FOR REFERENCE ONLY
This version is now archived.

Updated 2019 Columbia Region Action Plans available at: fwcp.ca/region/columbia-region

Photo credit: Larry Halverson

FISH AND WILDLIFE
COMPENSATION PROGRAM

COLUMBIA BASIN

LARGE LAKES ACTION PLAN

June 2012

BC hydro FOR GENERATIONS
British Columbia The Best Place on Earth
Canada
Fisheries and Oceans Canada Pêches et Océans Canada

Table of Contents

Columbia Large Lakes Action Plan

1. Introduction

In 1995 the Fish & Wildlife Compensation Program (Columbia Basin) was created to coordinate efforts to compensate for fish and wildlife losses associated with BC Hydro projects in the region (Figure 1). An Administrative Agreement was signed in 1999 between the BC Ministry of Environment and BC Hydro to formalize the management of the program, which was developed to satisfy the obligations regarding fish and wildlife attached to the Arrow, Duncan, Mica, Seven Mile and Revelstoke project water licences. The program is delivered as a partnership between BC Hydro, the BC Provincial Government, Fisheries and Oceans Canada, First Nations and public stakeholders.

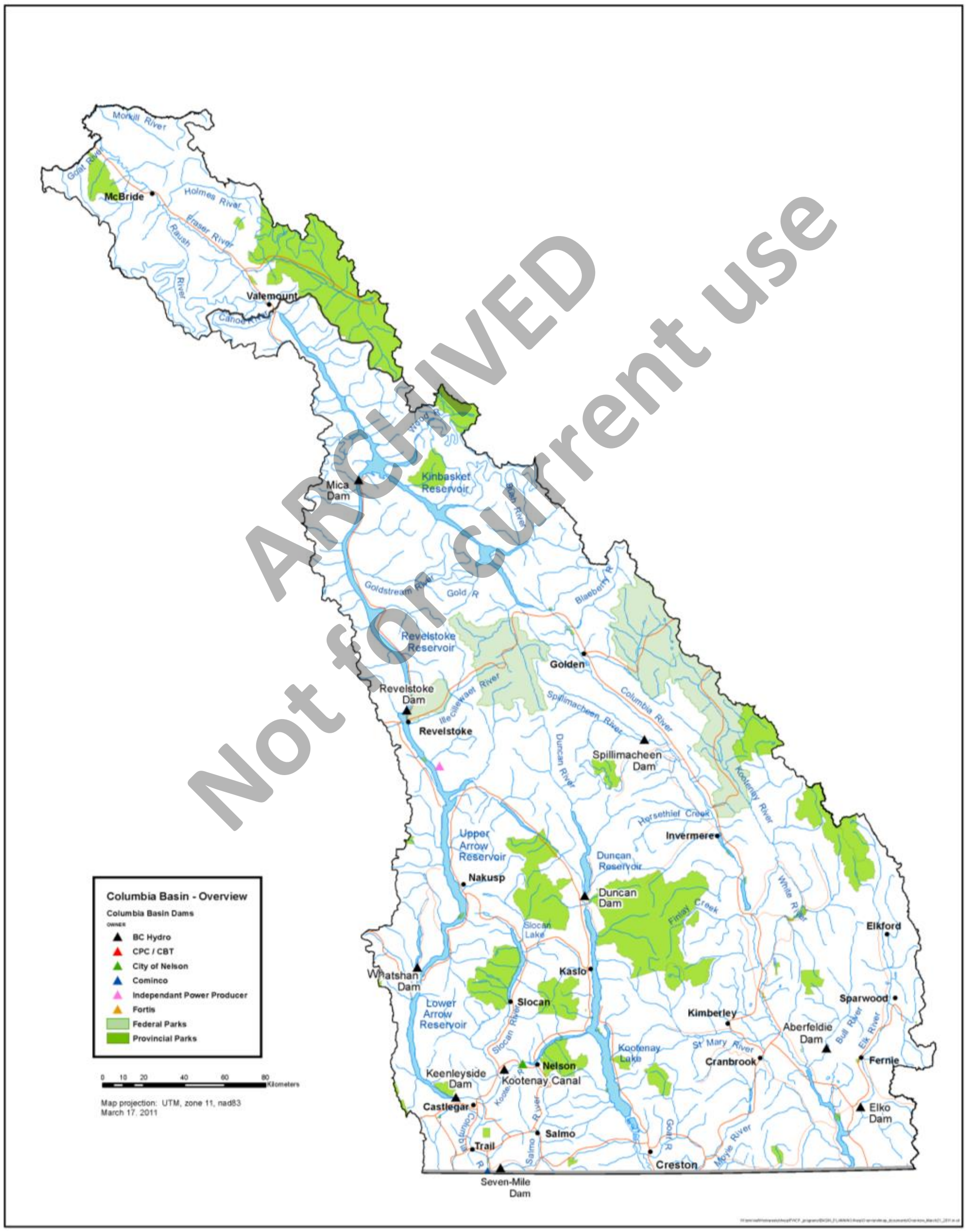

Figure 1. The Columbia basin generation system, indicating the region's major dams and reservoirs

The FWCP developed a strategic framework that guides overall planning for compensation investments (MacDonald 2009). The framework has guided the development of strategic plans for each basin within the FWCP program area, which are in turn informing action plans that focus on specific priorities within each basin (Figure 2).

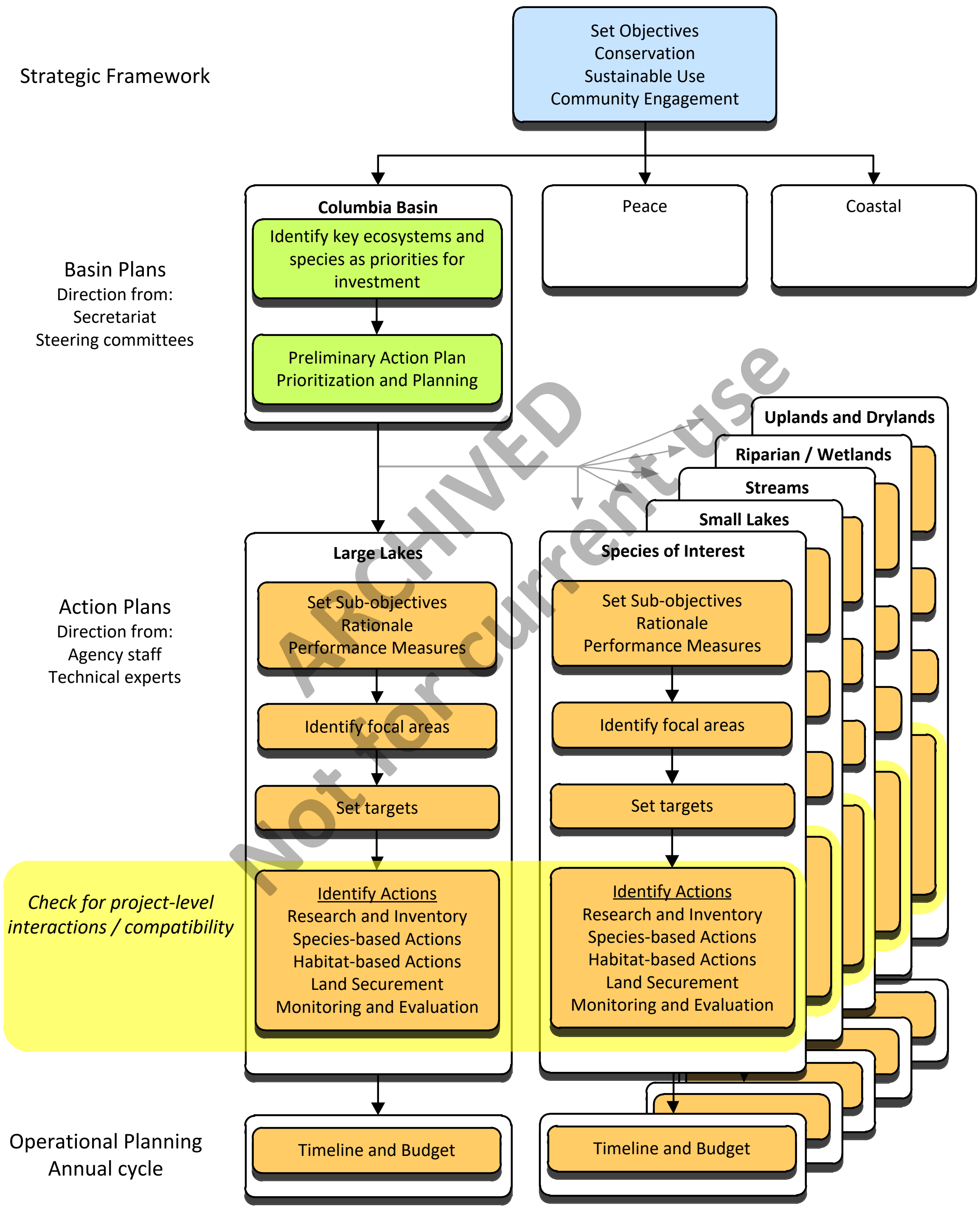

Figure 2. Relationship between the Large Lakes Action Plan and higher level planning and objectives.

This document provides a compensation “action plan” for large lakes within the Columbia compensation area, with a focus on fisheries resources in five high-priority lakes: Kootenay Lake, Duncan Reservoir, Arrow Lakes Reservoir, Revelstoke Reservoir and Kinbasket Reservoir (Figure 3). The plan builds on the FWCP’s strategic objectives and the Columbia Basin Plan (Fish and Wildlife Compensation Program 2011). Action plans have also been developed for small lakes, streams, riparian and wetland areas, upland and dryland areas, and species of interest;[1] some actions may be complementary across the different plans.

The Large Lakes Action Plan does not preclude FWCP work on other large lakes, and in fact some actions are proposed, particularly for wildlife, in these other lakes. The action plan may be expanded in the future to include additional detail for other large lakes, but for the moment concentrates on those that have received the most attention from the FWCP.

Large lakes are defined in BC as those bigger than 1,000 hectares and are typically complex ecosystems supporting a more diverse fish/aquatic community than that found in small lakes (MOE 2007). This action plan presents fisheries objectives, measures and targets, and the actions required to meet the targets. The actions and priorities described here have been developed with input from the BC Ministry of Environment (MOE), BC Ministry of Forests, Lands and Natural Resource Operations (FLNRO), Fisheries and Oceans Canada (DFO), BC Hydro, First Nations and local stakeholders. It is important to understand, however, that planning priorities within action plans may not translate immediately into funded projects. Limited program funding requires that priority-setting has to also be developed across the program as a whole, not just within action plans. The process of selecting which actions will be implemented in any given year will occur during the annual implementation planning cycle.

Early efforts by pre-cursors to the compensation program addressed dam-related impacts in large lakes by focussing mainly on spawning habitat losses. These were addressed with hatchery production for bull trout and rainbow trout (e.g., Hill Creek Hatchery, Meadow Creek mini-hatchery) and spawning channels for kokanee at Hill Creek and Meadow Creek. Hatchery funding by FWCP has been discontinued due to poor survival of stocked fish, but spawning channels continue to be operated, and there have been record levels of fry production in recent years. There is future opportunity to use kokanee survival and growth data to determine optimal densities of kokanee for each reservoir in relation to angling targets and forage for larger species.

Another early attempt to address spawning habitat losses was the removal of an older dam on the Illecillewaet River in 1977 (under the auspices of an FWCP precursor). This re-established access to 38 km of the mainstem river, plus tributaries, for adfluvial bull trout spawning and rearing. Recent surveys have shown this work was very successful, as the Illecillewaet is now the most important bull trout spawning stream for Arrow Lakes Reservoir, supporting about half of all spawning (Decker and Hagen 2008).

Large lake nutrient restoration programs were started in 1992 on Kootenay Lake and 1999 on Arrow Lakes Reservoir, and have successfully increased productivity at lower trophic levels and increased kokanee biomass by approximately 300% over pre-nutrient addition levels. At higher trophic levels the response of predators has been more variable, but also more difficult to assess given the lack of quantitative time series data on recruitment, abundance and harvest. A future opportunity is to improve monitoring data to investigate relationships between trophic levels, so the potential benefits of the large spawning channel and nutrient projects may be more fully understood.

[1] All of the FWCP Columbia Plans are available at: http://www.fwcpcolumbia.ca/version2/index.php

The monitoring programs associated with compensation projects have produced valuable long-term datasets that have great potential for learning how to better manage large lake ecosystems. On Arrow Lakes Reservoir, for example, there are angler catch data and kokanee spawner counts going back to the 1970s, as well as lower trophic level sampling started in 1997. The potential for learning from these datasets has yet to be fully realized. Another recent contribution of FWCP is an inventory and assessment of remaining bull trout spawning and rearing habitats for Arrow Lakes Reservoir, which is valuable for habitat protection, restoration planning, and population monitoring. This basic inventory of remaining spawning and rearing habitats still needs to be completed for Kootenay and other large lakes.

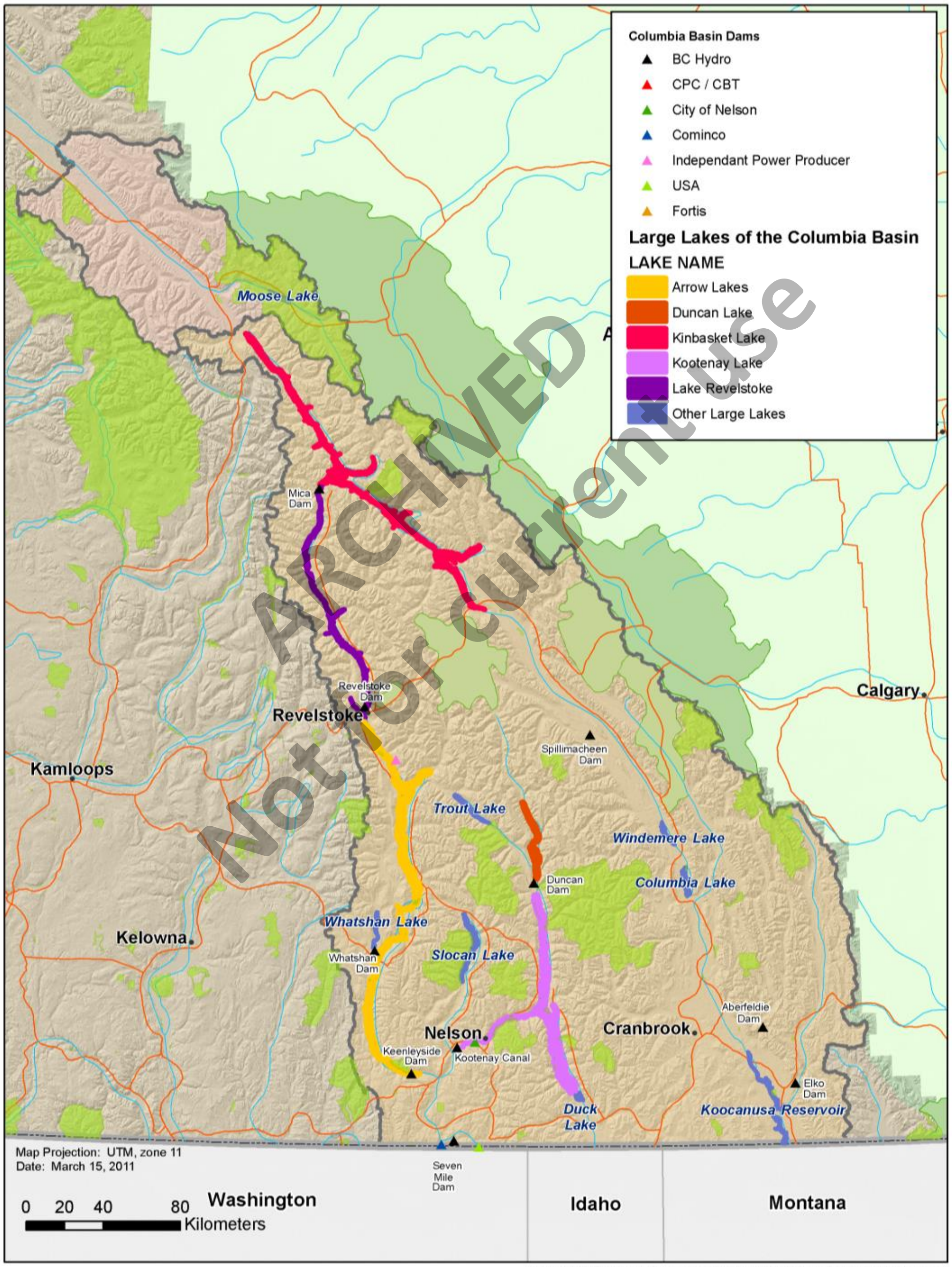

Figure 3. Priority Large Lakes in the Columbia Basin.

