Lakes Reservoir. prepared for Columbia Basin Fish & Wildlife Compensation Program. Nelson, B.C.

Arndt, S., and J. Hutchinson. 2000. Characteristics of burbot spawning in a tributary of Columbia Lake, British Columbia, over a four-year period. Pages 48-59 in V. L. Paragamian and D. W. Willis, editors. Burbot: biology, ecology, and management. American Fisheries Society.

BC Hydro. 2007. Columbia River Project Water Use Plan Monitoring Program Terms of Reference. Kinbasket Reservoir Fish and Wildlife Information Plan - CLBMON-5 Kinbasket Reservoir Burbot Life History and Habitat Use Assessment. BC Hydro, Castlegar, BC, pp. 10.

Baxter, J., C. Spence, and M. D. Neufeld, 2002. Kootenay Lake burbot studies – Progress 2001 - 2002. prepared for L. a. P. Ministry of Environment. Nelson, B.C., pp. 32

Bernard, D. R., J. F. Parker, and R. Lafferty. 1993. Stock assessment of burbot populations in small and moderate-size lakes. North American Journal of Fisheries Management 13:657-675.

Bisset, J. E., and R. S. Cope, 2002. Goat River burbot spawner enumeration program, Creston, B.C. prepared for Columbia-Kootenay Fisheries Renewal Partnership. Westslope Fisheries Ltd. Cranbrook, B.C., pp. 23.

Bisset, J. E., S. Arndt, and R. S. Cope, 2002. Columbia Lake burbot population estimate program, Canal Flats, B.C. prepared for Columbia-Kootenay Fisheries Renewal Partnership. Westslope Fisheries Ltd and Columbia Basin Fish and Wildlife Compensation Program. Nelson, B.C., pp. 21.

Brown, R. S., S. J. Cooke, W. G. Anderson, and R. S. McKinley. 1999. Evidence to challenge to "2% rule" for biotelemetry. North American Journal of Fisheries Management 19:867-871.

Cope, R. S., 2008. Footprint impacts of BC Hydro dams on burbot populations in the Columbia River Basin, British Columbia. prepared for Fish and Wildlife Compensation Program. W. F. Ltd. Nelson, B.C., pp. 75

Cope, R. S., 2009. Duncan Reservoir burbot monitoring annual report: 2008-2009. prepared for BC Hydro. Westslope Fisheries Ltd. Cranbrook, B.C., pp. 35

Cope, R. S., 2010. Duncan Reservoir burbot monitoring annual report: 2009-2010. prepared for BC Hydro. Westslope Fisheries Ltd. Cranbrook, B.C., pp. 56

Cope, R. S., 2011. Duncan Reservoir burbot monitoring annual report: 2010-2011. prepared for BC Hydro. Westslope Fisheries Ltd. Cranbrook, B.C., pp. 57

Cott, P. A., A. D. Hawkins, D. Zeddies, B. Martin, T. A. Johnston, J. D. Reist, J. M. Gunn, and D. M. Higgs. 2014. Song of the burbot: Under-ice acoustic signaling by a freshwater gadoid fish. Journal of Great Lakes Research 40:435-440.

Dunnigan, J. L., and C. L. Sinclair. 2008. Home range and movement patterns of burbot in Koocanusa Reservoir, Montana, USA. Pages 43-54 in V. L. Paragamian and D. H. Bennett, editors. Burbot: ecology, management, and culture. American Fisheries Society, Bethesda, M.D.

Dunnigan, J. L., J. DeShazer, L. Garrow, T. Ostrowski, M. Benner, J. Lampton, and J. Tohtz. 2014. Libby mitigation program, 2012 annual progress report: mitigation for the construction and operation of Libby Dam. prepared for Bonneville Power Administration. Libby, MT

Ford, B. S., P. S. Higgins, A. F. Lewis, K. L. Cooper, T. A. Watson, C. M. Gee, G. L. Ennis, and R. L. Sweeting, 1995. Literature reviews of the life history, habitat requirements and mitigation/compensation strategies for selected fish species in the Peace, Liard and Columbia River drainages of British Columbia. prepared for F. a. O. Canada. Vancouver, BV

Glova, G., D. Robichaud, and R. Bussanich, 2009. Arrow Lakes Reservoir burbot life history and habitat use (Year 1). prepared for BC Hydro. LGL Limited. Sidney, B.C., pp. 35

Glova, G., D. Robichaud, E. Plate, and M. Matthew, 2010. Arrow Lakes Reservoir burbot life history and habitat use (Year 2). prepared for BC Hydro. LGL Limited. Sidney, B.C., pp. 37

Gutowsky, L., P. Harrison, E. Martins, A. Leake, D. Patterson, M. Power, and S. Cooke. 2013. Diel vertical migration hypotheses explain size-dependent behaviour in a freshwater piscivore. Animal Behaviour 86:365-373.

Harrison, P. M., L. F. Gutowsky, E. G. Martins, D. A. Patterson, A. Leake, S. J. Cooke, and M. Power. 2013. Diel vertical migration of adult burbot: A dynamic trade-off between feeding opportunity, predation avoidance, and bioenergetic gain. Canadian Journal of Fisheries and Aquatic Sciences 70: 1765-1774.

Martins, E. G., L. F. Gutowsky, P. M. Harrison, D. A. Patterson, M. Power, D. Z. Zhu, A. Leake, and S. J. Cooke. 2013. Forebay use and entrainment rates of resident adult fish in a large hydropower reservoir. Aquatic Biology 19:253-263.

McPhail, J. D. 2007. The freshwater fishes of British Columbia. The University of Alberta Press, Edmonton, AB.

Neufeld, M. D., 2006. Kootenay burbot recovery projects in British Columbia, 2005-2006. prepared for BC Ministry of Environment. Nelson, B.C., pp. 24

Neufeld, M. D., and C. Spence, 2009. Moyie Lake burbot program 2008-2009: Sport Fishery, Juvenile Sampling and Conservation Aquaculture/Spawning Surveys. prepared for BC Ministry of Environment. Nelson, B.C., pp. 48

Paragamian, V. L. 2000. The effects of variable flows on burbot spawning migrations in the Kootenai River, Idaho, USA, and Kootenay Lake, British Columbia, Canada, after construction of the Libby Dam. Pages 30-37 in V. L. Paragamian and D. W. Willis, editors. Burbot: biology, ecology, and management. American Fisheries Society, Bethesda, M.D.

Paragamian, V. L., and V. D. Wakkinen. 2008. Seasonal movement of burbot in relation to temperature and discharge in the Kootenai River, Idaho, USA and British Columbia, Canada. Pages 55-77 in V. L. Paragamian and D. H. Bennett, editors. Burbot: ecology, management, and culture. American Fisheries Society, Bethesda, M.D.

Prince, A., 2001. Local knowledge of Columbia River fisheries in British Columbia, Canada. Prepared for Columbia-Kootenay Fisheries Renewal Partnership. Westslope Fisheries Ltd. Cranbrook, B.C., pp. 50

Prince, A., 2007. East Kootenay burbot population assessment. Prepared for BC Ministry of Environment. Westslope Fisheries Ltd. Cranbrook, B.C., pp. 25

Prince, A. 2009. Kinbasket Reservoir white sturgeon inventory and habitat use assessment (CLBMON-19). Prepared for BC Hydro. Canadian Columbia River Inter-tribal Fisheries Commission. Cranbrook, B.C., pp. 54.

Prince, A., 2011. Kinbasket Reservoir white sturgeon inventory and habitat use assessment (CLBMON-19). Prepared for BC Hydro. Canadian Columbia River Inter-tribal Fisheries Commission. Cranbrook, B.C., pp. 20.

Prince, A. and R.S. Cope. 2008. North Moyie Lake Burbot Creel Survey 2008. Prepared for Ministry of Environment. Westslope Fisheries Ltd. Cranbrook, BC, pp. 26.

Reddekopp, S., S. McLoughlin, and H. Murphy, 2003. Characteristics of burbot (Lota lota) in Lac Des Roches and Birch Lake, British Columbia. prepared for BC Ministry of Environment. Kamloops, B.C., pp. 23.

Robichaud, D., G. Glova, and S. Kingshott, 2013. Arrow Lakes Reservoir burbot life history and habitat use (Year 5). prepared for BC Hydro. LGL Limited. Sidney, B.C., pp. 23

Robichaud, D., G. Glova, M. Matthews, and S. Kingshott, 2012. Arrow Lakes Reservoir burbot life history and habitat use (Year 4). prepared for BC Hydro. LGL Limited. Sidney, B.C., pp. 40

Robichaud, D., G. Glova, E. Plate, and M. Matthew, 2011. Arrow Lakes Reservoir burbot life history and habitat use (Year 3). prepared for BC Hydro. LGL Limited. Sidney, B.C., pp. 41

Spence, C., 1999. Kootenay Lake burbot studies progress 1998-99. prepared for M. o. Environment. Nelson, B.C., pp. 42

Spence, C., and M. D. Neufeld, 2002. Radio telemetry studies of Duncan Reservoir burbot. prepared for BC Ministry of Environment. Nelson, B.C., pp. 21

Stephenson, S., and V. Evans, 2015. 2014-15 Kootenay burbot summary: Moyie Lake and Kootenay Lake. prepared for BC Ministry of Forests, Lands and Natural Resource Operations. Nelson, B.C., pp. 56

Taylor, J. L., and J. D. McPhail. 2000. Temperature, development and behaviour in the early life history of burbot from Columbia Lake, British Columbia. Pages 30-37 in V. L. Paragamian and D. W. Willis, editors. Burbot: biology, ecology, and management. American Fisheries Society, Bethesda, M.D.

Warnock, W.G., R.S. Cope, and A. Prince. 2014. WLR Monitoring Study No. CLBMON-05 (Year 1) Kinbasket Reservoir Burbot Life History and Habitat Use Assessment. Prepared for BC Hydro by the Canadian Columbia River Inter-Tribal Fisheries Commission and Westslope Fisheries Ltd. Cranbrook, BC, pp. 48.

Appendix 1: Burbot trapping and capture data from April 28 to May 10, 2015.

	Trap Set			Trap Set Location			Trap Pull			Species	RECAP	Acoustic	Radio	Radio	Length	Weight	MORT	Sex		Acoustic	Radio	Radio	Anaesthesia	Surgery	Recovery	Release	Camera drop	Set	Pull	Weather & Water	
ID #	Date	Time	Depth (m)	Easting	Northing	General Description	Date	Time	Catch	Code	(Y/N)	Code	Code	Freq	(mm)	(kg)	(Y/N)	(M/F)	ID #	Code	Code	Freq	(min:sec)	(min:sec)	(min:sec)	(min:sec)	Habitat Comments	H_2O^0C:	H_2O^0C:	Conditions	Photos
1	28-Apr-15	9:20	8.1	420255	5782092	Wood River Confluence	29-Apr-15	9:15	0										1												38-56
2	28-Apr-15	9:23	11.8	420276	5782178	Wood River Confluence	29-Apr-15	9:25	2	BB	Y	38000	1	150.3	703	1.35	N	U	2	38000	1	150.3	8:30	14:00	26:00	35:00	River outlet, Silt Flats, High Turbidity, some submerged LWD, lots organics	6.8	7.5	Warm, west, windy, Turbid, silt bottom	38-56
2	28-Apr-15	9:23	11.8	420276	5782178	Wood River Confluence	29-Apr-15	9:25		BB	N	39200	25	150.3	600	1.18	N	U	2	39200	25	150.3	7:45	11:04	28:00	38:00	River outlet, Silt Flats, High Turbidity, some submerged LWD, lots organics	6.8	7.5	Warm, west, windy, Turbid, silt bottom	38-56
3	28-Apr-15	9:26	9.1	420228	5782365	Wood River	29-Apr-15	12:20	2	BB	N				445	0.78	N	U	3								River outlet, Silt , High Turbidity, some submerged LWD, lots organics	6.8	7.5	Warm, west, windy, Turbid, silt bottom	38-56
3	28-Apr-15	9:26	9.1	420228	5782365	Wood River	29-Apr-15	12:20		BB	N	38,900	22	150.3	697	1.36	N	U	3	38,900	22	150.3	9:33	12:15	30:00	41:00	River outlet, Silt , High Turbidity, some submerged LWD, lots organics	6.8	7.5	Warm, west, windy, Turbid, silt bottom	38-56
4	28-Apr-15	9:30	11	420046	5782635	Wood River	29-Apr-15	13:15	1	BB	N	36900	24	150.27	715	1.86	N	U	4	36900	24	150.27	8:50	12:20	30:00	42:00	River outlet, Silt , High Turbidity, some submerged LWD, lots organics	6.8	7.5	Warm, west, windy, Turbid, silt bottom	38-56
7	28-Apr-15	10:00	9.1	420373	5782133	Wood Outlet	29-Apr-15	10:50	3	CC									7								River outlet, Silt Flats, High Turbidity	6.8	7.5	Warm, west, windy, Turbid, silt bottom	38-56
8	28-Apr-15	10:05	12.2	420315	5782027	Wood Outlet	29-Apr-15	11:00	2	BB	N	32900	9	150.3	748	1.76	N	U	8	32900	9	150.3	10:00	15:30	30:00	35:00	River outlet, Silt Flats, High Turbidity	6.8	7.5	Warm, west, windy, Turbid, silt bottom	38-56
8	28-Apr-15	10:05	12.2	420315	5782027	Wood Outlet	29-Apr-15	11:00		BB	N	39300	26	150.3	625	1.26	N	U	8	39300	26	150.3	7:05	9:50	27:00	36:00	River outlet, Silt Flats, High Turbidity	6.8	7.5	Warm, west, windy, Turbid, silt bottom	38-56
9	28-Apr-15	10:10	9.1	420179	5781943	Wood Outlet	29-Apr-15	9:20	0										9								River outlet, Silt Flats, High Turbidity	6.8	7.5	Warm, west, windy, Turbid, silt bottom	38-56
10	28-Apr-15	10:15	13.3	420249	5781837	Wood Bay	29-Apr-15	15:00	2	BB	N	36800	23	150.27	697	1.58	N	U	10	36800	23	150.27	8:00	12:00	25:45	37:00	River outlet, Silt Flats, High Turbidity	6.8	7.5	Warm, west, windy, Turbid, silt bottom	38-56
10	28-Apr-15	10:15	13.3	420249	5781837	Wood Bay	29-Apr-15	15:00		BB	N				616	1.24	N	U	10								River outlet, Silt Flats, High Turbidity	6.8	7.5	Warm, west, windy, Turbid, silt bottom	38-56
11	28-Apr-15	10:30	13.2	420399	5781873	Wood Bay	02-May-15	8:25	3	BB	N	36600	21	150.27	746	1.66	N	U	11	36600	21	150.27	10:00	13:46	27:30	32:00	River outlet, Silt Flats, High Turbidity	6.8	7.5	Warm, west, windy, Turbid, silt bottom	38-56
11	28-Apr-15	10:30	13.2	420399	5781873	Wood Bay	02-May-15	8:25		BB	N				485	0.8	N	U	11								River outlet, Silt Flats, High Turbidity	6.8	7.5	Warm, west, windy, Turbid, silt bottom	38-56
11	28-Apr-15	10:30	13.2	420399	5781873	Wood Bay	02-May-15	8:25		BB	N				595	1.3	N	U	11								River outlet, Silt Flats, High Turbidity	6.8	7.5	Warm, west, windy, Turbid, silt bottom	38-56
12	28-Apr-15	10:35	9.2	420447	5781669	Wood Bay	02-May-15	10:00	1	BB	N				581	1.28	N	U	12								River outlet, Silt Flats, High Turbidity	6.8	7.5	Warm, west, windy, Turbid, silt bottom	38-56
13	28-Apr-15	10:40	10.1	420282	5781220	Wood Bay	02-May-15	9:20	1	BB	N	36200	17	150.27	700	1.72	N	U	13	36200	17	150.27	9:20	14:26	23:55	31:28	River outlet, Silt Flats, High Turbidity	6.8	7.5	Warm, west, windy, Turbid, silt bottom	38-56
14	28-Apr-15	10:45	16.1	420131	5781306	Wood Bay	02-May-15	10:55	2	BB	N	36400	19	150.27	723	1.8	N	U	14	36400	19	150.27	9:00	12:30	22:30	30:00	River outlet, Silt Flats, High Turbidity	6.8	7.5	Warm, west, windy, Turbid, silt bottom	38-56
14	28-Apr-15	10:45	16.1	420131	5781306	Wood Bay	02-May-15	10:55		BB	N				561	0.79	N	U	14								River outlet, Silt Flats, High Turbidity	6.8	7.5	Warm, west, windy, Turbid, silt bottom	38-56
15	28-Apr-15	10:50	10.5	419825	5782369	Wood Bay	02-May-15	10:45	0										15								River outlet, Silt Flats, High Turbidity	6.8	7.5	Warm, west, windy, Turbid, silt bottom	38-56
16	28-Apr-15	12:40	9.4	396294	5775619	Encampment Bay	30-Apr-15	8:20	0										16								gravel, cobble, sand bay with Encampment channel in middle	4.3		Warm, west, windy, Turbid, silt bottom	38-56
17	28-Apr-15	12:50	11.8	396396	5775934	Encampment Bay	30-Apr-15	8:15	0										17								gravel, cobble, sand bay with Encampment channel in middle	4.3		Warm, west, windy, Turbid, silt bottom	38-56
18	28-Apr-15	13:00	9.1	396816	5775942	Encampment Bay	30-Apr-15	8:25	0										18								gravel, cobble, sand bay with Encampment channel in middle	4.3		Warm, west, windy, Turbid, silt bottom	38-56
19	28-Apr-15	13:15	9	396701	5778116	Encampment Creek	30-Apr-15	8:35	1	BB	N	38800	21	150.3	601	1.08	N	M	19	38800	21	150.3	8:30	11:20	22:00	29:00	silt over cobble, lots bedrock	4.3		Warm, west, windy, Turbid, silt bottom	38-56
19	28-Apr-15	13:15	9	396701	5778116	Encampment Creek	30-Apr-15	8:35	1	RB					355	0.46	Y	U	19								silt over cobble, lots bedrock	4.3		Warm, west, windy, Turbid, silt bottom	38-56
20	28-Apr-15	13:20	10.9	397306	5778015	Encampment Creek	30-Apr-15	9:30	1	BB	Y	39100	24	150.3	610	0.9	N	M	20	39100	24	150.3	9:30	13:04	19:00	25:00	silt over cobble, lots bedrock	4.3		Warm, west, windy, Turbid, silt bottom	38-56
21	28-Apr-15	13:30	9.5	398140	5777528	Encampment Bay	30-Apr-15	10:00	2	BB	N				604	1.3	N	U	21								gravel, cobble, sand bay with Encampment channel in middle	4.3		Warm, west, windy, Turbid, silt bottom	
21	28-Apr-15	13:30	9.5	398140	5777528	Encampment Bay	30-Apr-15	10:00		BB	N				383	0.29	N	U	21								gravel, cobble, sand bay with Encampment channel in middle	4.3		Warm, west, windy, Turbid, silt bottom	
22	28-Apr-15	13:35	10.9	398428	5777978	Encampment Bay	30-Apr-15	10:10	1	BB	N	38600	19	150.3	644	1.34	N	U	22	38600	19	150.3	8:26	11:00	30:00	38:00	gravel, cobble, sand bay with Encampment channel in middle	4.3		Warm, west, windy, Turbid, silt bottom	
23	28-Apr-15	14:00	9.6	408523	5768700	Yellowbird Creek mouth	30-Apr-15	11:20	1	BB	N				571	1.16	N	U	23								Silt bottom, LWD			Warm, west, windy, Turbid, silt bottom	
24	28-Apr-15	14:05	12.6	408605	5768432	Yellowbird Creek mouth	30-Apr-15	11:20	1	BB	N				658	1.46	N	U	24								Silt Bottom, LWD			Warm, west, windy, Turbid, silt bottom	57-58
25	28-Apr-15	14:20	9.3	408798	5769750	Narrows between island and creek	30-Apr-15	11:30	1	BB	N				510	0.76	N	U	25								Cobble gravel			Warm, west, windy, Turbid, silt bottom	57-58
26	28-Apr-15	14:35	6.5	416139	5767423	Cummins Creek	30-Apr-15	11:50	1	NPM	N				409	0.58	N	U	26								silt overlain bedrock in historic flooded canyon, lots submerged LWD	6.7	7.5	rain, warm, windy	59-60