2. Overview Context

2.1 Kootenay Lake

Impacts and Threats

Hydro-related Impacts.— Kootenay Lake inflows and outflows are primarily driven by the terms of the Columbia River Treaty, a joint agreement between the United States and Canada to optimize hydro-electric generation and minimize flooding in the Columbia basin. The outlet of Kootenay Lake has been controlled by Corra Linn Dam since 1939. Inflows from the Duncan River have been controlled by the Duncan Dam since 1967. Inflows from the Kootenay River have been controlled by Libby Dam in Montana since 1973. Daley et al. (1981) estimated that the impoundments have reduced P inputs to Kootenay Lake by 45% and N inputs by 35%. Declines in overall productivity are thought to be related in part to this reduction in nutrient inputs. In addition to reduced nutrient inputs, lake levels have been regulated and flattened the hydrograph, resulting in lower high water levels during spring and summer and slightly higher low water levels during the winter (Moody et al. 2007). The presence of upstream dams has also decreased turbidity levels in Kootenay Lake (Moody et al. 2007). There have been other impacts to Kootenay Lake habitat, such as a barrier to upstream migration of kokanee, which led to the creation of the Meadow Creek spawning channel as compensation.

Non-Hydro Impacts.— The introduction of mysid shrimp (*Mysis diluviana*) in 1949 is believed to have had a large and mostly negative effect on the ecology of Kootenay Lake, primarily by sequestering a large portion of carbon production in biomass that is unavailable to higher trophic levels like fish. Due to unique bathymetry and flow patterns this effect is much less pronounced in the West Arm. Another oft-cited effect is that of effluent discharges from the Cominco phosphate fertilizer plant in 1952 - 1975, which eutrophied the waterbody in this period. Other impacts include historic effects of logging, mining, flood protection, and land use changes from agriculture and urbanization.

Limiting Factors

Kootenay Lake is naturally a low productivity (oligotrophic) system. Other limiting factors for fish likely include habitat quantity and quality, access to habitats (i.e., passage), and predation. The limiting factors include natural and human-induced aspects, and the latter include both hydropower and other developments.

Limiting factors likely vary among species and trophic levels. Overall productivity is limited by nutrient levels: productivity declined with the cessation of effluents from Cominco and the interception of nutrients in upstream reservoirs, and there is good evidence of a measurable response by lower trophic levels to nutrient additions from the lake nutrient restoration program. Historically, productivity was also related to turbidity of Kootenay Lake, which has decreased due to the removal of suspended solids by upstream dams (Moody et al. 2007). Kokanee, as zooplankton grazers, have responded positively to increased nutrients in Kootenay Lake. The limiting factors for higher trophic levels are more uncertain, particularly for the highest level piscivores. For example, the extent to which Gerrard rainbow trout are limited by juvenile rearing habitat in Lardeau River and the lower Duncan River versus kokanee prey density and size remains a question requiring additional attention. The sequestration of carbon production in biomass (e.g., *Mysis*) that is unavailable to many fish likely plays a role in limiting fish production. The historic alteration of rearing and spawning habitats in various tributaries may also limit some fish species, and the concentration of kokanee spawning in spawning channels may have detrimental effects on contributions from other spawning streams.

Trends and Knowledge Status

Habitat Trends.— The annual pattern of lake level fluctuations of Kootenay Lake has changed from historical patterns due to hydropower development, but the quantity of inlake physical habitat has not changed markedly (Thorley 2008). Water quality in Kootenay Lake has changed through time, as nutrient concentrations and water clarity have been affected by upstream dams and industrial effluent discharges (Moody et al. 2007). Coupled with these has been the effect of introduced *Mysis*, as mentioned previously. The most notable effect on habitat from these changes is a decline in aquatic productivity. By 1991, Kootenay Lake spawning kokanee returning to Meadow Creek and the Lardeau River had plummeted to 270,000 compared to pre-dam estimates of at least 1 million spawners.

Tributary habitats have been affected by dams and altered discharge regimes on the two largest in-flowing rivers, Duncan and Kootenay rivers, affecting availability of spawning and rearing habitat. Other tributaries have also been affected by smaller developments. Riparian and floodplain habitats have been altered by agriculture, forestry and other land uses.

The nutrient restoration program was implemented to offset declines in Kootenay Lake productivity and has been operating since 1992. Monitoring confirms that the density and abundance of kokanee is higher than before fertilization started (Sebastian et al. 2010). An abundant kokanee population is better able to support the other species that rely on kokanee as a food source, including sport fish, grizzly and black bears, bald eagles and other species.

Stock Trends.— Long term monitoring data for kokanee and Gerrard rainbow indicates these stocks are currently in a good to very good shape in Kootenay Lake. The abundance of fry and age 1-2+ kokanee in the lake during 2009-2010 was the highest on record (i.e., since 1985). Gerrard rainbow spawners have also reached the highest numbers on record for two consecutive years. Angler reports have been very favourable for Gerrard rainbow for the third consecutive year on Kootenay Lake. Bull trout stocks are not monitored; however, angler reports and recent tagging studies suggest that current stock status may be good. Burbot stocks are all but depleted in the West Arm and little is known of their status in the main portion of the lake. Current status of insectivorous rainbow is not currently known and is not being monitored.

Kokanee.— Kokanee trends have been monitored through adult returns to Meadow Creek and spawning channel (fence counts) and aerial counts of the Lardeau River. Combined spawner returns were highest during the mid-70s during a eutrophication phase as a result of effluent from Cominco's phosphate fertilizer plant. This was followed by a 10 year decline in abundance (and size) from 1981-91 as the impacts of nutrient trapping behind upstream dams was realized on Kootenay Lake. A third phase occurred from 1992-2010 in response to a large scale nutrient addition experiment in the North Arm and addition of nitrogen to the South Arm since 2004. This phase was characterized by oscillations between high and low kokanee spawner returns with a peak of 2.2 million and lows of 0.5 million spawners. More recently trends in kokanee abundance, size and biomass in the lake have been monitored using hydroacoustic and trawl surveys. Note that pre-treatment hydroacoustic data began in 1985 so no data is available for the eutrophication phase in the 60s and 70s. The current status (2010) for kokanee appears to be very good based on the highest numbers of fry and age 1-2+ kokanee observed since acoustic monitoring began (Fig. 5). In-lake biomass density increased from an average of $3.5 kg.ha^{-1}$ to $10.5 kg.ha^{-1}$ during the 19 year nutrient addition period. A Biomass density of $18.5 kg.ha^{-1}$ in 2009-10 was among the highest on record since 1985.

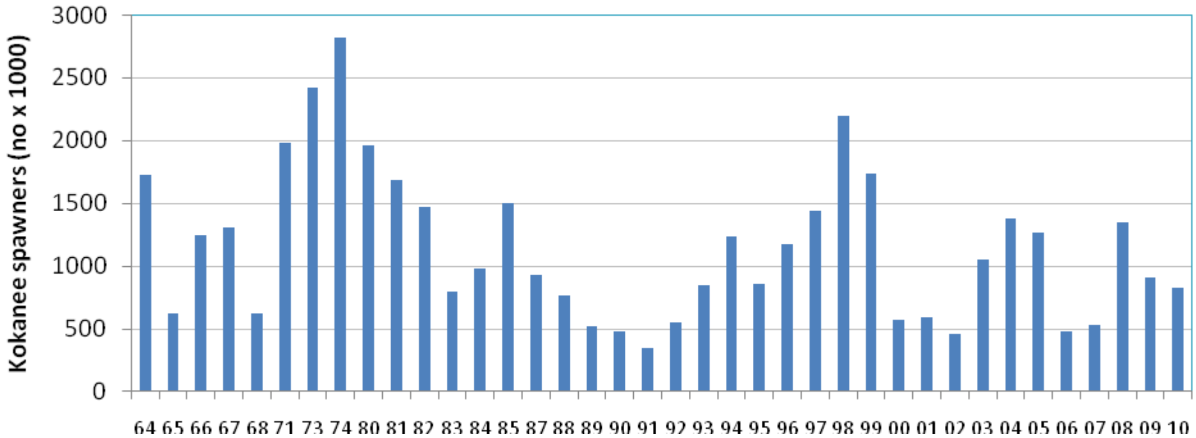

Figure 4. Trends in Kootenay Lake kokanee spawn returns combined for Meadow Creek and Lardeau River. Note years without Lardeau data have been omitted from the graph.

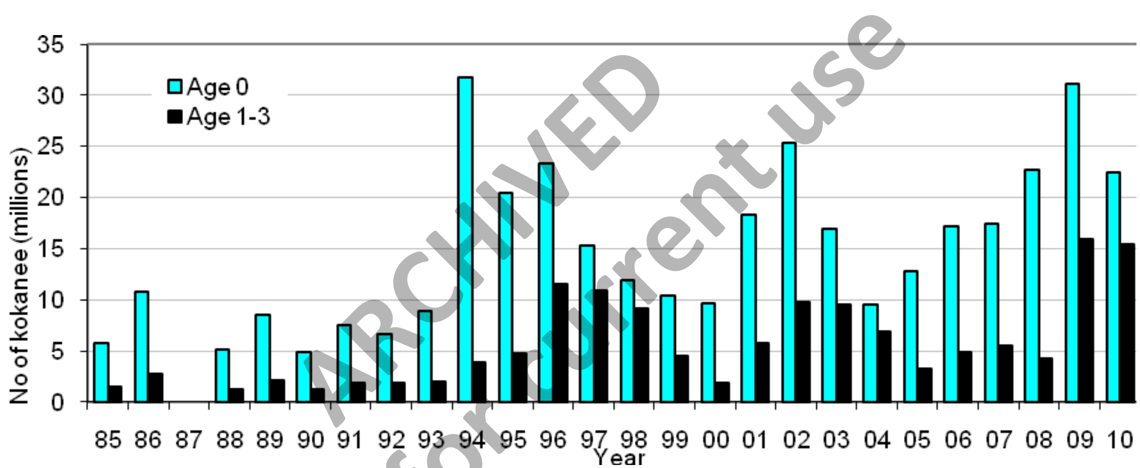

Figure 5. Trends in kokanee juvenile abundance in Kootenay Lake from hydroacoustic surveys

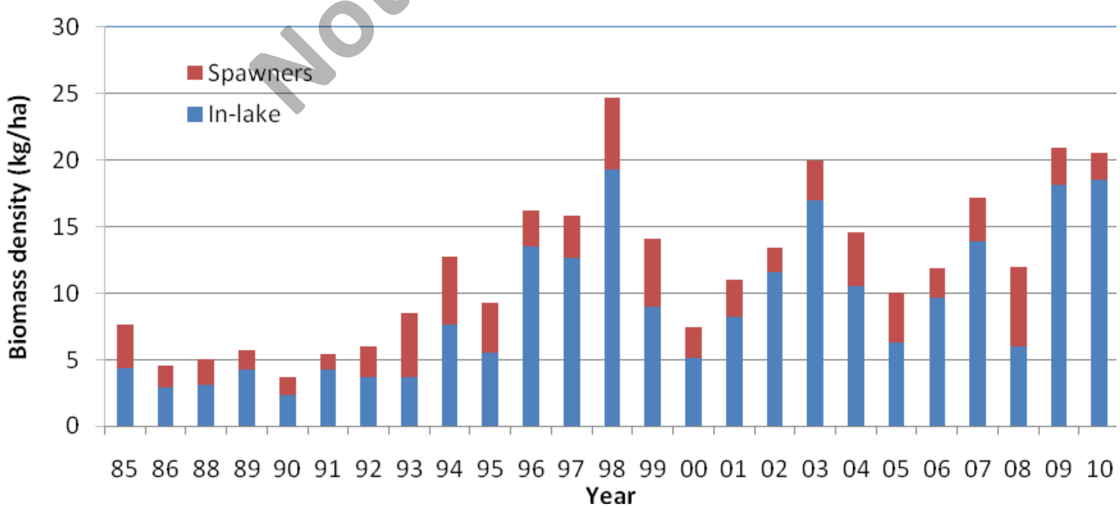

Figure 6. Trends kokanee in-lake and spawner biomass density ($kg.ha^{-1}$) for Kootenay Lake based on hydroacoustic, trawl and spawning channel data (FLNRO file data).

Gerrard rainbow trout.— Rainbow escapement (after harvest) has been monitored for Gerrard rainbow trout since 1961. Except for a peak in the late 1970s following a peak of kokanee, the Gerrard spawner returns have been quite stable at about 300 fish and ranged from 200-400 (Fig. 7). The exception is that since 2004, the returns have been increasing steadily, concurrent with relatively strong kokanee populations. Anecdotal reports from angling guides indicate good catch results over the past three years.

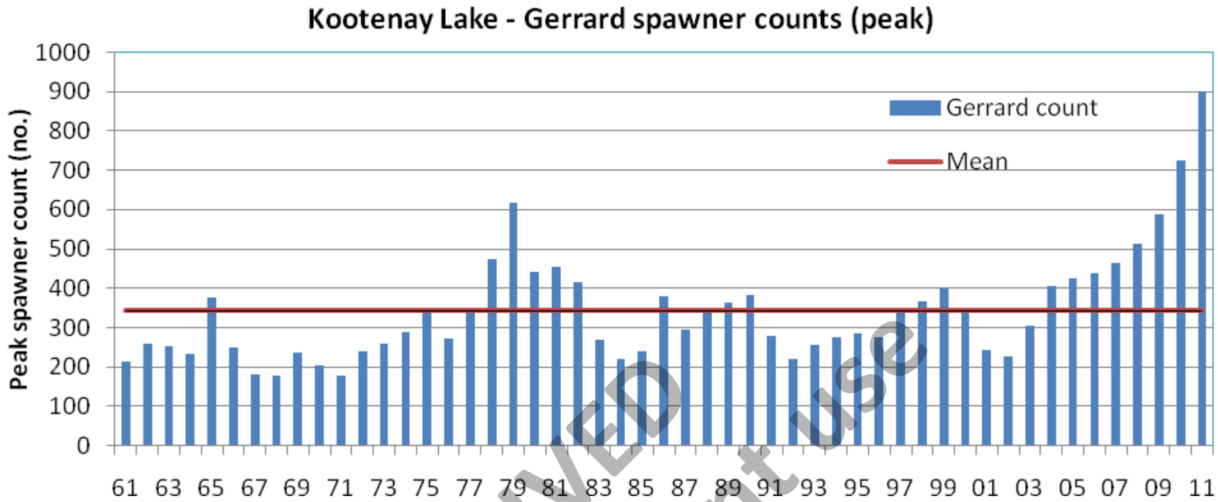

Figure 7. Trends in Gerrard rainbow peak spawner counts during 1961-2011 (FLNRO file data)

White sturgeon.— The Kootenay River population of white sturgeon extends from Kootenai Falls, Montana, downstream through Kootenay Lake to Corra Linn Dam on the lower West Arm of Kootenay Lake, British Columbia. A natural barrier at Bonnington Falls downstream of Kootenay Lake has isolated the Kootenay River white sturgeon from other white sturgeon populations in the Columbia River basin since the end of the Pleistocene, approximately 10,000 years ago (Northcote 1973). Spawning habitat is located in the US, whereas much of the adult and juvenile rearing habitat is located in the Canadian portion of Kootenay River plus Kootenay Lake (e.g., Kootenay delta and tributary creek mouths). White sturgeon can also be found in very small numbers in Duncan Reservoir, and these are considered remnants of the Kootenay Lake population (RL&L Environmental Services Ltd. 1998). Population surveys in the Kootenay River began in 1977 and became more intensive after 1990, using radio telemetry, recreational catch statistics, mark-recapture estimates and life history studies (Duke et al. 1999, Paragamian et al. 2005). Analysis of age structure indicates recruitment began to decline in the mid-1960s (Partridge 1983 cited in Duke et al. 1999, Paragamian et al. 2005), and has been negligible since 1974, the year Libby Dam became operational. Total abundance was estimated in 2000 to be 760 individuals. The population is now being augmented with hatchery-produced offspring (Porto 2008).

Burbot.— The Kootenay Lake stock has been severely depleted and is likely extirpated (Ahrens and Korman 2002). Burbot are of moderate to high value to anglers. They are monitored by fisheries managers as opportunities allow, but information collection is typically fairly modest.

Other species.— Hagen (2008) reviewed dam impacts to bull trout. Bull trout are also known to be abundant in Kootenay Lake and contribute significantly to the sport fishery. Data from tagging studies indicates that bull trout are caught more often than Gerrards. Preliminary review suggests bull trout are widespread with presence confirmed in at least 19 tributaries (Decker and Hagen 2007,2008, Hagen and Decker 2009); however, there is no trend data other than three years of redd counts in Kaslo River and Crawford Creek.

Knowledge Gaps.— A key requirement for managing the Kootenay Lake ecosystem is a model that synthesizes available data, reveals knowledge gaps, and allows exploration of different management alternatives, such as the predicted response of different ecological units to aquatic productivity or changes in kokanee escapement. This information is critical to informing fisheries management decisions with respect to compensation efforts, particularly the nutrient restoration and spawning channel programs. This information is also essential to setting targets where there may be trade-offs among species. The model would help address the following questions:

1. What are the recruitment bottlenecks for different fish species?
2. What is the optimal nutrient addition? (e.g., amount, timing, distribution, micronutrient limitation)
3. What should be the components of a successful compensation program monitoring program for performance? (e.g., BT escapement, fish harvest, standing crop and/or consumption rates at different trophic levels)

Bull trout are also important as apex predators in Kootenay Lake, possibly having a larger effect on kokanee dynamics than Gerrard rainbow trout, and the species is highly regarded by anglers (FWCP, file data). Spawning distribution and abundance of bull trout has not been well described to date; however, the FWCP has recently developed a plan that would provide a basis for evaluating and monitoring this species in Kootenay Lake (Hagen and Decker 2009).

Kootenay Lake Fish Priorities

The following statements articulate some of the current management priorities for Kootenay Lake and were used when setting management targets for this waterbody.

1. Province of BC's highest sport fishery priority is the Gerrard rainbow trout, followed by bull trout, and there is a desire to increase the in-lake population of large fish to support a world class recreational fishery.
2. Province of BC's highest sport fishery priority in the West Arm of Kootenay Lake is kokanee, and there is a desire to improve this fishery. Province of BC would also like to explore the possibility of increasing opportunities for kokanee fishing in the North and South arms but not at the expense of achieving Gerrard objectives.
3. White sturgeon and burbot are Province of BC's highest aquatic conservation priorities in Kootenay Lake and the compensation program will support actions to facilitate their recovery.

2.2 Duncan Reservoir

Impacts and Threats

Hydro-related Impacts.— The Duncan Dam is located immediately upstream of the confluence of the Duncan and Lardeau Rivers, approximately 10 km upstream of Kootenay Lake. Duncan Dam was completed in 1967 and the reservoir is approximately 45 km in length at full pool. It impounded river, lake, wetland and tributary habitat. The dam has no dedicated fish passage facilities, but the Low Level Operating Tunnel #2 is operated from the end of May to September annually for the purpose of providing upstream bull trout passage. At times, particularly during freshet, the reservoir can be turbid, which may limit aquatic productivity. Annual drawdowns of the reservoir have likely affected reservoir productivity, and discharge patterns from the dam have likely affected productivity and suitability of riverine habitat downstream of the dam. Changes in operations due to the Duncan Water Use Plan may have reduced some of these effects. The current Water Licence Requirements monitoring programs are being implemented to address these uncertainties.

Historically, white sturgeon occurred in the Duncan River, and a few still occur in Duncan Reservoir (Porto 2008). The area upstream of Duncan Dam was clearly part of white sturgeon historic habitat, but it is not considered critical habitat and recovery actions are not planned for this area (National Recovery Team for White Sturgeon 2009). There have also been impacts to other fish species like rainbow trout (Arndt 2009a), bull trout (Hagen 2008), and burbot (Cope 2008).

Non-Hydro Impacts.— Other impacts include historic and ongoing effects of logging, mining and some linear development.

Limiting Factors

Limiting factors for fish in Duncan Reservoir have not been studied, but likely include habitat quantity and quality, access to habitats (i.e., passage), predation, and potentially competition. The limiting factors include natural and human-induced aspects, and the latter include both hydropower and other developments. Duncan Reservoir is a cold, seasonally turbid waterbody, which likely limits productivity at all trophic levels.

Trends and Knowledge Status

Habitat Trends.— 42 km of small stream, 12 km of small river, and 46 km of medium-sized river were inundated by Duncan Reservoir (Thorley 2008). Also inundated was Duncan Lake (26 km^2) and a further 1.72 km^2 of shallow water habitat (Thorley 2008). Reservoir operations result in annual drawdown of approximately 30 m, which dewaters an area of over 5,000 ha (Cope 2008). Operational changes associated with the Duncan Water Use Plan (BC Hydro 2007) have likely improved habitat downstream of Duncan Reservoir in recent years, though the effect is not quantified; no improvements are expected within the reservoir itself. Reservoir aging may have caused a decline in pelagic productivity over time (Moody et al. 2007).

Stock Trends.— Fish stocks in Duncan Reservoir have not been monitored in detail, so trends are largely unknown. The species thought to be most affected by Duncan Dam are kokanee, rainbow trout and bull trout (Cope 2008), but it also likely affected migrations of burbot and whitefish (Vonk 2001 cited in Cope 2008). Before the dam there was habitat connectivity between Kootenay Lake and the Duncan system, and there were abundant spawning runs of kokanee, rainbow and bull trout from Kootenay Lake (Peterson and Withler 1965a cited in Cope 2008). Peterson and Withler (1965a cited in Cope 2008) describe extensive slough areas in the Duncan River and rated these sloughs as excellent rearing areas for juvenile game fish.

In 1995 and 1996 white sturgeon abundance was assessed. A total of five adults were caught, and all were older than 48 years (RL&L Environmental Services Ltd. 1998), which is considerably older than Duncan Dam. Burbot have been assessed periodically, often as part of conservation investigations aimed at Kootenay Lake stocks. More recently longer-term baseline monitoring studies have been initiated as part of the Duncan Water Use Plan. Bull trout monitoring is ongoing as part of the Water Use Plan implementation, and upstream and downstream passage through Duncan Dam is being monitored.

Knowledge Gaps.— The greatest gaps in knowledge of fish in Duncan Reservoir are long-term trends in status of the main fish species of interest like burbot, bull trout, kokanee and rainbow trout. General limnological information is also a key data gap, along with knowledge of whether and how pelagic productivity could be improved. Potential compensation projects are discussed in Thorley (2008) for habitat losses, Appendix F of Arndt (2009a) for rainbow trout, Hagen (2009) for bull trout, and Cope (2008) for burbot, though detailed site-specific, prioritized recommendations are lacking.

There are several ongoing studies of Duncan River and Duncan Reservoir to quantify the effects of the WUP flow implementation, including:

1.Duncan Reservoir Fish Habitat Use Monitoring (2008 to 2011+)

2.Duncan Reservoir Burbot Monitoring (2009 to 2011+)

3.Upper Duncan River Bull Trout Migration Monitoring (2008 to 2010+). Annually reports are produced for each project, none of which have been cited within this section.

4.Lower Duncan River Habitat Use Monitoring (Gerrard Trout, Whitefish, Burbot components) (2008 to 2011+);

5.Lower Duncan River Ecohydraulic Modeling (2008 to 2011+);

6.Lower Duncan River Kokanee Assessment Monitoring (2008 to 2011+);

7.Lower Duncan River Stranding Assessment Monitoring (2008 to 2011+).

Reports are prepared annually and posted on the BC Hydro website.

Duncan Reservoir Fish Priorities

Province of BC's sport fishery and conservation priorities are, in order: bull trout, kokanee, rainbow trout, and burbot.

2.3 Arrow Lakes Reservoir

Impacts and Threats

Hydro-related Impacts.— Hugh Keenleyside Dam (HLK) is located on the Columbia River about 8 km upstream of Castlegar. The facility was completed in 1968. HLK raised maximum water levels by 14 m (Arndt 2009a), inundating the former Upper and Lower Arrow Lakes to form Arrow Lakes Reservoir. The reservoir is about 240 km in length and is licensed to operate between the normal full pool elevation of 440.1 m and minimum pool elevation of 418.64 m; annual drawdown is about 20 m (Hirst 1991). The increased water levels inundated high quality spawning and rearing habitat in tributaries. Total stream habitat losses were estimated as 203 km (Thorley 2008), about 90% of this by area was low gradient, high quality habitat. Revelstoke Dam blocked access to spawning and rearing habitat in tributaries upstream of the reservoir, and both Mica and Revelstoke Dams caused long-term changes in light penetration and nutrients in the lentic habitat of Arrow Lakes Reservoir (Moody et al. 2007). Despite the habitat changes, potential total annual primary production was estimated to be 1.6 times higher after dams than before, due to the greater area of the reservoir and reduced turbidity (Moody et al. 2007). However, this estimate is based only on in-lake processes (nutrient/turbidity interactions) and does not take into account possible effects of hydraulic changes resulting from dam operations (Matzinger et al. 2007), and possibly wetland losses upstream. Prior to Mica and Revelstoke dams, P loading to Arrow Lakes was 163 mg/m^2 (range of 131 to 193.5 mg/m^2), or 59.9 tonnes of P (range 48.1 to 71 tonnes). Currently, P loading is 43.7 mg/m^2 (range 34.4 to 56 mg/m^2), or 20.0 tonnes (range 16 to 26 tonnes). This represents a reduction of 119.4 mg/m^2, or 55.5 tonnes of P (E. Schindler, MOE, pers. comm.).

Non-Hydro Impacts.— A potentially significant impact for fish production was the introduction of *Mysis diluviana* shortly after HLK was constructed. Mysids have become an important competitor with kokanee and are believed to have had a large and mostly negative effect on the ecology of Arrow Lakes, primarily by sequestering a large portion of carbon production in biomass that is unavailable to higher trophic levels like fish.

Other impacts include historic and ongoing effects of logging.

Limiting Factors

Limiting factors for fish in Arrow Lakes likely include habitat quantity and quality, access to habitats (i.e., passage), and predation, though the extent to which each contribute to different species has not been determined. The limiting factors include natural and human-induced aspects, and the latter include effects from both dam construction and other developments. For kokanee, the main limiting factor is productivity and there is some evidence that operations such as summer drawdown may reduce productivity capacity for kokanee.

Trends and Knowledge Status

Habitat Trends.— Overall C production in Arrow Lakes Reservoir (within lake primary production) is higher post-dam by a factor of about 1.6 (Moody et al. 2007), but this does not include C production in other habitats like adjacent wetlands. Also, HLK flooded 25-30% of the low gradient stream habitat used for spawning and rearing by salmonids and other fishes (Lindsay and Seaton 1978 cited in Hagen 2008). Additional spawning habitat was cut off by Revelstoke Dam, upstream of Arrow Lakes. The construction of Hill Creek Spawning Channel has improved available spawning area for kokanee, and the removal of barriers has benefited bull trout by increasing access to spawning and rearing areas (Arndt 2009b). The extent to which spawning habitat is currently limiting different fish species is not known. As a result of dam construction, Arrow Lakes seems to have switched from light limitation during pre-dam conditions, to nutrient limitation today (Moody et al. 2007), which has been the primary motivation for compensation through nutrient restoration.

Stock Trends.— Fish stocks have been monitored fairly consistently through time, using creel surveys and directed research efforts. Overall, the reservoir has provided "a reasonably good rainbow trout fishery supported by natural reproduction in the remaining tributaries," but it is uncertain whether total production of rainbow trout has changed relative to pre-dam conditions (Arndt and Baxter 2006). Some life history types have certainly been affected. A separate large-bodied piscivorous rainbow stock ("yellow-fin" rainbow trout) occurred in Arrow Lakes, but is thought to be extirpated or at such low abundance as to be unrecoverable (Spence et al. 2005). Some of the effect on this stock may have been due to hybridization with hatchery-reared stocks (Arndt 2009a). There is a self-sustaining population of piscivorous rainbow trout that in some years has provided a fishery to rival Kootenay Lake (most recently 2002-2005; Steve Arndt, FWCP, pers. comm.). Also, much is known about the population structure of bull trout and a monitoring program has already been started (Decker and Hagen 2008).