ID #	Trap Set			Trap Set Location			Trap Pull		Catch	Species	RECAP	Acoustic	Radio	Radio	Length	Weight	MORT	Sex		Acoustic	Radio	Radio	Anaesthesia	Surgery	Recovery	Release	Camera drop	Set	Pull	Weather & Water	
	Date	Time	Depth (m)	Easting	Northing	General Description	Date	Time		Code	(Y/N)	Code	Code	Freq	(mm)	(kg)	(Y/N)	(M/F)	ID #	Code	Code	Freq	(min:sec)	(min:sec)	(min:sec)	(min:sec)	Habitat Comments	H_2O^0C:	H_2O^0C:	Conditions	Photos
27	28-Apr-15	14:40	13.7	416009	5767338	Cummins Creek	30-Apr-15	12:00	3	BB	N	36700	22	150.27	736	1.81	N	U	27	36700	22	150.27	8:00	11:09	21:30	29:00	silt overlain bedrock in historic flooded canyon, lots submerged LWD	6.7	7.5	rain, warm, windy	
27	28-Apr-15	14:40	13.7	416009	5767338	Cummins Creek	30-Apr-15	12:00		BB	N				530	0.88	N	U	27								silt overlain bedrock in historic flooded canyon, lots submerged LWD	6.7	7.5	rain, warm, windy	
27	28-Apr-15	14:40	13.7	416009	5767338	Cummins Creek	30-Apr-15	12:00		BB	N				490	0.66	N	U	27								silt overlain bedrock in historic flooded canyon, lots submerged LWD	6.7	7.5	rain, warm, windy	
28	28-Apr-15	14:50	12.3	414930	5766574	Cummins Creek Mouth	30-Apr-15	12:45	0										28								silt overlain bedrock in historic flooded canyon, lots submerged LWD	6.7	7.5	rain, warm, windy	
29	28-Apr-15	14:55	10.2	415102	5766434	Cummins Creek Mouth	30-Apr-15	12:50	0										29								silt overlain bedrock in historic flooded canyon, lots submerged LWD	6.7	7.5	rain, warm, windy	
30	28-Apr-15	15:00	10.3	415317	5766359	Cummins Creek Mouth	30-Apr-15	12:55	0										30								silt overlain bedrock in historic flooded canyon, lots submerged LWD	6.7	7.5	rain, warm, windy	
31	29-Apr-15	15:25	11.9	420329	5782078	Wood River Flats at outlet (reset)	02-May-15	12:15	1	BB	N	35800	13	150.27	770	2.06	N	U	31	35800	13	150.27	9:40	14:30	23:00	36:00	River outlet, Silt Flats, High Turbidity	6.7	7.5	rain, warm, windy	
32	29-Apr-15	15:30	11.2	420300	5782175	Wood River Flats at outlet (reset)	02-May-15	13:10	2	BB	N				740	1.85	N	U	32								River outlet, Silt Flats, High Turbidity	6.7	7.5	rain, warm, windy	
32	29-Apr-15	15:30	11.2	420300	5782175	Wood River Flats at outlet (reset)	02-May-15	13:10		BB	N				681	1.91	N	U	32								River outlet, Silt Flats, High Turbidity	6.7	7.5	rain, warm, windy	
33	29-Apr-15	15:35	9.5	420263	5782340	Wood River Flats at outlet (reset)	02-May-15	13:15	3	BB	N								33								River outlet, Silt Flats, High Turbidity	6.7	7.5	rain, warm, windy	
34	29-Apr-15	15:45	7.5	420247	5782096	Wood River Flats at outlet (reset)	02-May-15	12:10	0										34								River outlet, Silt Flats, High Turbidity	6.8	7.5	Warm, west, windy, Turbid, silt bottom	
35	29-Apr-15	15:50	11.8	420226	5781975	Wood River Flats at outlet (reset)	02-May-15	11:30	1	BB	N	36500	20	150.27	776	1.96	N	U	35	36500	20	150.27	9:20	13:30	24:00	35:00	River outlet, Silt Flats, High Turbidity	6.8	7.5	Warm, west, windy, Turbid, silt bottom	
36	29-Apr-15	15:55	13.9	420169	5781846	Wood River Flats at outlet (reset)	02-May-15	10:50	0										36								River outlet, Silt Flats, High Turbidity	6.8	7.5	Warm, west, windy, Turbid, silt bottom	
37	29-Apr-15	16:00	14.4	420172	5781716	Wood River Flats at outlet (reset)	02-May-15	10:45	0										37								River outlet, Silt Flats, High Turbidity	6.8	7.5	Warm, west, windy, Turbid, silt bottom	
38	29-Apr-15	16:10	14.8	420202	5781552	Wood River Flats at outlet (reset)	02-May-15	10:00	1	BB	N	36300	18	150.27	804	2.41	N	M	38	36300	18	150.27	9:40	13:10	24:30	32:00	River outlet, Silt Flats, High Turbidity	6.8	7.5	Warm, west, windy, Turbid, silt bottom	
39	30-Apr-15	13:30	10.5	422345	5761128	Kinbasket Lake Outlet	03-May-15	8:50	0										39								Silt Flats, Stumps	4.9		Calm Sunny Cool	
40	30-Apr-15	13:35	10.7	422839	5761142	Kinbasket Lake Outlet	03-May-15	8:55	0										40								Silt Flats, Stumps	4.9		Calm Sunny Cool	
41	30-Apr-15	13:40	10.5	423510	5760739	Kinbasket Lake Outlet	03-May-15	9:00	1	BB	N	38700	20	150.3	667	1.26	N	U	41	38700	20	150.3	9:35	13:45	25:00	31:30	Silt Flats, Stumps	4.9		Calm Sunny Cool	
42	30-Apr-15	13:50	12	423743	5760707	Kinbasket Lake Outlet	03-May-15	9:45	1	PMC	N				120		N	U	42								Silt Flats, Stumps	4.9		Calm Sunny Cool	
43	30-Apr-15	14:00	10	424030	5760763	Kinbasket Lake Outlet	03-May-15	9:50	0										43								Silt Flats, Stumps	4.9		Calm Sunny Cool	
44	30-Apr-15	14:15	13.1	431442	5757697	Kinbasket River Mouth	03-May-15	11:30	0										44								silt bottom outflow plume	4.9		Calm Sunny Cool	
45	30-Apr-15	14:20	12.9	431241	5757702	Kinbasket River Mouth	03-May-15	11:40	1	BT	N				319	0.27	N	U	45								silt bottom outflow plume	4.9		Calm Sunny Cool	
46	30-Apr-15	14:25	8.5	430787	5757498	Kinbasket River Mouth	03-May-15	13:15	1	BB	N	39000	23	150.3	587	1.28	N	M	46	39000	23	150.3	9:10	12:55	22:00	45:00	silt bottom outflow plume	4.9		Calm Sunny Cool	
47	30-Apr-15	14:30	13.5	430824	5757399	Kinbasket River Bay	03-May-15	11:50	0										47								Silt covered cobble-gravel	4.9		Calm Sunny Cool	
48	30-Apr-15	14:35	15	430756	5758605	Kinbasket River Bay	03-May-15	12:05	2	BB	N	35900	14	150.27	864	3.06	N	U	48	35900	14	150.27	8:30	12:35	20:00	29:30	Silt covered cobble-gravel	4.9		Calm Sunny Cool	
48	30-Apr-15	14:35	15	430756	5758605	Kinbasket River Bay	03-May-15	12:05		BB	N	36000	15	150.27	788	2.26	N	U	48	36000	15	150.27	9:30	12:30	21:00	34:00	Silt covered cobble-gravel	4.9		Calm Sunny Cool	
49	30-Apr-15	14:40	9.5	430657	5757661	Kinbasket River Bay	03-May-15	13:00	0										49								Silt covered cobble-gravel	4.9		Calm Sunny Cool	
50	30-Apr-15	14:45	11.5	430462	5757728	Kinbasket River Bay	03-May-15	13:05	0										50								Silt covered cobble-gravel	4.9		Calm Sunny Cool	
51	30-Apr-15	15:00	12.7	425687	5760283	East Creek mouth	03-May-15	10:00	0										51								Silt covered cobble-gravel	4.9		Calm Sunny Cool	
52	30-Apr-15	15:10	11.2	422058	5761242	Kinbasket lake outlet	03-May-15	8:45	0										52								silt bottom outflow plume	4.9		Calm Sunny Cool	
53	30-Apr-15	15:20	13	421741	5761419	Kinbasket lake outlet	03-May-15	8:40	0										53								silt bottom outflow plume	4.9		Calm Sunny Cool	
54	02-May-15	15:00	14.4	436701	5756386	Sullivan River Mouth	04-May-15	9:00	2	BB	N	36100	16	150.27	792	2.24	N	U	54	36100	16	150.27	9:20	13:41	20:00	39:00	silt bottom, turbid	6.6	7.1	Calm Cloudy Turbid	64-69
54	02-May-15	15:00	14.4	436701	5756386	Sullivan River Mouth	04-May-15	9:00		BB	N				560	0.94	N	U	54								silt bottom, turbid	6.6	7.1	Calm Cloudy Turbid	
55	02-May-15	15:05	11.8	436904	5756406	Sullivan River Mouth	04-May-15	9:50	0										55								silt bottom, turbid	6.6	7.1	Calm Cloudy Turbid	
56	02-May-15	15:10	8.8	437132	5756445	Sullivan River Mouth	04-May-15	9:55	0										56								silt bottom, turbid	6.6	7.1	Calm Cloudy Turbid	
57	02-May-15	15:15	10.3	437365	5756563	Sullivan River Mouth	04-May-15	10:00	0										57								silt bottom, turbid	6.6	7.1	Calm Cloudy Turbid	