Catches of burbot during sturgeon investigations demonstrated that the species is widely distributed throughout the reservoir (Arndt and Baxter 2006). Recent data suggests the population is widespread, relatively abundant, and healthy with many large, mature fish (Arndt 2009a). It remains uncertain if the net impact of HLK and Revelstoke dams on the Arrow Lakes Reservoir burbot has been positive or negative (Cope 2008).

Kokanee stocks in Arrow Lakes declined substantially by the mid-1990s, and it was believed that nutrient retention in upstream reservoirs was responsible (Schindler et al. 2006). Nutrient additions in combination with use of the Hill Creek Spawning Channel appear to have been successful at restoring kokanee escapement to pre-impoundment levels (Hagen 2008), but the kokanee fishery has declined substantially (FWCP file data). Time series data from hydroacoustic and trawl work show inlake biomass density has increased from a pre-treatment average of 2.7$kg.ha^{-1}$ to an average of 9.7$kg.ha^{-1}$ (FLNRO file data).

A bull trout hatchery program was conducted between 1982-2000, after which it was stopped due to poor results and concerns about population declines in donor streams (Arndt 2004 cited in Arndt 2009a). Bull trout growth and survival conditions appear to have been enhanced from reservoir fertilization and barrier removal (Hagen 2008). Recent work by FWCP has identified the key spawning tributaries remaining for bull trout in Arrow Lakes, and a relatively affordable method of monitoring population trends has been started (Decker and Hagen 2007).

White sturgeon historically had access from the ocean all the way to Columbia Lake in the upper Columbia and Shoshone Falls in the upper Snake River. At least two significant populations remain in the upper Columbia River and other remnant populations consisting of a few individuals occur, or are suspected, throughout other portions of the historic range (Porto 2008). The largest population resides in the free-flowing transboundary reach between Hugh L. Keenleyside Dam (HLK) and Roosevelt Reservoir (FDR). A second significant subpopulation of white sturgeon currently inhabits Arrow Lakes Reservoir (ALR), upstream of HLK. The history of this subpopulation is uncertain, and its present occurrence as a subpopulation may simply reflect splitting of a larger population by the construction of HLK. Abundance in this subpopulation is substantially lower than in the reach from HLK to FDR, and is likely on the order of several dozen adult fish (National Recovery Team for White Sturgeon 2009).

Knowledge Gaps.— Knowledge gaps for fish in Arrow Lakes Reservoir are not as profound as for lesser-studied waterbodies, but additional information would help manage fisheries in this reservoir. Long-term trends in status of the main fish species of interest like burbot, bull trout and rainbow trout are always useful, as is general limnological information. Potential compensation projects are listed in the dam impacts reports dealing with primary productivity (Moody et al. 2007), habitat (Thorley 2008) and species impacts (Cope 2008, Hagen 2008, Porto 2008, Arndt 2009a,b). There is also a rainbow trout restoration and management plan for Arrow Lakes Reservoir (Spence et al. 2005) with more detailed recommendations and priorities for inventory, monitoring and compensation. The historical habitat losses are well described (Thorley 2008), but the implications for a variety of species are less well understood.

Much like Kootenay Lake, a key requirement for managing the Arrow Lakes ecosystem is a model that synthesizes available data, reveals knowledge gaps, and allows exploration of different management alternatives, such as the predicted response of different ecological units to aquatic productivity or changes in kokanee escapement. This information is critical to informing fisheries management decisions with respect to compensation efforts, particularly the nutrient restoration and spawning channel programs. This information is also essential to setting targets where there may be trade-offs among species.

Several Arrow Lake Reservoir WLR study programs are planned or ongoing, to assess implementation of the WUP, including:

1. Arrow Lakes Tributary Fish Migration Access Assessment and Monitoring Program, and
2. Arrow Lake Reservoir Burbot Life History and Habitat Use.

Arrow Lakes Reservoir Fish Priorities

The following statements articulate some of the current management priorities for Arrow Lakes Reservoir and were used when setting management targets for this waterbody.

1. MOE’s highest sport fishery priority is piscivorous rainbow trout and bull trout, and there is a desire to increase the in-lake population of large fish to support a world class recreational fishery.
2. MOE would also like to explore the possibility of increasing opportunities for kokanee fishing in the upper and lower Arrow Lakes.
3. Burbot are a third fishery priority.
4. White sturgeon are MOE’s highest aquatic conservation priorities in Arrow Lakes Reservoir and the compensation program will support actions to facilitate their recovery.

2.4 Revelstoke Reservoir

Impacts and Threats

***Hydro-related Impacts.*—** Revelstoke Dam is located on the Columbia River about 5 km upstream from the City of Revelstoke. The Revelstoke Project was completed in 1984, and impounds about 142 km of the Columbia River (Thorley 2008). Revelstoke is operated as a run-of-river reservoir based on storage in Kinbasket Reservoir released from Mica Dam (Hirst 1991). The reservoir is narrow, deep and cold, with an average width of less than 1 km (Cope 2008). Mean depth is about 15 m, but reaches 125 m in the forebay (Hirst 1991). The reservoir flooded 268 km of stream habitat, most of which was (by area) the Columbia mainstem (Thorley 2008).

The former free-flowing section of the Columbia River with moderate productivity has been replaced by an ultra-oligotrophic reservoir with low residence time (Moody et al. 2007). Significant resident and adfluvial fish populations were supported throughout the mainstem river and its side-channels and tributaries (Martin 1978 cited in Moody et al. 2007). Production was supported by a high abundance of nursery streams, particularly from tributary alluvial fans and side-channels (Martin 1978). Impoundment has eliminated the great majority of this type of habitat, which limits local recruitment. Revelstoke Dam has no passage facilities and blocks access to former spawning habitats used by fish in Arrow Lakes. Likewise, there is no passage at Mica Dam for stocks that may have migrated past this point to use upstream spawning and rearing habitat.

***Non-Hydro Impacts.*—** The main other impact is the historic and ongoing effects of logging.

Limiting Factors

Limiting factors for fish in Revelstoke Reservoir likely include habitat quantity and quality, entrainment, access to habitats (i.e., passage), competition and predation, though the relative importance for each species has not been determined. Revelstoke is the least productive of the Columbia reservoirs (Moody et al. 2007). This is at least in part is due to the low residence time, which precludes development of a productive lentic community, with the exception of some embayments where the residence time is higher (K. Bray, BC Hydro, pers. comm,). The limiting factors include natural and human-induced aspects, and the latter include effects from both hydropower and other developments.

Most kokanee spawning habitat has been inundated, and recruitment to the reservoir is driven primarily by entrainment from Kinbasket (Arndt 2009b). Bull trout abundance is generally directly related to kokanee, its main fish prey.

Trends and Knowledge Status

***Habitat Trends.*—** As noted above, Revelstoke Reservoir has transformed a former free-flowing section of the Columbia River with moderate productivity into an ultra-oligotrophic reservoir with low residence time (Moody et al. 2007). There have been no significant habitat trends since the project was built, although there has been relatively little monitoring.

Stock Trends.— Difficult sampling conditions made it hard to accurately estimate standing stocks of fish in the area prior to hydro development, and stocks have not been monitored consistently or intensively since then. As a result, trends are poorly known for fish stocks in this reservoir. Bull trout populations appear to be abundant in Revelstoke Reservoir and possibly more productive than pre-impoundment (Hagen 2008). Burbot, too, are likely to have increased in the reservoir environment (Cope 2008). Arndt (2009b) estimated losses at more than 80,000 kokanee spawners, but this has been at least partially offset by recruitment from entrainment through Mica Dam; once in Revelstoke Reservoir, kokanee seem to do well as evidenced by their large body size and a targeted fishery (Bray and Campbell 2001 cited in Arndt 2009a). Kokanee densities have been generally low and variable and consist largely of age 0+ fish (fry) as indicated by acoustic surveys during 1993-2005. Variations in the age 1-3+ population from year to year support the notion that entrainment is playing a significant role. The relatively high growth rates observed for older kokanee does indicate that food supply is not limiting, at least not at low densities.

Knowledge Gaps.— The greatest gaps in knowledge of fish in Revelstoke Reservoir have to do with long-term status and abundance trends of the main fish species of interest like kokanee, burbot, bull trout and rainbow trout. General limnological information has been, until very recently, a key data gap, as is the contribution from entrainment to population abundance and productivity. Information is currently being collected as part of BC Hydro water license requirements and entrainment work. Potential compensation projects are listed in the dam impacts reports dealing with primary productivity (Moody et al. 2007), habitat (Thorley 2008) and species impacts (Cope 2008, Hagen 2008, Porto 2008, Arndt 2009a,b), though detailed site-specific, prioritized recommendations are lacking.

Revelstoke Reservoir Fish Priorities

The following statements articulate some of the current management priorities for Revelstoke Reservoir and were used when setting management targets for this waterbody.

1. Province of BC's highest sport fishery priorities are kokanee and bull trout.
2. Burbot and rainbow trout are secondary fishery priorities.

2.5 Kinbasket Reservoir

Impacts and Threats

Hydro-related Impacts.— Mica Dam is located on the Columbia River about 135 km north of Revelstoke. The dam was completed in 1973. Kinbasket Reservoir, formed by construction of Mica Dam, is 216 km long and the reservoir is operated under the terms of the Columbia River Treaty. The normal operating range of the reservoir is between elevation 754.38 m and 707.41 m.

Kinbasket Reservoir inundated 539 km of rivers and streams, 24 km^2 of small and medium lakes, 5.5 km^2 of shallow water habitat, and extensive flood plain and wetland habitat (Thorley 2008). Much of this included the Columbia River mainstem and lower portions of the Canoe, Wood, Bush, Gold, Sullivan, Kinbasket and Cummins Rivers (Arndt 2009a). The typical annual drawdown of 40 m results in a reduction in reservoir surface area of roughly 50%, which restricts littoral productivity and the suitability of littoral habitat for early life history stages and spawning of many fish species (Cope 2008).

Non-Hydro Impacts.— Other impacts include historic and ongoing effects of logging.

Limiting Factors

Kinbasket Reservoir is relatively deep, cold and nutrient poor, which limits biological productivity (Cope 2008). The water is turbid with the onset of freshet, further limiting aquatic productivity. The valley is steep-sided and the deep drawdown each year limits littoral productivity and available habitat for many species of fish. In addition, many of the tributaries entering the reservoir are steep, ephemeral or glacial fed and have obstructions in their lower reaches. These characteristics have been exacerbated by inundation and limit spawning habitat for most species (Cope 2008).

Trends and Knowledge Status

Habitat Trends.— Kinbasket Reservoir flooded the largest amount of aquatic and terrestrial habitat of any of the Columbia reservoirs in BC (Arndt 2009a). Stream and lake habitat was replaced with reservoir habitat that covers 370 km^2 at average elevation during the growing season (Moody et al. 2007). The reservoir itself is ultra-oligotrophic (Hirst 1991). The vast area of the reservoir means that pelagic productivity is higher than pre-dam, but there were large losses of production (e.g., the flooding of wetlands) (Moody et al. 2007).

Prior to the formation of Kinbasket Reservoir there was a great amount of stream habitat, mostly in the Columbia River mainstem. The Columbia River above Kinbasket Lake, and many of the tributaries, were turbid and cold until late summer due to glacial melt. Downstream of Kinbasket Lake the river was less turbid, because suspended sediment settled in the lake (Moody et al. 2007). Temperatures in this reach were low: maximum summer temperature was less than 13 ºC even below Kinbasket Lake (Hamblin and McAdam 2003). Conditions were likely best suited to fall-spawning species such as whitefish and bull trout (Peterson and Withler 1965b cited in Arndt 2009a).

Stock Trends.— Fishing pressure was low in this area prior to construction of Mica Dam. Fish stocks have not been intensively studied prior to or since the reservoir was established, so trends are poorly known for most fish stocks.

White sturgeon were likely present in this area at times to feed on anadromous salmon runs prior to the construction of Grand Coulee dam (Prince 2001), but recent efforts have failed to catch sturgeon in Kinbasket Reservoir (Prince 2010). Investigations are currently underway to assess the risks and feasibility of establishing a white sturgeon population in Kinbasket Reservoir as part of recovery efforts (Porto 2008).

Rainbow trout were likely quite limited in abundance and distribution in this area, though large piscivorous rainbow from Arrow Lakes spawned in tributaries like Camp Creek (Arndt 2009a), and were present in small lakes (e.g., Bush Lakes) that were lost through impoundment. Whitefish probably comprised the majority of biomass, with a smaller proportion being rainbow trout and bull trout (Arndt 2009a).

Kokanee were not observed in this area prior to Mica Dam, but were introduced to the reservoir in the 1980s and have become well-established (Arndt 2009b, Sebastian et al. 2010). Hydroacoustic estimates indicate a stable and abundant population with estimates ranging from 6.7 to 11 million for the years 2001 to 2005 (Sebastian et al. 2010). Preliminary biomass estimates were 5.4 kg.ha-1 (range: 4-7 kg.ha-1). This is close to the predicted kokanee biomass based on primary productivity estimates (Moody et al. 2007).

Relatively little is known about the status of the burbot population in Kinbasket Reservoir, but the current population status is considered reasonable (M. Neufeld, MOE, pers. comm.). There is also little known about bull trout in the reservoir.

Knowledge Gaps.— This is a relatively isolated waterbody with low recreation and angling use, and hence is lower priority for collecting fisheries and other ecological data. As a result, less fisheries and other ecological information is available for this reservoir. The greatest gaps in knowledge of fish in Kinbasket Reservoir have to do with long-term status and abundance trends of the main fish species of interest like kokanee, burbot, bull trout and rainbow trout. General limnological information is also a key data gap, although information is currently being collected as part of BC Hydro water license requirements. Potential compensation projects are listed in the dam impacts reports dealing with primary productivity (Moody et al. 2007), habitat (Thorley 2008) and species impacts (Cope 2008, Hagen 2008, Porto 2008, Arndt 2009a,b), though detailed site-specific, prioritized recommendations are lacking. A monitoring program for kokanee has been implemented to assess WUP-related operational changes at Mica and Revelstoke dams.

Kinbasket Reservoir Fish Priorities

The following statements articulate some of the current management priorities for Kinbasket Reservoir and were used when setting management targets for this waterbody.

1. Province of BC's highest sport fishery priority is bull trout.
2. Burbot, rainbow trout, and kokanee are secondary fishery priorities.

2.6 Other Large Lakes

Other large lakes in the FWCP: Columbia region include:

1. Columbia Lake
2. Duck Lake
3. Koocanusa Reservoir
4. Moose Lake
5. Slocan Lake
6. Trout Lake
7. Whatshan Reservoir
8. Windermere Lake

As noted earlier, this Large Lakes Action Plan does not restrict FWCP investment on large lakes to the five lakes discussed in detail in Sections 2.1 to 2.5. In fact, some actions are proposed in Section 4.2 for these other lakes and some of these actions are considered high priority. The action plan may be expanded in the future to include additional detail for other large lakes.

3. Action Plan Objectives, Measures and Targets

Clear management objectives are necessary to guide information acquisition and prioritize management actions. Priority actions and information needs will change as both improvements to the system are realized and information is gained. The current plan reflects the information available and values expressed by stakeholders (FWCP partners, First Nations and local communities) through reports, interviews and regional workshops held between 2009 and 2011.

3.1 Objective and Target Setting

The following terminology is used in this report.

Objectives:	Objectives are high-level statements of desired future conditions (outcomes), consistent with FWCP partner mandates and policies.
Sub-objectives and Status Indicators:	Sub-objectives are detailed statements of desired future conditions within objectives, from which status indicators can be derived and alternative management actions evaluated. Sub-objectives and indicators provide the details necessary to translate policy into actions and to evaluate their consequences. They may be arranged hierarchically within objectives, and usually indicate conditions necessary to attain the objective to which they refer.
Measures:	Measures are specific metrics whose values indicate the degree to which desired future conditions have been achieved. They can be either qualitative or quantitative. There is a preference to develop the latter where possible for ease of monitoring.
Targets:	Targets are the values of measurable items that indicate the attainment of a desired condition. In the current context these may be expressed as a single value or as a range to acknowledge the inherent variability of ecosystems.
Actions:	Management actions, plans or policies for achieving the objectives.

Objectives are the “ends” or the outcomes we ultimately care about. Actions are the “means,” or the things we do to achieve them. This report focuses on describing the actions required to achieve the objectives in relation to fish and wildlife in small and medium size lakes. Actions relating to specific species or habitats may also be related to actions in other Action Planning documents such as the Riparian and Wetlands or Species of Interest plans.

3.2 The FWCP Large Lakes

Management objectives are common to all lakes discussed in this plan, although the species of interest vary among the lakes and thus the list of indicators and measures may differ. While the objectives are expected to remain stable over time, the indicators and targets may evolve as agencies’ priorities shift, or new information becomes available. Summary tables of the objectives, sub-objectives, measures and targets for each water body are presented in Appendix A.

There are three FWCP objectives:

1. Conservation – Ensure a productive and diverse aquatic ecosystem,
2. Conservation – Improve the status of species of conservation concern,
3. Sustainable Use – Maintain or improve opportunities for sustainable use.

Objective 1 – Ensure a productive and diverse aquatic ecosystem.

This objective is supported by up to seven status indicators, depending on the waterbody:

1. Aquatic productivity status
2. Structure and function of ecological communities
3. Piscivorous rainbow trout status
4. Insectivorous rainbow trout status
5. Kokanee status
6. Bull trout status
7. Burbot status

The indicators address issues at both the landscape and species level. Landscape-level issues are addressed through targets for the overall productivity of each lake and the overall structure of the fish communities and wildlife they support. The species-level indicators focus on species of greatest management concern. There is a tacit assumption that these are to some extent indicator species and that meeting targets for these species will support conservation of other fish species not in this list.

Objective 2 – Improve the status of species of conservation concern.

Rationale: Species of conservation concern (e.g., white sturgeon) may also benefit from general improvements in large lake habitat, but often there are specific factors that may be limiting the abundance and distribution of priority species. Actions to address these factors are presented in the Species of Interest Action Plan for the Columbia Basin. There may be good opportunities to meet conservation objectives through actions that are part of several different action plans, and the priorities presented in this plan should not be interpreted as constraining restoration actions aimed at supporting species of interest.

Objective 3 – Optimize recreational angling opportunities, participation and local benefits.

Rationale: This objective reflects the important sustainable use benefits that can be derived from a healthy fish population. The status indicator is the socio-economic value of the fishery, where value is expressed in both monetary and non-monetary terms. The measures to be used include number of angler days and allowable harvest.

As additional context, it should be noted that fisheries management agencies have an overall responsibility to manage the fisheries resource at a level of abundance and distribution to support First Nations' traditional uses and rights. These responsibilities are dealt with through the ongoing process of decision-making, which is not a formal part of this FWCP plan.

4. Action Plan

4.1 Overview

The Action Plan has many individual actions that are presented in Section 4.2. Some actions support multiple sub-objectives, which in turn support multiple objectives. Figure 4 provides an overview of the link between actions and objectives.

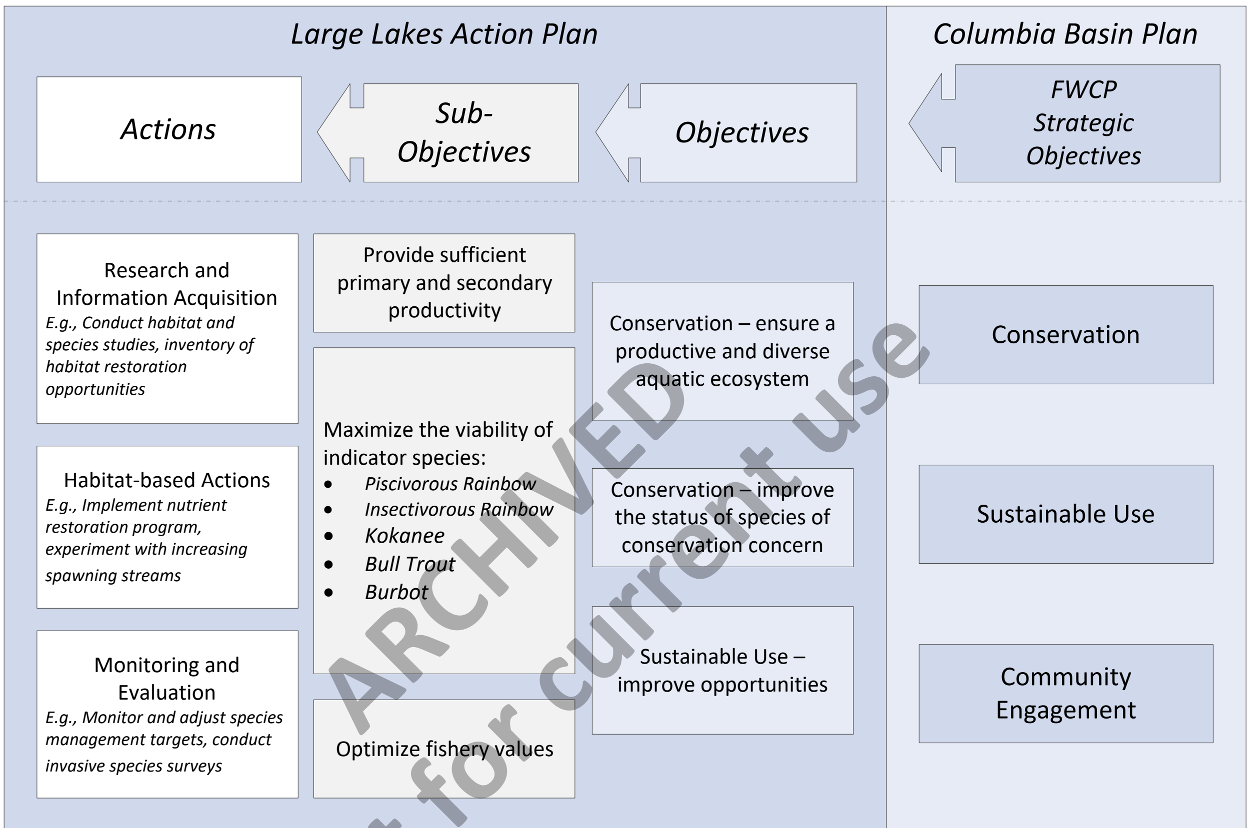

Figure 4: Relationship between actions, sub-objectives and objectives in this Large Lakes Action Plan and the FWCP strategic objectives in the Columbia Basin Plan.

Measures and Targets.— Considerable planning effort went into developing initial measures and targets to help link objectives and actions, and to ensure that the set of proposed actions in Section 4.2 is complete. The full suite of proposed objectives, sub-objectives, measures and targets is presented in Appendix A for each of the five priority large lakes. Some of the targets are qualitative, whereas others are very specific and quantitative. It is fully expected that some of these targets will be revised as additional information is collected as part of program monitoring, and as the FWCP program further engages its partners and stakeholders. All of the actions presented and discussed in Section 4.2 should be traceable to targets, measures and objectives presented in the tables in Appendix A.

Program Delivery.— The overall vision and common principles of the FWCP program are discussed in greater detail in the Basin Plan (Fish and Wildlife Compensation Program 2011). The bulk of projects undertaken will be delivered under Action Plans that lay out a suite of key actions to achieve specific goals associated with priority species and ecosystems. Nevertheless, a portion of the FWCP program activities will include small-scale, short-duration strategic projects that target specific issues identified by program partners or others (e.g., community members). These could include projects not yet identified in any action plans, as well as lower priority action plan items that require timely response to take advantage of an investment or partnership opportunity.

4.2 Components

This section presents the main actions identified under each sub-objective along with the supporting rationale for why the action is required and what it will achieve. Actions are organized under five broad categories: Research and Information Acquisition, Habitat-based Actions, Species-based Actions, Land Securement, and Monitoring and Evaluation. Also provided are priority ratings to guide investment planning efforts. Actions are assigned priorities from 1-3. Note that more comprehensive lists of actions are in the dam footprint impact reports; these could be assigned rankings when funding resources for delivery become available.

The actions were developed using two complementary approaches. The first was to review the targets for each waterbody separately and assess the actions required to reach each target. Typically, several actions were required for each target. The second approach used two outputs from the Species Rating and Database Tool (FWCP 2011b) to identify high priority species that would benefit most from FWCP investment on large lakes and the generic types of actions required. The first output from the Database Tool is the subset of species that depend on large lakes more than any other type of habitat. The list includes seven fish, and four bird species (Appendix B). These are the species that have been heavily impacted by dam footprint on large lakes and for which there is a regional conservation concern and/or high local interest. Appendix B identifies the highest priority habitat-based actions on large lakes that will directly benefit these species. The second output is a longer list of species (Appendix B **Table B2**) for which large lakes represent a “supporting” habitat; that is, these species occur in large lakes, but they occur more often or are more dependent on one or more other habitat types. Habitat-based actions taken on large lakes may benefit these species, but actions on their primary habitat are likely to provide greater benefit.

<u>Status Indicator 1 Aquatic Productivity.</u> Sub-objective: Provide sufficient primary and secondary productivity to support targets for higher trophic levels.

	Actions	Kootenay	Duncan	Arrow	Kinbasket	Revelstoke
	Habitat Based Actions					
1	Continue the Kootenay Lake and Arrow Lakes nutrient restoration program to sustain inlake productivity at levels sufficient to support fisheries management and ecosystem objectives, measures and targets. - Apply seasonally adjusted nutrients to mimic natural inputs. - Monitor nutrient and plankton status to help achieve proper implementation of the nutrient restoration program. - Review possible management actions when nutrient status is outside target range. - Adjust targets as information becomes available or if management priorities change.	1		1		
	Research & Information Acquisition					
2	Assess feasibility of nutrient additions to other waterbodies.		2		2	2
	Species Based Actions					
3	Support Bear Smart initiatives within and surrounding spawning channels to reduce human-grizzly bear conflicts. Priority is Meadow Ck, possibly in the future Hill Ck.	1		2		

Rationale.— The nutrient restoration program is the primary means currently being used to offset losses of aquatic productivity in Kootenay and Arrow lakes due to impoundment and upstream dams. The program started in 1992 with the purpose of rebuilding the food web by releasing a seasonally-adjusted mixture of liquid nitrogen and phosphorus to mimic natural, pre-dam nutrient inputs. The program started with Kootenay Lake and was expanded in 1999 to include upper Arrow Lake. The nutrients support phytoplankton, which feeds the zooplankton which in turn feed the kokanee. Kokanee are the fish species most preyed on by piscivorous fish (like Gerrard rainbow trout and bull trout) and wildlife (like birds and bears). The nutrient restoration program is therefore critical to meeting many of the program objectives and targets.

A fundamental trade-off exists between the nutrient restoration program and cost of fertilizer. The present cost of fertilizer absorbs a substantial portion of the currently available FWCP budget, which precludes spending on other FWCP program initiatives. Evaluating this trade-off requires good information on the benefits and costs of nutrient addition – information that is incomplete though currently being collected (provide REF). Independent reviews (provide REF) indicate that the program is providing substantial aquatic benefits and have recommended that the program continue in its present form for the time being. As additional information becomes available through modeling and empirical study or as new resources become available, the program may decide to maintain, expand or reduce nutrient restoration programs in different lakes. Until this information is available there is clear management direction to maintain the current approach.

Implementation and efficacy of the nutrient restoration program should be reviewed on a regular basis and targets should be adjusted appropriately. There is already a detailed monitoring program to assess the response at multiple trophic levels to nutrient additions, from plankton to kokanee abundance and biomass; however, evaluation of success at the apex predator level (e.g., bull trout) is only being initiated. Such a program is required to ensure effective implementation of fertilizing. Some additional review and planning may be required to ensure this monitoring is providing the best information and effectively communicates results.

<u>Status Indicator 2 Structure and function of ecological communities.</u> Sub-objectives: Maintain the overall ecological structure and function of the fish community and associated wildlife communities. Minimize invasive species.

	Actions	Kootenay	Duncan	Arrow	Kinbasket	Revelstoke
	Research & Information Acquisition					
4	Develop and implement invasive species monitoring and response plan	2	3	2	3	3
	Monitoring & Evaluation					
5	Monitor status of fish communities not monitored under other actions	2	3	2	3	3
6	Review possible management actions when relative abundance or invasive species are outside target range	2	3	2	3	3
7	Adjust targets for relative abundance or invasive species as information becomes available or if management priorities change	2	3	2	3	3

Rationale.— All species are important, but in some cases it is possible to identify a subset that can be used as indicators for the status of the broader community. Managing for and tracking the status of these species provides a good overall picture of progress toward fish and wildlife management goals. This action plan focuses on a list of up to five species depending on the waterbody (see status indicators 3 to 7 below), with the assumption that meeting targets for these will support conservation of other fish species not in this list. Nevertheless, there is a desire to provide a backup measure for the community as a whole, as a sort of safety net. The measure proposed is the relative abundance of representative species. Additional work would be required to refine targets, but the current status is proposed as the interim target. (Note that current relative abundance, given the large capacity for fry production at spawning channels, may be quite different than relative abundance under pre-dam or other conditions, and may not be optimal for angling or ecosystem productivity.) Monitoring of the whole fish community would be required to assess trends and departures from targets.

Another aspect of community-wide monitoring is invasive aquatic species. At this time invasive species are not a large problem in these lakes, but invasives continue to spread in British Columbia and there are risks that such species could become established here. An invasive species monitoring and response plan should be developed and implemented.

Targets for relative abundance and invasive species should be reviewed regularly and adjusted if necessary.

<u>Status Indicator 3 Piscivorous rainbow trout.</u> Sub-objective: Maximize the viability of large piscivorous rainbow trout.