ID #	Trap Set Date	Trap Set Time	Trap Set Depth (m)	Trap Set Location Easting	Trap Set Location Northing	Trap Set Location General Description	Trap Pull Date	Trap Pull Time	Catch	Species Code	RECAP (Y/N)	Acoustic Code	Radio Code	Radio Freq	Length (mm)	Weight (kg)	MORT (Y/N)	Sex (M/F)	ID #	Acoustic Code	Radio Code	Radio Freq	Anaesthesia (min:sec)	Surgery (min:sec)	Recovery (min:sec)	Release (min:sec)	Camera drop Habitat Comments	Set H_2O^0C:	Pull H_2O^0C:	Weather & Water Conditions	Photos
58	02-May-15	15:20	12.5	437308	5756815	Sullivan River Mouth	04-May-15	10:05	0										58								silt bottom, turbid	6.6	7.1	Calm Cloudy Turbid	
59	02-May-15	15:25	11.2	437347	5756916	Sullivan River Mouth	04-May-15	10:10	2	CC									59								silt bottom, turbid	6.6	7.1	Calm Cloudy Turbid	
60	02-May-15	15:30	9.7	437658	5756964	Sullivan River Mouth	04-May-15	10:20	2	BB	N	35400	9	150.27	700	1.7	N	F	60	35400	9	150.27	9:28	12:47	23:00	44:00	silt bottom, turbid	6.6	7.1	Calm Cloudy Turbid	
60	02-May-15	15:30	9.7	437658	5756964	Sullivan River Mouth	04-May-15	10:20		BB	N	38300	4	150.3	669	1.3	N	U	60	38300	4	150.3	8:10	11:45	22:00	32:00	silt bottom, turbid	6.6	7.1	Calm Cloudy Turbid	
61	02-May-15	15:35	8.2	437973	5756861	Sullivan River Mouth	04-May-15	11:25	1	BB	N	35500	10	150.27	760	1.91	N	M	61	35500	10	150.27	8:30	14:55	21:00	36:00	silt bottom, turbid	6.6	7.1	Calm Cloudy Turbid	
62	02-May-15	15:40	10.9	437466	5756978	Sullivan River Mouth	04-May-15	10:15	0										62								silt bottom, turbid	6.6	7.1	Calm Cloudy Turbid	
63	02-May-15	15:45	12.1	437294	5756971	Sullivan River Mouth	04-May-15	12:20	6	CC									63								silt bottom, turbid	6.6	7.1	Calm Cloudy Turbid	
64	02-May-15	15:50	13.1	437172	5756879	Sullivan River Mouth	04-May-15	12:28	2	BB	N	35600	11	150.27	760	1.96	N	U	64	35600	11	150.27	9:00	13:00	19:00	34:00	silt bottom, turbid	6.6	7.1	Calm Cloudy Turbid	
64	02-May-15	15:50	13.1	437172	5756879	Sullivan River Mouth	04-May-15	12:28		BB	N				534	0.96	N	U	64								silt bottom, turbid	6.6	7.1	Calm Cloudy Turbid	
65	02-May-15	15:53	14.5	437052	5756827	Sullivan River Mouth	04-May-15	5:15	0										65								silt bottom, turbid	6.6	7.1	Calm Cloudy Turbid	
66	02-May-15	15:55	14.7	437167	5756755	Sullivan River Mouth	04-May-15	13:20	3	BB	N	35700	12	150.27	939	3.96	N	U	66	35700	12	150.27	9:00	12:35	18:00	34:00	silt bottom, turbid	6.6	7.1	Calm Cloudy Turbid	
66	02-May-15	15:55	14.7	437167	5756755	Sullivan River Mouth	04-May-15	13:20		BB	N				633	1.26	N	U	66								silt bottom, turbid	6.6	7.1	Calm Cloudy Turbid	
66	02-May-15	15:55	14.7	437167	5756755	Sullivan River Mouth	04-May-15	13:20		BB	N						N	U	66								silt bottom, turbid	6.6	7.1	Calm Cloudy Turbid	74-82
67	02-May-15	15:58	14	437006	5756948	Sullivan River Mouth	04-May-15	13:10	1	CC									67								silt bottom, turbid	6.6	7.1	Calm Cloudy Turbid	74-82
68	02-May-15	16:00	11.3	436902	5757105	Sullivan River Mouth	04-May-15	13:05	0										68								silt bottom, turbid	6.6	7.1	Calm Cloudy Turbid	74-82
69	03-May-15	10:25	12.6	430325	5749673	Windy Creek outley bay	05-May-15	9:45	1	BB	N	35000	5	150.27	893	2.96	N	U	69	35000	5	150.27	9:40	15:45	22:00	34:30	Silt - sand - gravel bottom, Turbid	3.5		light breeze, sunny	74-82
70	03-May-15	10:30	12.1	430269	5749554	Windy Creek outley bay	05-May-15	10:20	2	BB	N	35100	6	150.27	713	1.73	N	F	70	35100	6	150.27	9:20	13:45	21:00	33:00	Silt - sand - gravel bottom, Turbid	3.5		light breeze, sunny	74-82
70	03-May-15	10:30	12.1	430269	5749554	Windy Creek outley bay	05-May-15	10:20		BB	N				623	1.45	N	U	70								Silt - sand - gravel bottom, Turbid	3.5		light breeze, sunny	74-82
71	03-May-15	10:35	11.1	429965	5749402	Windy Creek outley bay	05-May-15	11:10	2	BB	N				677	1.31	N	U	71								Silt - sand - gravel bottom, Turbid	3.5		light breeze, sunny	74-82
71	03-May-15	10:35	11.1	429965	5749402	Windy Creek outley bay	05-May-15	11:10		BB	N				608	1.16	N	U	71								Silt - sand - gravel bottom, Turbid	3.5		light breeze, sunny	74-82
72	03-May-15	10:40	13.8	430426	5749857	Windy Creek outley bay	05-May-15	9:15	1	BB	N	38400	5	150.3	588	0.84	N	U	72	38400	5	150.3	9:20	10:25	20:00	33:30	Silt - sand - gravel bottom, Turbid	3.5		light breeze, sunny	74-82
73	03-May-15	10:45	15.4	430565	5750107	Windy Creek outley bay	05-May-15	9:00	0										73								Silt - sand - gravel bottom, Turbid	3.5		light breeze, sunny	74-82
74	03-May-15	10:50	13.2	430711	5750663	Windy Creek outley bay	05-May-15	8:55	0										74								Silt - sand - gravel bottom, Turbid	3.5		light breeze, sunny	74-82
75	03-May-15	11:00	15.2	431128	5750773	Windy Creek outley bay	05-May-15	8:50	0										75								Silt - sand - gravel bottom, Turbid	3.5		light breeze, sunny	74-82
76	03-May-15	11:45	14.6	431007	5757623	Kinbasket River outlet reset	05-May-15	13:25	1	BB	N	35200	7	150.27	739	1.62	N	U	76	35200	7	150.27	8:42	11:47	30:00	41:00	silt bottom outflow plume	3.5		Calm Sunny Cool	74-82
77	03-May-15	11:50	15.1	430865	5757607	Kinbasket River outlet reset	05-May-15	13:50	0										77								silt bottom outflow plume	3.5		Calm Sunny Cool	74-82
78	03-May-15	11:55	14.6	430784	5757479	Kinbasket River outlet reset	05-May-15	14:15	0										78								silt bottom outflow plume	3.5		Calm Sunny Cool	74-82
79	03-May-15	12:25	15.1	430643	5757558	Kinbasket River outlet reset	05-May-15	15:05	2	CC									79								silt bottom outflow plume	3.5		Calm Sunny Cool	74-82
80	03-May-15	13:00	14.6	430521	5757627	Kinbasket River outlet reset	05-May-15	15:00	0										80								silt bottom outflow plume	3.5		Calm Sunny Cool	74-82
81	03-May-15	13:45	17	430712	5757533	Kinbasket River outlet reset	05-May-15	14:25	1	BB	N	35300	8	150.27	859	2.66	N	U	81	35300	8	150.27	8:30	11:00	18:00	28:00	silt bottom outflow plume	3.5		Calm Sunny Cool	74-82
82	03-May-15	13:50	18.3	430763	5757497	Kinbasket River outlet reset	05-May-15	14:20	0										82								silt bottom outflow plume	3.5		Calm Sunny Cool	74-82
83	03-May-15	14:00	17	430789	5757562	Kinbasket River outlet reset	05-May-15	14:50	1	CC									83								silt bottom outflow plume	3.5		Calm Sunny Cool	
84	04-May-15	9:50	10.6	436736	5756377	Sullivan River outlet-Bay reset	06-May-15	13:10	1	BT	N				145	0.035	N	U	84								silt bottom outflow plume	7.1	6.9	cloudy, windy, cool	
85	04-May-15	10:05	13.5	437289	5756786	Sullivan River outlet-Bay reset	06-May-15	13:45	1	BB	N				444	0.65	N	U	85								silt bottom outflow plume	7.1	6.9	cloudy, windy, cool	
86	04-May-15	10:10	12.4	437296	5756864	Sullivan River outlet-Bay reset	06-May-15	10:40	2	BB	N	38500	6	150.3	720	1.41	N	U	86	38500	6	150.3	8:00	13:00	20:00	35:00	silt bottom outflow plume	7.1	6.9	cloudy, windy, cool	
86	04-May-15	10:10	12.4	437296	5756864	Sullivan River outlet-Bay reset	06-May-15	10:40		BB	N				566	1.16	N	U	86								silt bottom outflow plume	7.1	6.9	cloudy, windy, cool	