	Actions	Kootenay	Duncan	Arrow	Kinbasket	Revelstoke
	Research & Information Acquisition					
8	Conduct risk assessments of establishing a fishery for large piscivorous rainbow, and if acceptable develop the fishery. Note that steps have already been taken toward establishing a fishery in some of these waterbodies.		2	1	3	
9	Conduct habitat- and species-based biological studies to support understanding of compensation options for piscivorous rainbow trout, such as the benefits of habitat restoration.	1	2	1	3	
10	Develop an inventory of potential lake-specific habitat restoration and enhancement projects for piscivorous rainbow trout, the likely costs, benefits and priorities, to guide selection of enhancement and restoration options. As part of this planning effort, incorporate restoration recommendations from the dam impacts studies, where appropriate.	1	2	1	3	
11	Inventory existing spawning tributaries used by piscivorous rainbows in ALR.			1		
	Habitat Based Actions					
12	Implement habitat-based recommendations from detailed planning efforts (#8, #9, #10), to support restoration of piscivorous rainbow trout. (Note: a portion of the FWCP program activities will include small-scale, short-duration strategic projects that target specific issues identified by program partners or others. These could include projects not yet identified in any action plans, as well as lower priority action plan items that require timely response to take advantage of an investment or partnership opportunity.)	1	2	1	3	
	Monitoring & Evaluation					
13	Monitor status of multiple ecosystem components relative to current fisheries and ecosystem objectives, measures and targets to guide management actions for piscivorous rainbow trout.	1	2	1	3	
14	Review possible management actions when results for piscivorous rainbow trout are outside the target range.	1	2	1	3	
15	Adjust targets for piscivorous rainbow trout as information becomes available or if management priorities change.	1	2	1	3	

Rationale.— To support targets for piscivorous rainbow trout in Kootenay and Arrow lakes, the nutrient program should continue, along with its associated monitoring and evaluation. As noted earlier, the nutrient restoration program is the primary means currently being used to offset losses of aquatic productivity in Kootenay and Arrow lakes due to impoundment and upstream dams. The nutrient restoration program is critical to meeting many of the program objectives and targets, and is described further in the discussion related to actions regarding aquatic productivity.

There is a goal of establishing a fishery for large piscivorous rainbow trout in Duncan, Kinbasket and Arrow Lakes reservoirs. Triploid Gerrard strain fish have been stocked in some of these waterbodies for several years, and there is a desire to move toward developing self-sustaining stocks, if feasible and a low risk to other species. A risk assessment is the first step in this process, and depending on the outcome of the assessment, would be followed by additional planning and implementation.

There is much we don’t know biologically and physically about the species and habitats of interest, and it is often necessary to collect information to help evaluate and implement compensation options. For example, to address recruitment limitations in a particular species it may be necessary to understand which streams are used for spawning and the limiting conditions in those streams. Collecting basic biological information will often be a precursor to developing viable compensation projects.

Compensation requires increases in biological productivity to offset hydro development-related declines in productivity. In truth, there are myriad ways to compensate for fisheries impacts, from broad-scale fertilization of streams and reservoirs to small-scale habitat restoration and enhancements. Some of these work better for some species than others, and some may be more suited to certain physical settings. To make informed choices on implementing the most cost-effective projects requires understanding what is possible and the costs and benefits of different approaches. Applying compensation to large lakes in the compensation area would be greatly helped by an assessment of likely benefits and cost of compensation options for each waterbody. This would aid priority setting both within and among waterbodies.

Monitoring is a cornerstone of good resource management because it provides information on present status and trends and allows post-implementation assessment of management decisions and programs. Fundamentally, monitoring provides direction on adjustments that may be necessary. There are multiple elements related to piscivorous rainbow trout that require monitoring. For example, habitat utilization by different life stages, spawning escapements, size and age of spawners, status and trends of abundance and biomass, and monitoring of the fishery harvest and effort are all worthy of a dedicated monitoring program. Realistically, monitoring will likely focus on sportfish and species of concern, efforts should be coordinated, and the level of effort will likely vary among waterbodies. Results of monitoring should feed directly into compensation program evaluation and help revise objectives and targets, where necessary.

<u>Status Indicator 4 Kokanee.</u> Sub-objectives: Ensure sufficient abundance of forage fish to meet targets for large piscivores. Increase the number of spawning populations in Kootenay Lake. Maximize the abundance of large kokanee in support of angling and harvest.

	Actions	Kootenay	Duncan	Arrow	Kinbasket	Revelstoke	West Arm Kootenay
	Research & Information Acquisition						
16	Conduct habitat- and species-based biological studies to support understanding of compensation options for kokanee, such as the benefits of habitat restoration.	3	3	3	3	3	3
17	Develop an inventory of potential habitat restoration and enhancement projects for kokanee, the likely costs, benefits and priorities, to guide selection of enhancement and restoration options. As part of this planning effort, incorporate restoration recommendations from the dam impacts studies, where appropriate.	3	3	3	3	3	3
	Habitat Based Actions						
18	Experiment with increasing the number of spawning stocks to reduce risk of a single spawning location.	2		2			3
19	Implement habitat-based recommendations from detailed planning efforts (#16 and #17), to support restoration of kokanee. (Note: a portion of the FWCP program activities will include small-scale, short-duration strategic projects that target specific issues identified by program partners or others. These could include projects not yet identified in any action plans, as well as lower priority action plan items that require timely response to take advantage of an investment or partnership opportunity.)	3	3	3	3	3	3
	Monitoring & Evaluation						
20	Monitor status of multiple ecosystem components relative to current fisheries and ecosystem objectives, measures and targets to guide management actions for kokanee.	1	3	1	3	3	2
21	Review possible management actions when results for kokanee are outside the target range.	1	3	1	3	3	2
22	Adjust targets for kokanee as information becomes available or if management priorities change.	1	3	1	3	3	2

Rationale.— The rationale for several of the proposed actions related to kokanee are similar to those discussed earlier for piscivorous rainbow trout. The one exception is the species-specific activity of experimenting with increasing the number of kokanee spawning stocks to reduce the risk of a dominant spawning locations and to spread the ecosystem benefits of kokanee spawners around the lake. At present, kokanee abundance in the north and south arm of Kootenay Lake is supported by spawning in the Meadow Creek spawning channel, and although the production level is high, there is a concern that other runs in natural tributaries are being suppressed by production from the dominant stock (Arndt 2009b). There are concerns of lowered genetic diversity and increasing risk of catastrophe (e.g., a spill or accident) when relying primarily on dominant spawning locations. The action proposed here would be to evaluate the concerns and explore the viability of alternative management actions. A similar action could be undertaken for Arrow Lakes in relation to Hill Creek spawning channel, and the Kootenay Lake west arm stock, which is supported primarily by spawning in artificial channels.

<u>Status Indicator 5 Bull trout.</u> Sub-objective: Maximize the viability of bull trout.

	Actions	Kootenay	Duncan	Arrow	Kinbasket	Revelstoke
	Research & Information Acquisition					
23	Conduct habitat- and species-based biological studies to support understanding of compensation options for bull trout, such as the benefits of habitat restoration.	1	3	1	3	3
24	Develop an inventory of potential habitat restoration and enhancement projects for bull trout, the likely costs, benefits and priorities, to guide selection of enhancement and restoration options. As part of this planning effort, incorporate restoration recommendations from the dam impacts studies, where appropriate.	1	3	1	3	3
	Habitat Based Actions					
25	Implement habitat-based recommendations from detailed planning efforts (#23 and #24), to support restoration of bull trout. (Note: a portion of the FWCP program activities will include small-scale, short-duration strategic projects that target specific issues identified by program partners or others. These could include projects not yet identified in any action plans, as well as lower priority action plan items that require timely response to take advantage of an investment or partnership opportunity.)	1	3	1	3	3
	Monitoring & Evaluation					
26	Monitor status of multiple ecosystem components relative to current fisheries and ecosystem objectives, measures and targets to guide management actions for bull trout.	2	3	2	3	3
27	Monitor status and trends of lake-specific bull trout populations.	2	3	2	3	3
28	Review possible management actions when results are outside the target range for bull trout.	2	3	2	3	3
29	Adjust targets for bull trout as information becomes available or if management priorities change.	2	3	2	3	3

Rationale.— The rationale for the proposed actions related to bull trout are similar to those discussed earlier for piscivorous rainbow trout. The one exception is the species-specific activity of monitoring bull trout in Arrow and Kootenay lakes. Monitoring plans for bull trout in these lakes have been developed (Decker and Hagen 2007, Hagen and Decker 2009) and should be used as guidance when developing a coordinated monitoring program for all species and waterbodies.

<u>Status Indicator 6 Burbot.</u> **Sub-objective: Maximize the viability of burbot.**

	Actions	Kootenay	Duncan	Arrow	Kinbasket	Revelstoke
	Research & Information Acquisition					
30	Conduct habitat- and species-based biological studies to support understanding of compensation options for burbot, such as the benefits of habitat restoration.	2	3	3	3	3
31	Develop an inventory of potential habitat restoration and enhancement projects for burbot, the likely costs, benefits and priorities, to guide selection of enhancement and restoration options. As part of this planning effort, incorporate restoration recommendations from the dam impacts studies, where appropriate.	2	3	3	3	3
	Habitat Based Actions					
32	Implement habitat-based recommendations from detailed planning efforts (#30 and #31), to support restoration of burbot. (Note: a portion of the FWCP program activities will include small-scale, short-duration strategic projects that target specific issues identified by program partners or others. These could include projects not yet identified in any action plans, as well as lower priority action plan items that require timely response to take advantage of an investment or partnership opportunity.)	2	3	3	3	3
	Monitoring & Evaluation					
33	Monitor status of multiple ecosystem components relative to current fisheries and ecosystem objectives, measures and targets to guide management actions for burbot.	2	3	3	3	3
34	Review possible management actions when results are outside the target range for burbot.	2	3	3	3	3
35	Adjust targets for burbot as information becomes available or if management priorities change.	3	3	3	3	3

Rationale.— The rationale for the proposed actions related to burbot are similar to those discussed earlier for piscivorous rainbow trout. Possible exceptions relate to the current endangered status of burbot in Kootenay Lake. Specific activities for burbot in Kootenay Lake may be required to recover this population, but these efforts are better developed and described within the "Species Action Plan."

<u>Status Indicator 7 Insectivorous rainbow trout.</u> Sub-objective: Maximize the viability of insectivorous rainbow trout.

	Actions	Kootenay	Duncan	Arrow	Kinbasket	Revelstoke
	Research & Information Acquisition					
36	Conduct habitat- and species-based biological studies to support understanding of compensation options, such as the benefits of habitat restoration.	2	3	2	3	3
37	Develop an inventory of potential habitat restoration and enhancement projects, the likely costs, benefits and priorities, to guide selection of enhancement and restoration options. As part of this planning effort, incorporate restoration recommendations from the dam impacts studies, where appropriate.	2	3	2	3	3
	Habitat Based Actions					
38	Implement habitat-based recommendations from detailed planning efforts (#36 and #37), to support restoration of insectivorous rainbow trout. (Note: a portion of the FWCP program activities will include small-scale, short-duration strategic projects that target specific issues identified by program partners or others. These could include projects not yet identified in any action plans, as well as lower priority action plan items that require timely response to take advantage of an investment or partnership opportunity.)	2	3	2	3	3
	Monitoring & Evaluation					
39	Monitor status of multiple ecosystem components relative to current fisheries and ecosystem objectives, measures and targets to guide management actions.	3	3	3	3	3
40	Review possible management actions when results are outside the target range.	3	3	3	3	3
41	Adjust targets as information becomes available or if management priorities change.	3	3	3	3	3

Rationale.— The rationale for the proposed actions related to insectivorous rainbow trout are similar to those discussed earlier for piscivorous rainbow trout.

Status Indicator 8 Socio-economic value. **Sub-objective: Optimize the monetary and non-monetary values from the fishery.**

	Actions	Kootenay	Duncan	Arrow	Kinbasket	Revelstoke
	Research & Information Acquisition					
42	Collect biological and use information to allow modeling of management scenarios.	1	2	1	3	2
43	Support modeling efforts to develop and update angling effort targets.	1	2	1	3	2
44	Develop sustainable use targets based on analysis of trade-offs on multiple objectives.	1	2	1	3	2
45	Monitor catch of piscivorous rainbow trout, insectivorous rainbow trout, bull trout and kokanee.	2	3	2	3	3
	Habitat Based Actions					
46	Implement habitat-based recommendations from detailed planning efforts (#8, #9, #10, #16, #17, #23, #24, #30, #31, #36 and #37), to support restoration of species targeted by fisheries. (Note: a portion of the FWCP program activities will include small-scale, short-duration strategic projects that target specific issues identified by program partners or others. These could include projects not yet identified in any action plans, as well as lower priority action plan items that require timely response to take advantage of an investment or partnership opportunity.)	see priorities in tables above				
	Monitoring & Evaluation					
47	Adjust targets as information becomes available or if management priorities change.	2	3	2	3	3

Rationale.— The rationale for continuing the nutrient restoration program and associated monitoring is presented in earlier discussions of indicators for aquatic productivity and individual species. The nutrient restoration program clearly is intended to support fishery targets in Kootenay Lake and Arrow Lakes Reservoir.

Other actions for this sub-objective relate to sustainable use of the fishery resource, specifically to optimizing fish populations to support management goals for the fishery on each waterbody. Developing fisheries management targets requires consideration of multiple objectives, some of which may be in competition. Where objectives are competing, targets implicitly include trade-offs (e.g., more of one thing requires accepting less of another) and decisions should be informed by the best available information. One of the actions is to collect the kind of data and develop the kind of interactive models that will inform development of targets for sustainable use.

Management choices have been made to give highest angling priority to piscivorous rainbows in Kootenay Lake, and high priority in other lakes that can support them. For example, Kootenay Lake kokanee in the north and south arm are managed primarily as a prey species for large piscivores and secondarily as a target species for anglers. As additional information becomes available through modeling and empirical study, it may be acceptable to increase the relative priority of other species. Until this information is available there is clear management direction to favour the Gerrard stock in Kootenay Lake.

It is possible that other information could also influence choice of targets. For example, new information may change our understanding of Gerrard trout response to kokanee size and abundance, zooplankton response to lake fertilization, or numerical response of burbot to harvest restrictions. As new information becomes available, new targets may need to be considered.

Monitoring of the fishery currently occurs but could be improved. A single coordinated monitoring program for the fishery should be designed that will provide the information required to ensure the fishery is being managed effectively for desired outcomes. The level of effort will likely vary among waterbodies.

Other Large Lakes

Detailed planning for large lakes has focused on five high-priority lakes, but there are eight other large lakes in the FWCP: Columbia region (see list in Section 2.6) for which there may be good opportunities for enhancement and restoration within the FWCP mandate. The following actions will expand the current planning efforts to all large lakes in the region and conduct necessary research and implementation.