	Trap Set			Trap Set Location			Trap Pull			Species	RECAP	Acoustic	Radio	Radio	Length	Weight	MORT	Sex		Acoustic	Radio	Radio	Anaesthesia	Surgery	Recovery	Release	Camera drop	Set	Pull	Weather & Water	
ID #	Date	Time	Depth (m)	Easting	Northing	General Description	Date	Time	Catch	Code	(Y/N)	Code	Code	Freq	(mm)	(kg)	(Y/N)	(M/F)	ID #	Code	Code	Freq	(min:sec)	(min:sec)	(min:sec)	(min:sec)	Habitat Comments	H_2O^0C:	H_2O^0C:	Conditions	Photos
87	04-May-15	10:40	9.6	437685	5756963	Sullivan flooded river channel	06-May-15	10:20	1	PMC	N				215		N	U	87								silt bottom outflow plume	7.1	6.9	cloudy, windy, cool	
98	04-May-15	11:25	8	437343	5756061	Sullivan flooded river channel	06-May-15	9:40	1	BB	N	34700	2	150.27	715	1.6	N	F	98	34700	2	150.27	9:00	12:24	20:00	30:00	silt bottom outflow plume	7.1	6.9	cloudy, windy, cool	
99	04-May-15	11:55	5.8	438325	5756682	Sullivan flooded river channel	06-May-15	9:08	1	BB	N	34600	1	150.27	723	1.87	N	M	99	34600	1	150.27	8:40	12:16	20:00	26:29	silt bottom outflow plume	7.1	6.9	cloudy, windy, cool	
100	04-May-15	12:10	4.3	438549	5756884	Sullivan flooded river channel	06-May-15	9:00	1	BB	N				538	1.04	N	U	100								silt bottom outflow plume	7.1	6.9	cloudy, windy, cool	
101	04-May-15	12:25	11.5	437388	5756954	Sullivan River outlet-Bay reset	06-May-15	10:30	1	BB	Y	31400	20	150.25	746	2.11	N	U	101	31400	20	150.25					silt bottom outflow plume	7.1	6.9	cloudy, windy, cool	
102	04-May-15	12:30	13	437187	5756859	Sullivan River outlet-Bay reset	06-May-15	10:35	1	BB	N	34800	3	150.27	690	1.7	N	U	102	34800	3	150.27	9:45	14:40	17:00	23:00	silt bottom outflow plume	7.1	6.9	cloudy, windy, cool	
103	04-May-15	12:57	13	437238	5756780	Sullivan River outlet-Bay reset	06-May-15	11:30	0										103								silt bottom outflow plume	7.1	6.9	cloudy, windy, cool	
104	04-May-15	13:10	12	437066	5757025	Sullivan River outlet-Bay reset	06-May-15	12:10	2	BB	N	34900	4	150.27	847	2.61	N	U	104	34900	4	150.27	8:40	14:43	19:00	29:00	silt bottom outflow plume	7.1	6.9	cloudy, windy, cool	
104	04-May-15	13:10	12	437066	5757025	Sullivan River outlet-Bay reset	06-May-15	12:10		BB	N				445	0.62	N	U	104								silt bottom outflow plume	7.1	6.9	cloudy, windy, cool	
105	04-May-15	13:15	14	437009	5756949	Sullivan River outlet-Bay reset	06-May-15	12:00	0										105								silt bottom outflow plume	7.1	6.9	cloudy, windy, cool	
106	04-May-15	13:20	14.4	437063	5756831	Sullivan River outlet-Bay reset	06-May-15	12:50	1	BB	N				632	1.46	N	U	106								silt bottom outflow plume	7.1	6.9	cloudy, windy, cool	
107	04-May-15	13:50	15.1	437159	5756681	Sullivan River outlet-Bay reset	06-May-15	12:58	2	CC					55				107								silt bottom outflow plume	7.1	6.9	cloudy, windy, cool	
108	04-May-15	14:05	13	436488	5756399	Sullivan River outlet-Bay reset	06-May-15	13:20	1	BT	N				362	0.4	N	U	108								silt bottom outflow plume	7.1	6.9	cloudy, windy, cool	
109	05-May-15	11:40	12.1	437310	5747794	Kinbasket Lake Inlet Flats - Creek Mouth	07-May-15	10:12	0										109								sand, gravel, cobble	6.8	4.6	windy, rain, squalls	
110	05-May-15	11:45	12.7	437336	5747800	Kinbasket Lake Inlet Flats - Creek Mouth	07-May-15	10:15	1	BB	N				500	0.7	N	U	110								sand, gravel, cobble	6.8	4.6	windy, rain, squalls	
110	05-May-15	11:45	12.7	437336	5747800	Kinbasket Lake Inlet Flats - Creek Mouth	07-May-15	10:15	1	NPM	N				220	0.11	N	U	110								sand, gravel, cobble	6.8	4.6	windy, rain, squalls	
111	05-May-15	11:55	8.8	442941	5743507	Columbia Reach - Creek Mouth	07-May-15	12:15	3	NPM	N				324	0.34	N	U	111								sand, gravel, cobble	6.8	4.6	windy, rain, squalls	
111	05-May-15	11:55	8.8	442941	5743507	Columbia Reach - Creek Mouth	07-May-15	12:15		NPM	N				159	0.05	N	U	111								sand, gravel, cobble	6.8	4.6	windy, rain, squalls	
111	05-May-15	11:55	8.8	442941	5743507	Columbia Reach - Creek Mouth	07-May-15	12:15		NPM	N				147	0.05	N	U	111								sand, gravel, cobble	6.8	4.6	windy, rain, squalls	
112	05-May-15	12:00	12.5	442977	5743616	Columbia Reach - Creek Mouth	07-May-15	12:25	0										112								sand, gravel, cobble	6.8	4.6	windy, rain, squalls	
113	05-May-15	12:05	14.8	443037	5743687	Columbia Reach - Creek Mouth	07-May-15	12:30	1	BB	N	38100	2	150.3	595	1.08	N	M	113	38100	2	150.3	8:30	11:10	20:30	37:00	sand, gravel, cobble	6.8	4.6	windy, rain, squalls	
114	05-May-15	12:10	9.6	443313	5744533	Columbia Reach - Creek Mouth	07-May-15	13:55	0										114								sand, gravel, cobble	6.8	4.6	windy, rain, squalls	
115	05-May-15	12:20	13.6	443326	5744489	Columbia Reach - Creek Mouth	07-May-15	13:15	1	BB	N	37900	18	150.3	790	2.41	N	M	115	37900	18	150.3	8:15	12:00	26:00	37:30	sand, gravel, cobble	6.8	4.6	windy, rain, squalls	
116	05-May-15	13:30	14.8	430980	5757627	Kinbasket River outlet reset	07-May-15	8:40	0										116								silt bottom outflow plume	7.1	6.9	windy, rain, squalls	
117	05-May-15	14:00	14.8	430879	5757608	Kinbasket River outlet reset	07-May-15	8:45	0										117								silt bottom outflow plume	7.1	6.9	windy, rain, squalls	
118	05-May-15	14:10	16.5	430790	5757561	Kinbasket River outlet reset	07-May-15	8:50	0										118								silt bottom outflow plume	7.1	6.9	windy, rain, squalls	
119	05-May-15	14:20	12.7	430777	5757495	Kinbasket River outlet reset	07-May-15	8:55	0										119								silt bottom outflow plume	7.1	6.9	windy, rain, squalls	
120	05-May-15	14:25	18	430733	5757514	Kinbasket River outlet reset	07-May-15	8:58	1	BB	N	32800	8	150.3	806	2.18	N	U	120	32800	8	150.3	9:30	13:48	18:00	27:30	silt bottom outflow plume	7.1	6.9	windy, rain, squalls	
121	05-May-15	14:45	13.8	430575	5757614	Kinbasket River outlet reset	07-May-15	9:35	0										121								silt bottom outflow plume	7.1	6.9	windy, rain, squalls	
122	05-May-15	15:05	12.8	430488	5757667	Kinbasket River outlet reset	07-May-15	9:37	0										122								silt bottom outflow plume	7.1	6.9	windy, rain, squalls	
123	05-May-15	15:15	14.5	430643	5757568	Kinbasket River outlet reset	07-May-15	9:30	0										123								silt bottom outflow plume	7.1	6.9	windy, rain, squalls	
124	06-May-15	9:05	4.3	438549	5756884	Sullivan River outlet-Bay reset	08-May-15	8:55	0										124								silt bottom outflow plume	6.9	5.7	calm sunny	88-93
125	06-May-15	9:10	6.7	438325	5756682	Sullivan River outlet-Bay reset	08-May-15	9:00	1	BB	N	37800	17	150.3	727	1.6	N	U	125	37800	17	150.3	10:00	14:00	18:30	30:00	silt bottom outflow plume	6.9	5.7	calm sunny	
126	06-May-15	9:45	7.8	437343	5756061	Sullivan River outlet-Bay reset	08-May-15	9:20	1	CC									126								silt bottom outflow plume	6.9	5.7	calm sunny	91, 92
127	06-May-15	10:20	9.4	437659	5756970	Sullivan River outlet-Bay reset	08-May-15	9:30	0										127								silt bottom outflow plume	6.9	5.7	calm sunny	
128	06-May-15	10:35	11	437365	5756949	Sullivan River outlet-Bay reset	08-May-15	9:50	1	BB	N	38200	3	150.3	650	1.04	N	U	128	38200	3	150.3	9:30	16:27	26:00	31:00	silt bottom outflow plume	6.9	5.7	calm sunny	

ID #	Trap Set Date	Trap Set Time	Trap Set Depth (m)	Trap Set Location Easting	Trap Set Location Northing	Trap Set Location General Description	Trap Pull Date	Trap Pull Time	Catch	Species Code	RECAP (Y/N)	Acoustic Code	Radio Code	Radio Freq	Length (mm)	Weight (kg)	MORT (Y/N)	Sex (M/F)	ID #	Acoustic Code	Radio Code	Radio Freq	Anaesthesia (min:sec)	Surgery (min:sec)	Recovery (min:sec)	Release (min:sec)	Camera drop Habitat Comments	Set H_2O ^0C :	Pull H_2O ^0C :	Weather & Water Conditions	Photos
129	06-May-15	10:40	12.5	437296	5756864	Sullivan River outlet-Bay reset	08-May-15	10:30	5	CC	N				45				129								silt bottom outflow plume	6.9	5.7	calm sunny	
130	06-May-15	11:30	13	437203	5756781	Sullivan River outlet-Bay reset	08-May-15	10:40	0										130								silt bottom outflow plume	6.9	5.7	calm sunny	90
131	06-May-15	11:35	12.8	437187	5756859	Sullivan River outlet-Bay reset	08-May-15	10:45	1	BB	N	37400	13	150.3	734	1.96	N	M	131	37400	13	150.3	8:24	14:00	19:30	34:00	silt bottom outflow plume	6.9	5.7	calm sunny	
132	06-May-15	12:03	13.7	437656	5756949	Sullivan River outlet-Bay reset	08-May-15	11:30	1	BB	N				600	1.14	N	U	132								silt bottom outflow plume	6.9	5.7	calm sunny	
133	06-May-15	12:20	11.9	437066	5757025	Sullivan River outlet-Bay reset	08-May-15	11:20	1	BB	N				680	1.36	N	U	133								silt bottom outflow plume	6.9	5.7	calm sunny	
134	06-May-15	12:55	14.3	437063	5756831	Sullivan River outlet-Bay reset	08-May-15	11:35	1	BB	N	37500	14	150.3	877	3.06	N	U	134	37500	14	150.3	10:00	15:00	26:00	38:00	silt bottom outflow plume	6.9	5.7	calm sunny	
135	06-May-15	13:05	15	437159	5756681	Sullivan River outlet-Bay reset	08-May-15	12:35	0										135								silt bottom outflow plume	6.9	5.7	calm sunny	
136	06-May-15	13:15	13.5	436736	5756377	Sullivan River outlet-Bay reset	08-May-15	12:40	0										136								silt bottom outflow plume	6.9	5.7	calm sunny	
137	06-May-15	13:20	10.5	436488	5756399	Sullivan River outlet-Bay reset	08-May-15	12:45	1	CC	N				75		N	U	137								silt bottom outflow plume	6.9	5.7	calm sunny	
137	06-May-15	13:20	10.5	436488	5756399	Sullivan River outlet-Bay reset	08-May-15	12:45	1	BT	N				130		N	U	137								silt bottom outflow plume	6.9	5.7	calm sunny	
138	06-May-15	13:45	14.3	437280	5756777	Sullivan River outlet-Bay reset	08-May-15	10:35	0										138								silt bottom outflow plume	6.9	5.7	calm sunny	
139	07-May-15	10:55	12.3	452556	5735061	Surprise Rapids Narrows	09-May-15	9:15	0										139								silt overlain historic coarse substrate	8.2	9.4	sunny, light breeze	
140	07-May-15	11:00	10.3	452485	5735554	Surprise Rapids Narrows	09-May-15	9:30	1	BB	N				556	0.83	N	U	140								silt overlain historic coarse substrate	8.2	9.4	sunny, light breeze	
140	07-May-15	11:00	10.3	452485	5735554	Surprise Rapids Narrows	09-May-15	9:30	1	NPM	N				493	1.46	N	U	140								silt overlain historic coarse substrate	8.2	9.4	sunny, light breeze	
141	07-May-15	11:10	14	452821	5736075	Surprise Rapids Narrows	09-May-15	9:40	2	BB	N				825	3.4	N	U	141								silt overlain historic coarse substrate	8.2	9.4	sunny, light breeze	
141	07-May-15	11:10	14	452821	5736075	Surprise Rapids Narrows	09-May-15	9:40		BB	N	37600	15	150.3	818	2.7	N	M	141	37600	15	150.3	7:34	11:00	22:00	30:00	silt overlain historic coarse substrate	8.2	9.4	sunny, light breeze	
142	07-May-15	11:15	10.4	453219	5736262	Surprise Rapids Narrows	09-May-15	10:15	1	BB	N	37700	16	150.3	710	2.11	N	U	142	37700	16	150.3	8:50	13:50	20:00	30:00	silt overlain historic coarse substrate	8.2	9.4	sunny, light breeze	
142	07-May-15	11:15	10.4	453219	5736262	Surprise Rapids Narrows	09-May-15	10:15	1	NPM	N				195	0.125	N	U	142								silt overlain historic coarse substrate	8.2	9.4	sunny, light breeze	
143	07-May-15	11:20	8.1	452459	5736715	Surprise Rapids Narrows	09-May-15	10:55	4	NPM	N				147		N	U	143								silt overlain historic coarse substrate	8.2	9.4	sunny, light breeze	94-101
144	07-May-15	11:30	13.8	451724	5737999	Surprise Rapids outlet	09-May-15	11:05	3	BB	N	37000	25	150.27	780	2.16	N	U	144	37000	25	150.27	9:15	18:50	25:00	31:00	silt overlain historic coarse substrate	8.2	9.4	sunny, light breeze	
144	07-May-15	11:30	13.8	451724	5737999	Surprise Rapids outlet	09-May-15	11:05		BB	N				624	1.31	N	U	144								silt overlain historic coarse substrate	8.2	9.4	sunny, light breeze	99, 100
144	07-May-15	11:30	13.8	451724	5737999	Surprise Rapids outlet	09-May-15	11:05		BB	N				540	0.96	N	U	144								silt overlain historic coarse substrate	8.2	9.4	sunny, light breeze	98
145	07-May-15	11:40	12.1	451575	5738366	Surprise rapids outlet - Creek mouth	09-May-15	11:50	1	BB	N	37100	26	150.27	658	1.81	N	U	145	37100	26	150.27	10:30	15:50	21:00	30:00	silt overlain historic coarse substrate	8.2	9.4	sunny, light breeze	97
146	07-May-15	11:50	11.9	450127	5739737	Surprise rapids outlet - Creek mouth	09-May-15	12:50	1	NPM	N				518	1.71	N	U	146								silt overlain historic coarse substrate	8.2	9.4	sunny, light breeze	
147	07-May-15	11:55	8.3	450199	5739900	Surprise rapids outlet - Creek mouth	09-May-15	12:45	2	RSS	N				85		N	U	147								silt overlain historic coarse substrate	8.2	9.4	sunny, light breeze	
148	07-May-15	12:05	11.2	449108	5739467	Surprise rapids outlet - Creek mouth	09-May-15	12:55	1	BB	N	37200	11	150.3	885	2.51	N	U	148	37200	11	150.3	8:20	14:30	26:00	35:00	silt overlain historic coarse substrate	8.2	9.4	sunny, light breeze	
149	07-May-15	12:20	11.1	442958	5743535	Columbia Reach - Creek Mouth	09-May-15	14:05	1	BB	N				491	0.8	N	U	149								silt overlain historic coarse substrate	8.2	9.4	sunny, light breeze	94-96
151	07-May-15	13:00	14.3	443013	5743654	Columbia Reach - Creek Mouth	09-May-15	14:00	1	BB	N				565	0.95	N	U	151								silt overlain historic coarse substrate	8.2	9.4	sunny, light breeze	
153	07-May-15	14:00	11	443170	5744361	Columbia Reach - Creek Mouth	09-May-15	14:15	1	NPM	N				326	0.36	N	U	153								silt overlain historic coarse substrate	8.2	9.4	sunny, light breeze	
154	07-May-15	14:15	12.8	444715	5742335	Columbia Reach - Creek Mouth	09-May-15	13:50	1	BB	N				535	0.67	N	U	154												
155	08-May-15	13:35	12.7	426729	5758657	Kinbasket Lake Creek Mouth	10-May-15	9:25	1	BB	N				601	1.2	N	U	155								silt overlain gravel-cobble	5.9	7.2	sunny warm calm	
156	08-May-15	13:40	12.6	426556	5758869	Kinbasket Lake Creek Mouth	10-May-15	9:30	0										156								silt overlain gravel-cobble	5.9	7.2	sunny warm calm	
157	08-May-15	13:50	12.1	425027	5757191	Kinbasket Lake Creek Mouth	10-May-15	9:00	1	BB	N				597	1.09	N	U	157								silt overlain gravel-cobble	5.9	7.2	sunny warm calm	
158	08-May-15	13:55	12	425025	5757449	Kinbasket Lake Creek Mouth	10-May-15	8:50	0										158								silt overlain gravel-cobble	5.9	7.2	sunny warm calm	
159	08-May-15	14:00	12	426535	5755577	Kinbasket Lake Creek Mouth	10-May-15	9:10	1	BB	N				550	1.06	N	U	159								silt overlain gravel-cobble	5.9	7.2	sunny warm calm	
160	08-May-15	14:10	11.5	426633	5755568	Kinbasket Lake Creek Mouth	10-May-15	9:15	4	CC	N				124		N	U	160								silt overlain gravel-cobble	5.9	7.2	sunny warm calm	

	Trap Set			Trap Set Location			Trap Pull			Species	RECAP	Acoustic	Radio	Radio	Length	Weight	MORT	Sex		Acoustic	Radio	Radio	Anaesthesia	Surgery	Recovery	Release	Camera drop	Set	Pull	Weather & Water	
ID #	Date	Time	Depth (m)	Easting	Northing	General Description	Date	Time	Catch	Code	(Y/N)	Code	Code	Freq	(mm)	(kg)	(Y/N)	(M/F)	ID #	Code	Code	Freq	(min:sec)	(min:sec)	(min:sec)	(min:sec)	Habitat Comments	H_2O °C :	H_2O °C :	Conditions	Photos
161	08-May-15	14:20	13.2	423795	5760640	Kinbasket outlet	10-May-15	9:40	2	BB	N	37300	12	150.3	756	1.86	N	U	161	37300	12	150.3	9:16	14:00	22:00	30:00	silt overlain gravel-cobble	5.9	7.2	sunny warm calm	
161	08-May-15	14:20	13.2	423795	5760640	Kinbasket outlet	10-May-15	9:40		BB	N				630	1.18	N	U	161								silt overlain gravel-cobble	5.9	7.2	sunny warm calm	
162	08-May-15	14:25	13.4	423388	5760805	Kinbasket outlet	10-May-15	10:30	0										162								silt overlain gravel-cobble	5.9	7.2	sunny warm calm	
163	08-May-15	14:30	12.8	422854	5761224	Kinbasket outlet	10-May-15	10:35	0										163								silt overlain gravel-cobble	5.9	7.2	sunny warm calm	
164	08-May-15	14:55	14.6	422303	5760717	Columbia Reach - Creek Mouth	10-May-15	10:45	1	BB	N				550		N	U	164								silt overlain gravel-cobble	5.9	7.2	sunny warm calm	
165	08-May-15	15:05	12.5	418776	5762649	Columbia Reach - Creek Mouth	10-May-15	11:00	1	CC									165								silt overlain gravel-cobble	5.9	7.2	sunny warm calm	
166	08-May-15	15:20	10.2	414025	5765023	Columbia Reach - Creek Mouth	10-May-15	11:10	1	BB	N				514	0.82	N	U	166								silt overlain gravel-cobble	5.9	7.2	sunny warm calm	
168	08-May-15	15:35	13.1	415987	5767328	Cummings River outlet	10-May-15	11:45	2	BB	N				630	1.56	N	U	168								silt overlain gravel-cobble	5.9	7.2	sunny warm calm	
168	08-May-15	15:35	13.1	415987	5767328	Cummings River outlet	10-May-15	11:45		BB	N				564	0.94	N	U	168								silt overlain gravel-cobble	5.9	7.2	sunny warm calm	
169	08-May-15	13:45	11.9	415077	5766453	Cummings River outlet	10-May-15	11:30	0										169								silt overlain gravel-cobble	5.9	7.2	sunny warm calm	

APPENDIX 2: Maps of Burbot movement detected by fixed (n=38) and mobile acoustic tracking (n=13) in the Kinbasket Reservoir study area.

APPENDIX 3: Summary of radio tracked Burbot and water temperatures in Kinbasket Reservoir (February 17 – April 18, 2015). Burbot with acoustic codes marked by * indicate individuals exhibiting adfluvial movements.