	Actions	Priority
	Research & Information Acquisition	
48	Undertake additional planning for the large lakes not already addressed in detail in the large lakes action plan. This additional information will follow the approach used for the five large lakes currently discussed in detail, and will describe opportunities for FWCP investment and describe how results should be monitored.	2
49	Conduct surveys of "focal" and "inventory" species (see Species of Interest Plan)	2
	Habitat Based Actions	
50	Restore and create habitat elements for focal fish and wildlife species. Actions may include: - Enhance fish spawning and rearing habitat - Provide nesting islands for loons and waterfowl - Create emergent aquatic vegetation with slightly submerged floating islands - Create loafing logs or islands for turtles and waterfowl - Build nesting islands for turtles - Create wildlife trees on shorelines - Install nesting boxes on shorelines (see status indicators 1-8 for other fish-related actions, as applicable.) Note: a portion of the FWCP program activities will include small-scale, short-duration strategic projects that target specific issues identified by program partners or others. These could include projects not yet identified in any action plans, as well as lower priority action plan items that require timely response to take advantage of an investment or partnership opportunity.	2
	Land Securement	
51	Investigate land securement and stewardship opportunities. (Note that some existing stewardship programs are in place - e.g., Slocan Lake Stewardship Society - and may be expanded or used as good models.)	2
	Monitoring & Evaluation	
52	Develop an understanding of monitoring and evaluation needs and implement the program.	2

5. Conclusion

The development of BC Hydro dams and reservoirs in the Columbia Basin resulted in extensive inundation of small lakes, wetlands, streams, and floodplains. This extensive change in habitat resulted in direct and indirect impacts to a number of fish (and wildlife) species. Opportunities to restore and improve overall productivity have been identified in this plan for five large lake / reservoir systems:

1. Kootenay Lake
2. Duncan Reservoir
3. Arrow Lakes Reservoir
4. Revelstoke Reservoir
5. Kinbasket Reservoir

A key focus of the plan is on the nutrient restoration program for Kootenay Lake and Arrow Lakes (including seasonal nutrient additions, ongoing monitoring and adjustment). In addition, numerous research and information acquisition and monitoring actions are identified for key indicator species that include rainbow trout, kokanee, bull trout and burbot. Should sufficient resources become available, an additional set of habitat-based actions have been identified for eight other large lakes in the basin.

By making investments in these large lakes, FWCP directly addresses the program's strategic objective to maintain productive and diverse ecosystems. The investments contribute to improving the status of priority species by improving the habitats on which many of the species depend. These habitats also support a variety of consumptive and non-consumptive sustainable use activities by First Nations and the public.

6. References

Ahrens, R. and J. Korman. 2002. What happened to the West Arm burbot stock in Kootenay Lake? Use of an age-structured population model to determine the possible causes of recruitment failure. Report prepared for the B.C. Ministry of Water, Land, and Air Protection, the Habitat Conservation Trust Fund, and the Bonneville Power Administration. 29pp.

Arndt, S. 2009a. Footprint impacts of BC Hydro dams on rainbow trout in the Columbia River basin, British Columbia. Prepared by Fish and Wildlife Compensation Program – Columbia Basin, Nelson, BC.

Arndt, S. 2009b. Footprint impacts of BC Hydro dams on kokanee populations in the Columbia River basin, British Columbia. Prepared by: Fish and Wildlife Compensation Program - Columbia Basin, Nelson, BC.

Arndt, S. and J. Baxter. 2006. Status of burbot (*Lota lota*) in Arrow Lakes Reservoir. Report for Columbia Basin Fish and Wildlife Compensation Program, Nelson, BC and BC Hydro, Castlegar, BC.

BC Hydro. 2007. Duncan Dam Project Water Use Plan. Revised for acceptance by the Comptroller of Water Rights. December 20, 2007. Available at: http://www.bchydro.com/etc/medialib/internet/documents/environment/pdf/wup_duncan_dam_project_water_use_plan_december_2007.Par.0001.File.wup_duncan_dam_project_water_use_plan_december_2007.pdf.

Cope, 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 – Columbia Basin, Nelson, BC.

Daley, R. J., E. C. Carmack, C. B. J. Gray, C. H. Pharo, S. Jasper, and R. C. Wiegand. 1981. The effects of upstream impoundments on the limnology of Kootenay Lake, B.C. Environ. Canada, NWRI, Inland Waters Directorate, Sci. Series 117, Vancouver, B.C.

Decker, S. and J. Hagen. 2007. Distribution of Adfluvial Bull Trout Production in Tributaries of Arrow Lakes Reservoir and the Feasibility of Monitoring Juvenile and Adult Abundance. Prepared for Fish and Wildlife Compensation Program - Columbia Basin. Nelson, BC.

Decker, S. and J. Hagen. 2008. Adfluvial bull trout spawner abundance in tributaries of the Arrow Lakes Reservoir. Prepared for Fish and Wildlife Compensation Program - Columbia Basin. Nelson, BC.

Duke, S. D., P. Anders, G. Ennis, R. Hallock, J. Hammond, S. Ireland, J. Laufle, R. Lauzier, L. Lockhard, B. Marotz, V. L. Paragamian, and R. Westerhof. 1999. Recovery plan for Kootenai River white sturgeon (*Acipenser transmontanus*). Journal of Applied Ichthyology **15**:157-163.

Fish and Wildlife Compensation Program. 2010. Ministry of Environment fisheries management objectives for Kootenay Lake, Duncan Reservoir, Arrow Lakes, Revelstoke Reservoir and Kinbasket Reservoir. Draft report for the Fish and Wildlife Compensation Program: Columbia Basin, Nelson, BC.

Fish and Wildlife Compensation Program. 2011. Columbia Basin Plan. Available at: http://www.fwcpcolumbia.ca/version2/index.php

Hagen, J. 2008. Impacts of dam construction in the upper Columbia Basin, British Columbia, on bull trout (Salvelinus confluentus) production, fisheries, and conservation status. Prepared for: Fish and Wildlife Compensation Program - Columbia Basin, Nelson BC.

Hagen, J. and S. Decker. 2009. Bull trout monitoring plan for Kootenay Lake. Prepared for Fish and Wildlife Compensation Program - Columbia Basin, Nelson, BC. .

Hamblin, P. F. and S. O. McAdam. 2003. Impoundment effects on the thermal regimes of Kootenay Lake, the Arrow Lakes Reservoir and Upper Columbia River. Hydrobiologia **504**:3-19.

Hirst, S. M. 1991. Impacts of the operation of existing hydroelectric developments on fishery resources in British Columbia. Volume 2. Inland fisheries. Canadian Manuscript Report of Fisheries and Aquatic Sciences **2093**.

MacDonald, A. 2009. Fish & Wildlife Compensation Program: Executive Summary. Report for BC Hydro, Vancouver, BC.

Martin, A. D. 1978. Interim report of investigations on fish populations that will be affected by the Revelstoke 1880 dam. Report prepared for the BC Fish and Wildlife Branch. 11p.

Matzinger, A., R. Pieters, K. I. Ashley, G. A. Lawrence, and A. Wüest. 2007. Effects of impoundment on nutrient availability and productivity in lakes. Limnology and Oceanography **52**:2629-2640.

MOE. 2007. Freshwater Fisheries Program Plan, Province of British Columbia, Ministry of Environment. Available at: www.env.gov.bc.ca/esd.

Moody, A., P. Slaney, and J. Stockner. 2007. Footprint impact of BC Hydro dams on aquatic and wetland primary productivity in the Columbia Basin. Prepared for: Columbia Basin Fish & Wildlife Compensation Program. Final Draft - April, 2007.

National Recovery Team for White Sturgeon. 2009. Recovery strategy for white sturgeon (*Acipenser transmontanus*) in Canada [Proposed]. In Species at Risk Act Recovery Strategy Series. Ottawa: Fisheries and Oceans Canada. Draft.

Northcote, T. C. 1973. Some impacts of man on Kootenay Lake and its salmonids. Great Lakes Fishery Commission, Technical Report 2, Ann Arbor, Michigan.

Paragamian, V. L., R. C. P. Beamesderfer, and S. C. Ireland. 2005. Status, population dynamics, and future prospects of the endangered Kootenai River white sturgeon population with and without hatchery intervention. Transactions of the American Fisheries Society **134**:518–532.

Porto, L. 2008. White sturgeon populations in the BC Hydro dam footprint impacts area. Prepared for: Fish and Wildlife Compensation Program – Columbia Basin, Nelson, BC.

Prince, A. 2001. Local knowledge of Columbia River fisheries in British Columbia, Canada. Report prepared for Columbia-Kootenay Fisheries Renewal Partnership, Cranbrook, B.C. Prepared by Westslope Fisheries, Cranbrook, B.C. 50 p. + 1 app.

Prince, A. 2010. Kinbasket Reservoir white sturgeon inventory and habitat use assessment. Report for Columbia River Projects Water Use Plan, BC Hydro, Castlegar BC.

RL&L Environmental Services Ltd. 1998. The status of white sturgeon in Kootenay Lake and Duncan Reservoir, B.C., 1994-1996 study results. Report prepared for B.C. Ministry of Environment, Lands and Parks. R.L. & L. Report No. KD-515F: 36 p. + 3 app.

Schindler, E. U., D. Sebastian, and H. Andrusak. 2006. Arrow Lakes fertilization experiment summary report 1999-2004. BC Fisheries Project Report No. RD 116.

Sebastian, D., G.Scholten, H. Andrusak, and P. Woodruff. 2010. Results of hydroacoustic and trawl surveys on Kinbasket and Revelstoke Reservoirs during 2001-2005. Stock Management Report No. 30, Fisheries Science Section, Ecosystems Branch, Ministry of Environment, Victoria. 124p.

Spence, C. R., H. Andrusak, J. A. Burrows, and J. S. Baxter. 2005. Arrow Lakes Reservoir rainbow trout restoration and management plan, 2005-2014. Report for Ministry of Environment, Nelson, BC.

Thorley, J. L. 2008. Aquatic habitat losses and gains due to BC Hydro dams in the Columbia Basin. Prepared for Fish and Wildlife Compensation Program – Columbia Basin, Nelson BC.

Appendix A

Draft management objectives, sub-objectives, measures and targets for each waterbody are presented in the following tables. As discussed in Section 3 and 4, management objectives are common to all lakes in this plan, though the species of interest vary among lakes and thus the list of indicators and measures may differ. The objectives are expected to remain stable over time, but the indicators and targets may evolve as management priorities for agencies shift, or new information becomes available. For example, many of the targets are based on data obtained in recent years and new information may indicate different targets for optimal fish production in these lakes. Likewise, some of these targets will be revised as the FWCP program further engages with its partners, technical committees, First Nations and stakeholders.

The objectives also apply to other large lakes in the FWCP: Columbia region (see Section 2.6), but sub-objectives, measures and targets for these lakes have yet to be developed.

Current Fisheries Management Objectives and Targets for Kootenay Lake

Objective	Sub-Objective	Measure	Targets
Ecosystem Integrity and Productivity - Maintain a productive and diverse aquatic ecosystem capable of providing societal benefits	**Aquatic productivity** - provide sufficient primary and secondary productivity to support targets for higher trophic levels	Nutrient status	- Nitrate values not less than 30 ug/L in integrated 0 - 20 m samples - inlake phosphorus (average Apr to Nov) TDP = 3 - 3.5 ug/L TP = 5 - 6 ug/L - primary productivity (average Jun to Sep) not less than 300 mg C m^2/day
		Zooplankton community	20 - 30 individuals / L (for copepods) 1 - 3 individuals/L (for *Daphnia* preferred by kokanee - Jun to Oct/Nov mean)
	Structure and function of ecological communities - maintain the overall ecological structure and function of the fish community and associated wildlife communities - minimize invasive species	Relative abundance of fish species	current relative abundance of native fish species (additional work required to define current status) stable or reduced abundance and distribution of invasive species (additional work required to define current status)
	Rainbow trout (Gerrard stock) - maximize the viability of large piscivorous rainbow trout	Distribution	- utilization of whole lake for rearing - full spatial utilization by juveniles in Lardeau and lower Duncan, - full spatial utilization of existing spawning habitat, including Gerrard and lesser used areas such as Duncan tailrace
		Population Structure	NA
		Abundance / Biomass	spawning escapement ≥ 1000
		Size / Age Distribution	76 cm average for spawners (male & female)
	Kokanee - maintain sufficient abundance of forage fish to meet targets for large piscivores - increase the number of spawning populations in Kootenay Lake - maximize the abundance of large kokanee in support of angling and harvest	Distribution	whole lake/reservoir
		Population Structure	reduce risk of single spawning location
		Abundance / Biomass	31 spawners / ha (1,200,000 total) lower acceptable threshold: 19 spawners / ha (747,000 total)
		Size / Age Distribution	23 cm average for spawners
	Kokanee in West Arm of Kootenay Lake - maintain sufficient abundance of forage fish to meet targets for large piscivores - increase the number of spawning populations in Kootenay Lake - maximize the abundance of large kokanee in support of angling and harvest	Distribution	West Arm of Kootenay Lake
		Population Structure	- maintain as a separate, genetically distinct stock in relation to rest of Kootenay Lake - maintain use of two spawning channels, numerous tributaries and shore spawning
		Abundance / Biomass	31 spawners / ha (19,500 total) lower acceptable threshold: 22 spawners / ha (13,800 total)
		Size / Age Distribution	34 cm average for spawners
	Bull trout - maximize the viability of bull trout	Distribution	use of whole lake
		Population Structure	use of 20 or more tributaries for spawning every year
		Abundance / Biomass	5 to 10% of kokanee biomass
		Size / Age Distribution	current size and age distribution (additional work required to define current status)
	Burbot - maximize the viability of burbot	Distribution	use of whole lake
		Population Structure	use of multiple spawning locations: spawning populations in West Arm of Kootenay Lake, North end of Kootenay Lake, Kootenai River, and smaller tributaries (e.g., Goat River, Summit Creek, etc.)
		Abundance / Biomass	improving abundance trend (additional work required to define current status)
		Size / Age Distribution	a "normal" age distribution with individuals up to at least 10 years old
	Rainbow trout (insectivorous) - maximize the viability of insectivorous rainbow trout	Distribution	use of whole lake
		Population Structure	current population structure (additional work required to define current status)
		Abundance / Biomass	stable or improving abundance trend (additional work required to define current status)
		Size / Age Distribution	current size and age distribution (additional work required to define current status)
Ecosystem Integrity and Productivity - maintain or improve the status of species of concern	**White sturgeon** - support recovery and conservation actions for white sturgeon	Abundance	1,000 individuals 25 years or older
		Population Growth Rate	Ongoing natural recruitment, and increasing abundance trend when below the abundance target
		Population Structure	Natural sex ratio and natural age structure
		Population Diversity	Distribution across the natural range exclusive of Duncan Reservoir
	Burbot - support recovery and conservation actions for burbot	As per plan, when developed	As per plan, when developed
	Pygmy whitefish - if determined to be at risk, support recovery and conservation actions for pygmy whitefish (Note: this is identified by COSEWIC as a high priority candidate for status assessment, but has not yet been assessed)	Population Viability	Maintain current abundance and distribution (Note: additional work required to define current status; COSEWIC status not yet determined)
Sustainable Use - maintain the fisheries resource at a level of abundance and distribution to support First Nations' traditional uses and rights	*To be determined in consultation with First Nations*	TBD	TBD
Sustainable Use - optimize recreational angling opportunities, participation and local benefits	**Socioeconomic value** - optimize the monetary and non-monetary value from the fishery	Angler days	43,000
		Allowable harvest	RB (Gerrard): 4,400 RB (non-Gerrard): 2,000 BT: 1,615 KO: 27,500 KO (west arm): 6,250 RB (west arm): 2,000