Date	Time	Acoustic Code	Radio Code	Channel	Frequency	UTM Zone	UTM E	UTM N	Temperature (°C)
02/02/15	11:18:22	30400	10	1	150.25	11	431121	5757639	-2
06/03/15	11:38:02	30700	13	1	150.25	11	431816	5757734	1.2
06/03/15	14:21:31	32200	2	2	150.3	11	449294	5739646	-0.4
06/03/15	10:43:09	32400	4	2	150.3	11	453414	5736616	0.4
06/03/15	11:54:57	34100	21	2	150.3	11	419583	5762956	-0.4
06/03/15	11:21:37	*31000	16	1	150.25	11	441321	5756585	1.2
06/03/15	11:22:28	*31600	22	1	150.25	11	440643	5756551	0.4
06/03/15	11:58:48	*31700	23	1	150.25	11	414770	5766560	-1.1
22/03/15	11:42:45	30400	10	1	150.25	11	431354	5757621	1.2
22/03/15	11:44:00	30700	13	1	150.25	11	431368	5757673	2.8
22/03/15	12:03:07	31700	23	1	150.25	11	416325	5767494	2.8
22/03/15	14:32:44	32200	2	2	150.3	11	449526	5739489	-0.4
02/04/15	11:00:15	31000	16	1	150.25	11	441341	5756493	1.2
02/04/15	11:24:12	33100	11	2	150.3	11	431181	5757713	1.2
18/04/15	12:19:02	31000	16	1	150.25	11	441331	5756486	2.8
18/04/15	14:13:42	31500	21	1	150.25	11	390828	5767280	8.4
18/04/15	12:18:26	31600	22	1	150.25	11	440733	5756527	7.6
18/04/15	15:22:57	32200	2	2	150.3	11	449083	5739699	-0.4
18/04/15	11:52:09	32400	4	2	150.3	11	453133	5735739	17.2
18/04/15	12:46:13	33100	11	2	150.3	11	431167	5757680	2.8
18/04/15	14:55:55	34100	21	2	150.3	11	418952	5762651	16.4
29/04/15	10:03:18	32900	9	2	150.3	11	420305	5782135	8.4
03/05/15	15:14:36	30400	10	1	150.25	11	431339	5757699	2.8
03/05/15	15:27:31	30700	13	1	150.25	11	431493	5757684	3.6
03/05/15	15:34:56	33100	11	2	150.3	11	431339	5757699	3.6
06/05/15	11:28:21	31400	20	1	150.25	11	430695	5757496	6

APPENDIX 4: Summary of radio tracked Burbot and water depths (m) in Kinbasket Reservoir (February 17 – April 18, 2015). Burbot with acoustic codes marked by * indicate individuals exhibiting adfluvial movements. Burbot with **bolded** acoustic codes indicate individuals exhibiting possible shoal spawning behaviour.

Date	Time	Acoustic Code	Radio Code	Channel	Frequency	UTM Zone	UTM E	UTM N	Depth (m)
02/02/15	11:16:32	**30400**	10	1	150.25				0
02/02/15	11:18:13	**30400**	10	1	150.25				0
02/02/15	11:18:22	**30400**	10	1	150.25				0
02/02/15	11:18:33	**30400**	10	1	150.25				0
02/02/15	11:18:43	**30400**	10	1	150.25				4
02/02/15	11:21:05	**30400**	10	1	150.25				4
02/02/15	11:16:32	**30700**	13	1	150.25				0
02/02/15	11:16:51	**30700**	13	1	150.25	11	431530	5757666	0
02/02/15	08:49:18	**32800**	8	2	150.3				0
02/02/15	11:19:00	33100	11	2	150.3	11	430895	5757572	16
02/02/15	13:44:07	34100	21	2	150.3	11	418770	5762707	196
06/03/15	11:37:04	**30400**	10	1	150.25				0
06/03/15	11:37:24	***30400**	10	1	150.25	11	431201	5757618	0
06/03/15	11:41:29	**30400**	10	1	150.25				0
06/03/15	11:42:23	**30400**	10	1	150.25				0
06/03/15	11:43:22	**30400**	10	1	150.25				0
06/03/15	14:02:40	**30400**	10	1	150.25				0
06/03/15	14:02:58	**30400**	10	1	150.25				0
06/03/15	11:37:42	30700	13	1	150.25				12
06/03/15	11:38:02	**30700**	13	1	150.25				8
06/03/15	11:42:23	30700	13	1	150.25				12
06/03/15	11:07:50	**31000**	16	1	150.25				0
06/03/15	11:08:26	**31000**	16	1	150.25				0
06/03/15	11:21:04	**31000**	16	1	150.25				0
06/03/15	11:21:20	**31000**	16	1	150.25				0
06/03/15	11:21:54	**31000**	16	1	150.25				0
06/03/15	11:23:19	**31000**	16	1	150.25				4
06/03/15	11:07:33	**31600**	22	1	150.25				0
06/03/15	11:21:54	**31600**	22	1	150.25				0
06/03/15	11:22:28	**31600**	22	1	150.25				0
06/03/15	10:46:32	**32200**	2	2	150.3				0
06/03/15	10:46:49	**32200**	2	2	150.3				0
06/03/15	14:21:15	**32200**	2	2	150.3				0
06/03/15	14:21:46	**32200**	2	2	150.3				4
06/03/15	10:42:52	**32400**	4	2	150.3				0
06/03/15	09:05:22	**32800**	8	2	150.3				0
06/03/15	09:05:39	**32800**	8	2	150.3				0
06/03/15	11:36:35	**33100**	11	2	150.3				0

Date	Time	Acoustic Code	Radio Code	Channel	Frequency	UTM Zone	UTM E	UTM N	Depth (m)
06/03/15	11:36:54	**33100**	11	2	150.3				0
06/03/15	11:37:14	**33100**	11	2	150.3				0
06/03/15	11:37:34	**33100**	11	2	150.3				0
06/03/15	11:37:53	**33100**	11	2	150.3				0
06/03/15	11:38:13	**33100**	11	2	150.3				0
06/03/15	11:41:55	**33100**	11	2	150.3				0
06/03/15	11:42:35	**33100**	11	2	150.3				0
06/03/15	11:42:55	**33100**	11	2	150.3	11	430967	5757599	0
06/03/15	11:43:12	**33100**	11	2	150.3				0
06/03/15	11:43:31	**33100**	11	2	150.3				0
06/03/15	11:44:07	**33100**	11	2	150.3				0
06/03/15	11:44:25	**33100**	11	2	150.3				0
06/03/15	14:02:14	**33100**	11	2	150.3				0
06/03/15	14:02:48	**33100**	11	2	150.3				0
06/03/15	11:54:41	34100	21	2	150.3				200
06/03/15	11:55:12	34100	21	2	150.3				200
06/03/15	11:55:28	34100	21	2	150.3				200
06/03/15	13:55:38	34100	21	2	150.3				200
22/03/15	11:42:09	**30400**	10	1	150.25				0
22/03/15	11:42:27	**30400**	10	1	150.25				0
22/03/15	11:42:45	**30400**	10	1	150.25				0
22/03/15	11:43:08	**30400**	10	1	150.25				0
22/03/15	11:44:19	**30400**	10	1	150.25				0
22/03/15	14:14:15	**30400**	10	1	150.25				0
22/03/15	11:43:26	30700	13	1	150.25				12
22/03/15	11:15:04	**31000**	16	1	150.25				0
22/03/15	11:15:50	**31000**	16	1	150.25				0
22/03/15	11:16:38	**31000**	16	1	150.25	11	441448	5756498	0
22/03/15	11:27:09	**31000**	16	1	150.25				0
22/03/15	11:27:56	**31000**	16	1	150.25				0
22/03/15	13:43:46	**31500**	21	1	150.25				4
22/03/15	13:44:02	**31500**	21	1	150.25				4
22/03/15	13:45:21	**31500**	21	1	150.25				4
22/03/15	13:45:46	**31500**	21	1	150.25				4
22/03/15	13:46:03	**31500**	21	1	150.25	11	390817	5767174	4
22/03/15	13:46:11	**31500**	21	1	150.25				4
22/03/15	13:46:37	31500	21	1	150.25				12
22/03/15	11:28:12	**31600**	22	1	150.25	11	440575	5756492	0
22/03/15	12:02:35	**31700**	23	1	150.25				4
22/03/15	12:03:22	**31700**	23	1	150.25				0
22/03/15	12:03:38	**31700**	23	1	150.25				0
22/03/15	12:05:00	31700	23	1	150.25				20
22/03/15	10:55:33	**32200**	2	2	150.3				0

Date	Time	Acoustic Code	Radio Code	Channel	Frequency	UTM Zone	UTM E	UTM N	Depth (m)
22/03/15	14:32:29	**32200**	2	2	150.3				0
22/03/15	11:41:25	**33100**	11	2	150.3				0
22/03/15	11:42:17	**33100**	11	2	150.3				0
22/03/15	11:42:37	**33100**	11	2	150.3	11	431199	5757629	0
22/03/15	11:44:09	**33100**	11	2	150.3				0
22/03/15	11:44:28	**33100**	11	2	150.3				0
22/03/15	11:14:20	**34000**	20	2	150.3				0
22/03/15	11:29:23	**34000**	20	2	150.3	11	439293	5756694	0
22/03/15	11:56:55	34100	21	2	150.3	11	420011	576648	200
22/03/15	11:57:11	34100	21	2	150.3				200
22/03/15	14:07:46	34100	21	2	150.3				200
22/03/15	14:08:02	34100	21	2	150.3				200
02/04/15	11:22:12	**30400**	10	1	150.25				0
02/04/15	11:22:46	**30400**	10	1	150.25	11	431254	5757622	0
02/04/15	11:23:43	**30400**	10	1	150.25				0
02/04/15	11:24:01	**30400**	10	1	150.25				0
02/04/15	11:23:25	**30700**	13	1	150.25	11	431616	5757696	8
02/04/15	08:21:45	**30800**	14	1	150.25				0
02/04/15	08:22:04	**30800**	14	1	150.25				0
02/04/15	08:22:22	**30800**	14	1	150.25				0
02/04/15	10:59:58	**31000**	16	1	150.25				0
02/04/15	11:00:32	**31000**	16	1	150.25				0
02/04/15	11:07:28	**31000**	16	1	150.25				0
02/04/15	11:08:17	**31000**	16	1	150.25				0
02/04/15	12:42:02	**31500**	21	1	150.25	11	390644	5767553	4
02/04/15	12:42:50	**31500**	21	1	150.25				0
02/04/15	10:59:09	**31600**	22	1	150.25				0
02/04/15	10:59:41	**31600**	22	1	150.25				4
02/04/15	11:07:43	**31600**	22	1	150.25				0
02/04/15	11:08:02	**31600**	22	1	150.25	11	440767	5756576	0
02/04/15	10:39:17	**32200**	2	2	150.3	11	449318	5739889	0
02/04/15	13:42:08	**32200**	2	2	150.3				0
02/04/15	10:32:12	**32400**	4	2	150.3	11	453577	5735468	0
02/04/15	11:22:38	**33100**	11	2	150.3				0
02/04/15	11:22:57	**33100**	11	2	150.3				0
02/04/15	11:24:49	**33100**	11	2	150.3				0
02/04/15	11:36:22	34100	21	2	150.3				200
02/04/15	11:36:39	34100	21	2	150.3				200
02/04/15	11:37:10	34100	21	2	150.3	11	419456	5763014	200
02/04/15	11:37:27	34100	21	2	150.3				200
18/04/15	12:46:03	**30400**	10	1	150.25	11	431251	5757699	0
18/04/15	12:46:22	**30400**	10	1	150.25				0
18/04/15	12:29:16	**31000**	16	1	150.25				0

Date	Time	Acoustic Code	Radio Code	Channel	Frequency	UTM Zone	UTM E	UTM N	Depth (m)
18/04/15	13:03:14	**31700**	23	1	150.25				0
18/04/15	13:03:31	**31700**	23	1	150.25	11	416503	5767591	0
18/04/15	15:22:57	**32200**	2	2	150.3				4
18/04/15	11:52:24	**32400**	4	2	150.3				0
18/04/15	08:21:48	**32800**	8	2	150.3				0
18/04/15	10:38:32	**32800**	8	2	150.3				0
18/04/15	10:38:50	**32800**	8	2	150.3				0
18/04/15	10:39:10	**32800**	8	2	150.3				0
18/04/15	12:45:52	**33100**	11	2	150.3				0
18/04/15	12:46:30	**33100**	11	2	150.3				0
03/05/15	15:07:48	**30400**	10	1	150.25				0
03/05/15	15:08:07	**30400**	10	1	150.25				0
03/05/15	15:09:00	**30400**	10	1	150.25				0
03/05/15	15:09:54	**30400**	10	1	150.25				0
03/05/15	15:10:14	**30400**	10	1	150.25				0
03/05/15	15:10:34	**30400**	10	1	150.25				0
03/05/15	15:11:10	**30400**	10	1	150.25				4
03/05/15	15:11:30	**30400**	10	1	150.25				0
03/05/15	15:11:49	**30400**	10	1	150.25				0
03/05/15	15:12:29	**30400**	10	1	150.25				0
03/05/15	15:12:46	**30400**	10	1	150.25				0
03/05/15	15:13:21	**30400**	10	1	150.25				0
03/05/15	15:13:39	**30400**	10	1	150.25				4
03/05/15	15:13:58	**30400**	10	1	150.25				0
03/05/15	15:14:16	**30400**	10	1	150.25				0
03/05/15	15:14:36	**30400**	10	1	150.25				0
03/05/15	15:15:31	**30400**	10	1	150.25				0
03/05/15	15:16:11	**30400**	10	1	150.25				0
03/05/15	15:16:31	**30400**	10	1	150.25				0
03/05/15	15:18:32	**30400**	10	1	150.25				0
03/05/15	15:18:43	**30400**	10	1	150.25				0
03/05/15	15:19:04	**30400**	10	1	150.25				0
03/05/15	15:20:03	**30400**	10	1	150.25				0
03/05/15	15:20:14	**30400**	10	1	150.25				0
03/05/15	15:21:14	**30400**	10	1	150.25				0
03/05/15	15:22:06	**30400**	10	1	150.25				0
03/05/15	15:24:56	**30400**	10	1	150.25				0
03/05/15	15:25:16	**30400**	10	1	150.25				0
03/05/15	15:25:57	**30400**	10	1	150.25				0
03/05/15	15:26:54	**30400**	10	1	150.25				0
03/05/15	15:29:29	**30400**	10	1	150.25				0
03/05/15	15:32:28	**30400**	10	1	150.25				0
03/05/15	15:32:46	**30400**	10	1	150.25				0

Date	Time	Acoustic Code	Radio Code	Channel	Frequency	UTM Zone	UTM E	UTM N	Depth (m)
03/05/15	15:33:07	**30400**	10	1	150.25				0
03/05/15	15:33:25	**30400**	10	1	150.25				0
03/05/15	15:33:45	**30400**	10	1	150.25				0
03/05/15	15:34:29	**30400**	10	1	150.25				0
03/05/15	15:34:48	**30400**	10	1	150.25				0
03/05/15	15:35:07	**30400**	10	1	150.25				0
03/05/15	15:35:26	**30400**	10	1	150.25				0
03/05/15	15:35:46	**30400**	10	1	150.25				0
03/05/15	15:36:07	**30400**	10	1	150.25				0
03/05/15	15:14:55	**30700**	13	1	150.25				0
03/05/15	15:16:11	**30700**	13	1	150.25				0
03/05/15	15:16:31	**30700**	13	1	150.25				0
03/05/15	15:18:32	**30700**	13	1	150.25				0
03/05/15	15:20:53	**30700**	13	1	150.25				4
03/05/15	15:22:38	**30700**	13	1	150.25				0
03/05/15	15:25:36	**30700**	13	1	150.25				0
03/05/15	15:25:57	**30700**	13	1	150.25				0
03/05/15	15:26:36	**30700**	13	1	150.25				0
03/05/15	15:27:11	**30700**	13	1	150.25				0
03/05/15	15:27:31	**30700**	13	1	150.25				0
03/05/15	15:32:46	**30700**	13	1	150.25				0
03/05/15	15:33:25	**30700**	13	1	150.25				0
03/05/15	15:34:06	**30700**	13	1	150.25				4
03/05/15	15:07:57	**33100**	11	2	150.3				0
03/05/15	15:08:32	**33100**	11	2	150.3				0
03/05/15	15:08:49	**33100**	11	2	150.3				0
03/05/15	15:09:29	**33100**	11	2	150.3				4
03/05/15	15:10:04	**33100**	11	2	150.3				0
03/05/15	15:10:24	**33100**	11	2	150.3				0
03/05/15	15:10:43	**33100**	11	2	150.3				0
03/05/15	15:11:02	**33100**	11	2	150.3				0
03/05/15	15:11:20	**33100**	11	2	150.3				0
03/05/15	15:11:41	**33100**	11	2	150.3				0
03/05/15	15:12:00	**33100**	11	2	150.3				0
03/05/15	15:12:19	**33100**	11	2	150.3				0
03/05/15	15:12:54	**33100**	11	2	150.3				0
03/05/15	15:13:13	**33100**	11	2	150.3				0
03/05/15	15:13:31	**33100**	11	2	150.3				0
03/05/15	15:14:26	**33100**	11	2	150.3				0
03/05/15	15:15:42	**33100**	11	2	150.3				0
03/05/15	15:16:03	**33100**	11	2	150.3				0
03/05/15	15:16:22	**33100**	11	2	150.3				0
03/05/15	15:23:08	**33100**	11	2	150.3				0

Date	Time	Acoustic Code	Radio Code	Channel	Frequency	UTM Zone	UTM E	UTM N	Depth (m)
03/05/15	15:23:18	**33100**	11	2	150.3				0
03/05/15	15:23:28	**33100**	11	2	150.3				0
03/05/15	15:23:37	**33100**	11	2	150.3				0
03/05/15	15:24:04	**33100**	11	2	150.3				0
03/05/15	15:25:08	**33100**	11	2	150.3				0
03/05/15	15:25:27	**33100**	11	2	150.3				4
03/05/15	15:26:27	**33100**	11	2	150.3				0
03/05/15	15:29:00	**33100**	11	2	150.3				0
03/05/15	15:29:19	**33100**	11	2	150.3				0
03/05/15	15:29:58	**33100**	11	2	150.3				0
03/05/15	15:32:38	**33100**	11	2	150.3				0
03/05/15	15:32:56	**33100**	11	2	150.3				0
03/05/15	15:33:16	**33100**	11	2	150.3				0
03/05/15	15:33:57	**33100**	11	2	150.3				0
03/05/15	15:34:18	**33100**	11	2	150.3				0
03/05/15	15:34:39	**33100**	11	2	150.3				0
03/05/15	15:34:56	**33100**	11	2	150.3				0
03/05/15	15:35:16	**33100**	11	2	150.3				0
03/05/15	15:35:36	**33100**	11	2	150.3				0
03/05/15	15:35:57	**33100**	11	2	150.3				0
06/05/15	11:27:12	**31400**	20	1	150.25				0
06/05/15	11:28:12	**31400**	20	1	150.25				0
06/05/15	15:28:53	**32800**	8	2	150.3				0
06/05/15	15:29:03	**32800**	8	2	150.3				0
06/05/15	15:33:10	**32800**	8	2	150.3				0
06/05/15	15:33:18	**32800**	8	2	150.3				0
06/05/15	15:33:35	**32800**	8	2	150.3				0
06/05/15	15:33:44	**32800**	8	2	150.3				0
06/05/15	15:34:09	**32800**	8	2	150.3				0
06/05/15	15:34:34	**32800**	8	2	150.3				4
11/05/15	09:28:11	**30800**	14	1	150.25				0
11/05/15	09:28:23	**30800**	14	1	150.25				0
11/05/15	09:28:41	**30800**	14	1	150.25				0
02/06/15	10:25:38	**30800**	14	1	150.25				0
02/06/15	10:26:25	**30800**	14	1	150.25				0
02/06/15	11:12:40	**30800**	14	1	150.25				0
02/06/15	11:13:00	**30800**	14	1	150.25				0
02/06/15	11:13:57	**30800**	14	1	150.25				0
02/06/15	11:14:07	**30800**	14	1	150.25				0
18/07/15	13:17:27	**30800**	14	1	150.25				0
18/07/15	13:25:40	**30800**	14	1	150.25				0
21/07/15	10:40:54	**30800**	14	1	150.25				0
21/07/15	10:41:18	**30800**	14	1	150.25				0

Date	Time	Acoustic Code	Radio Code	Channel	Frequency	UTM Zone	UTM E	UTM N	Depth (m)
21/07/15	10:41:42	**30800**	14	1	150.25				0
22/07/15	11:20:25	**30800**	14	1	150.25				0
22/07/15	11:20:50	**30800**	14	1	150.25				0
22/07/15	11:22:00	**30800**	14	1	150.25				0
24/07/15	15:06:55	**30800**	14	1	150.25				0