Current Fisheries Management Objectives and Targets for Duncan Reservoir

Objective	Sub-Objective	Measure	Targets
Ecosystem Integrity and Productivity - Maintain a productive and diverse aquatic ecosystem capable of providing societal benefits	**Aquatic productivity** - provide sufficient primary and secondary productivity to support targets for higher trophic levels	Nutrient status	current status (additional work required to define current status)
		Zooplankton community	current status (additional work required to define current status)
	Structure and function of ecological communities - maintain the overall ecological structure and function of the fish community and associated wildlife communities - minimize invasive species	Relative abundance of fish species	current relative abundance of native fish species (additional work required to define current status) stable or reduced abundance and distribution of invasive species (additional work required to define current status)
	Rainbow trout (Gerrard stock) - maximize the viability of large piscivorous rainbow trout	Distribution	develop targets for stocking program for Gerrard trout in Duncan Reservoir, if risk assessment indicates acceptable risk
		Population Structure	develop targets for stocking program for Gerrard trout in Duncan Reservoir, if risk assessment indicates acceptable risk
		Abundance / Biomass	develop targets for stocking program for Gerrard trout in Duncan Reservoir, if risk assessment indicates acceptable risk
		Size / Age Distribution	develop targets for stocking program for Gerrard trout in Duncan Reservoir, if risk assessment indicates acceptable risk
	Kokanee - maintain sufficient abundance of forage fish to meet targets for large piscivores - increase the number of spawning populations in Kootenay Lake - maximize the abundance of large kokanee in support of angling and harvest	Distribution	whole lake/reservoir
		Population Structure	current spawning distribution (additional work required to define current status)
		Abundance / Biomass	20 spawners / ha (80,000 total) lower acceptable threshold: 10 spawners / ha (40,000 total)
		Size / Age Distribution	25 cm average for spawners
	Bull trout - maximize the viability of bull trout	Distribution	use of whole reservoir
		Population Structure	current population structure (additional work required to define current status)
		Abundance / Biomass	stable or improving abundance trend (additional work required to define current status)
		Size / Age Distribution	current size and age distribution (additional work required to define current status)
	Burbot - maximize the viability of burbot	Distribution	use of whole reservoir
		Population Structure	develop targets
		Abundance / Biomass	stable or improving abundance trend (additional work required to define current status)
		Size / Age Distribution	a "normal" age distribution with individuals up to at least 10 years old
	Rainbow trout (insectivorous) - maximize the viability of insectivorous rainbow trout	Distribution	use of whole reservoir
		Population Structure	current population structure (additional work required to define current status)
		Abundance / Biomass	stable or improving abundance trend (additional work required to define current status)
		Size / Age Distribution	current size and age distribution (additional work required to define current status)
Ecosystem Integrity and Productivity - maintain or improve the status of species of concern	**Pygmy whitefish** - if determined to be at risk, support recovery and conservation actions for pygmy whitefish (Note: this is identified by COSEWIC as a high priority candidate for status assessment, but has not yet been assessed)	Population Viability	Maintain current abundance and distribution (Note: additional work required to define current status; COSEWIC status not yet determined)
Sustainable Use - maintain the fisheries resource at a level of abundance and distribution to support First Nations' traditional uses and rights	*To be determined in consultation with First Nations*	TBD	TBD
Sustainable Use - optimize recreational angling opportunities, participation and local benefits	**Socioeconomic value** - optimize the monetary and non-monetary value from the fishery	Angler days	2,125
		Allowable harvest	RB: 420 BT: 925 KO: 780

Current Fisheries Management Objectives and Targets for Arrow Lakes

Objective	Sub-Objective	Measure	Targets
Ecosystem Integrity and Productivity - Maintain a productive and diverse aquatic ecosystem capable of providing societal benefits	**Aquatic productivity** - provide sufficient primary and secondary productivity to support targets for higher trophic levels	Nutrient status	- Nitrate values not less than 30 ug/L in integrated 0 - 20 m samples - inlake phosphorus (average Apr to Nov) TDP = 3 - 3.5 ug/L TP = 5 - 6 ug/L - primary productivity (average Jun to Sep) not less than 300 mg C m^2/day
		Zooplankton community	20 - 30 individuals / L (for copepods) 1 - 3 individuals/L (for *Daphnia* preferred by kokanee - Jun to Oct/Nov mean)
	Structure and function of ecological communities - maintain the overall ecological structure and function of the fish community and associated wildlife communities - minimize invasive species	Relative abundance of fish species	current relative abundance of native fish species (additional work required to define current status) stable or reduced abundance and distribution of invasive species (additional work required to define current status)
	Rainbow trout (Gerrard stock) - maximize the viability of large piscivorous rainbow trout	Distribution	whole lake/reservoir
		Population Structure	- establish at least one self-supporting population; - supplement with triploid stock as productivity permits
		Abundance / Biomass	- stock 80,000 hatchery-produced Gerrard yearlings annually - re-evaluate targets periodically or when self-supporting population is established
		Size / Age Distribution	establish an exploitable population of large piscivorous fish
	Kokanee - maintain sufficient abundance of forage fish to meet targets for large piscivores - increase the number of spawning populations in Kootenay Lake - maximize the abundance of large kokanee in support of angling and harvest	Distribution	whole lake/reservoir
		Population Structure	current spawning distribution (additional work required to define current status)
		Abundance / Biomass	20 spawners / ha (584,000 total) lower acceptable threshold: 13 spawners / ha (371,000 total)
		Size / Age Distribution	24 cm average for spawners
	Bull trout - maximize the viability of bull trout	Distribution	use of whole reservoir
		Population Structure	current population structure (additional work required to define current status)
		Abundance / Biomass	stable or improving abundance trend (additional work required to define current status)
		Size / Age Distribution	current size and age distribution (additional work required to define current status)
	Burbot - maximize the viability of burbot	Distribution	use of whole reservoir
		Population Structure	develop targets
		Abundance / Biomass	stable or improving abundance trend (additional work required to define current status)
		Size / Age Distribution	a "normal" age distribution with individuals up to at least 10 years old
	Rainbow trout (insectivorous) - maximize the viability of insectivorous rainbow trout	Distribution	use of whole reservoir
		Population Structure	current population structure (additional work required to define current status)
		Abundance / Biomass	stable or improving abundance trend (additional work required to define current status)
		Size / Age Distribution	current size and age distribution (additional work required to define current status)
Ecosystem Integrity and Productivity - maintain or improve the status of species of concern	**White sturgeon** - support recovery and conservation actions for white sturgeon	Abundance	1,000 individuals 25 years or older
		Population Growth Rate	Ongoing natural recruitment, and increasing abundance trend when below the abundance target
		Population Structure	Natural sex ratio and natural age structure
		Population Diversity	Distribution across the natural range exclusive of Slocan Lake
	Westslope cutthroat trout - support recovery and conservation actions for westslope cutthroat trout	Abundance	>0.4 of Nequilibrium in >80% of exploited populations >0.2 of Nequilibrium in >80% of unexploited headwater populations
		Distribution	Presence in over 80% of native range
		Genetic diversity	Introgression with RB in <10% of populations
		Sustainable Angler Use	<5% catch and release mortality in exploited populations
	Pygmy whitefish - if determined to be at risk, support recovery and conservation actions for pygmy whitefish (Note: this is identified by COSEWIC as a high priority candidate for status assessment, but has not yet been assessed)	Population Viability	Maintain current abundance and distribution (Note: additional work required to define current status; COSEWIC status not yet determined)
Sustainable Use - maintain the fisheries resource at a level of abundance and distribution to support First Nations' traditional uses and rights	*To be determined in consultation with First Nations*	TBD	TBD
Sustainable Use - optimize recreational angling opportunities, participation and local benefits	**Socioeconomic value** - optimize the monetary and non-monetary value from the fishery	Angler days	22,000
		Allowable harvest	RB: 3,300 BT: 7,500 KO: 11,100

Current Fisheries Management Objectives and Targets for Revelstoke Reservoir

Objective	Sub-Objective	Measure	Targets
Ecosystem Integrity and Productivity - Maintain a productive and diverse aquatic ecosystem capable of providing societal benefits	**Aquatic productivity** - provide sufficient primary and secondary productivity to support targets for higher trophic levels	Nutrient status	current status (additional work required to define current status)
		Zooplankton community	current status (additional work required to define current status)
	Structure and function of ecological communities - maintain the overall ecological structure and function of the fish community and associated wildlife communities - minimize invasive species	Relative abundance of fish species	current relative abundance of native fish species (additional work required to define current status) stable or reduced abundance and distribution of invasive species (additional work required to define current status)
	Kokanee - maintain sufficient abundance of forage fish to meet targets for large piscivores - increase the number of spawning populations in Kootenay Lake - maximize the abundance of large kokanee in support of angling and harvest	Distribution	whole lake/reservoir
		Population Structure	current spawning distribution (additional work required to define current status)
		Abundance / Biomass	35 fish / ha (250,000 total fish aged 1-3+) lower acceptable threshold: 24 fish / ha (175,000 total fish aged 1-3+) note that most recruitment is via entrainment, spawning streams are few in number and do not support this population abundance
		Size / Age Distribution	30-35 cm average for spawners
	Bull trout - maximize the viability of bull trout	Distribution	use of whole reservoir
		Population Structure	current population structure (additional work required to define current status)
		Abundance / Biomass	stable or improving abundance trend (additional work required to define current status)
		Size / Age Distribution	current size and age distribution (additional work required to define current status)
	Burbot - maximize the viability of burbot	Distribution	use of whole reservoir
		Population Structure	address information gaps and develop targets
		Abundance / Biomass	stable or improving abundance trend (additional work required to define current status)
		Size / Age Distribution	a "normal" age distribution with individuals up to at least 10 years old
	Rainbow trout (insectivorous) - maximize the viability of insectivorous rainbow trout	Distribution	use of whole reservoir
		Population Structure	current population structure (additional work required to define current status)
		Abundance / Biomass	stable or improving abundance trend (additional work required to define current status)
		Size / Age Distribution	current size and age distribution (additional work required to define current status)
Ecosystem Integrity and Productivity - maintain or improve the status of species of concern	**Pygmy whitefish** - if determined to be at risk, support recovery and conservation actions for pygmy whitefish (Note: this is identified by COSEWIC as a high priority candidate for status assessment, but has not yet been assessed)	Population Viability	Maintain current abundance and distribution (Note: additional work required to define current status; COSEWIC status not yet determined)
Sustainable Use - maintain the fisheries resource at a level of abundance and distribution to support First Nations' traditional uses and rights	*To be determined in consultation with First Nations*	TBD	TBD
Sustainable Use - optimize recreational angling opportunities, participation and local benefits	**Socioeconomic value** - optimize the monetary and non-monetary value from the fishery	Angler days	10,000
		Allowable harvest	RB: 240 BT: 560 KO: 9,200

Current Fisheries Management Objectives and Targets for Kinbasket Reservoir

Objective	Sub-Objective	Measure	Targets
Conservation - Ensure a productive and diverse aquatic ecosystem capable of providing societal benefits	**Aquatic productivity** - provide sufficient primary and secondary productivity to support targets for higher trophic levels	Nutrient status	current status (additional work required to define current status)
		Zooplankton community	current status (additional work required to define current status)
	Structure and function of ecological communities - maintain the overall ecological structure and function of the fish community and associated wildlife communities - minimize invasive species	Relative abundance of fish species	current relative abundance of native fish species (additional work required to define current status) stable or reduced abundance and distribution of invasive species (additional work required to define current status)
	Rainbow trout (Gerrard stock) - maximize the viability of large piscivorous rainbow trout	Distribution	develop targets for stocking program for Gerrard trout in Kinbasket Reservoir, if risk assessment indicates acceptable risk
		Population Structure	develop targets for stocking program for Gerrard trout in Kinbasket Reservoir, if risk assessment indicates acceptable risk
		Abundance / Biomass	develop targets for stocking program for Gerrard trout in Kinbasket Reservoir, if risk assessment indicates acceptable risk
		Size / Age Distribution	develop targets for stocking program for Gerrard trout in Kinbasket Reservoir, if risk assessment indicates acceptable risk
	Kokanee - maintain sufficient abundance of forage fish to meet targets for large piscivores - increase the number of spawning populations in Kootenay Lake - maximize the abundance of large kokanee in support of angling and harvest	Distribution	whole lake/reservoir
		Population Structure	current spawning distribution (additional work required to define current status)
		Abundance / Biomass	20 spawners / ha (550,000 total) lower acceptable threshold: 9 spawners / ha (240,000 total)
		Size / Age Distribution	26 cm average for spawners
	Bull trout - maximize the viability of bull trout	Distribution	use of whole reservoir
		Population Structure	current population structure (additional work required to define current status)
		Abundance / Biomass	stable or improving abundance trend (additional work required to define current status)
		Size / Age Distribution	current size and age distribution (additional work required to define current status)
	Burbot - maximize the viability of burbot	Distribution	use of whole reservoir
		Population Structure	develop targets
		Abundance / Biomass	stable or improving abundance trend (additional work required to define current status)
		Size / Age Distribution	a "normal" age distribution with individuals up to at least 10 years old
	Rainbow trout (insectivorous) - maximize the viability of insectivorous rainbow trout	Distribution	use of whole reservoir
		Population Structure	current population structure (additional work required to define current status)
		Abundance / Biomass	stable or improving abundance trend (additional work required to define current status)
		Size / Age Distribution	current size and age distribution (additional work required to define current status)
Sustainable Use - optimize recreational angling opportunities, participation and local benefits	**Socioeconomic value** - optimize the monetary and non-monetary value from the fishery	Angler days	11,000
		Allowable harvest	RB: 2,200 BT: 4,900 KO: 3,900

Appendix B

Species with Highest Priority Habitat Association to Large Lakes

The following species have been identified as having a high conservation concern and/or local interest and a strong dependence on large lake habitats. These species depend on large lakes more than any other type of habitat and have been heavily impacted by dam footprint on large lakes (see FWCP: Columbia Species of Interest Plan). The preliminary recommended actions and their priority (1 = first, 2 = second, - = not applicable) are identified for each species.

Table B1. Output from the Species Rating and Database Tool (FWCP 2011b). This table identifies species of regional conservation concern whose primary habitat is large lakes. First and second order priority actions are listed in twelve categories.

		Research & Information Acquisition			Species-Based Actions			Habitat-Based Actions			Land Securement			
Species	Guild	Inventory	Assessment (e.g., targets)	Integrated habitat planning	Translocate / Reintroduce	Alternate Predator Prey Man	Other	Habitat Creation	Hagitat restoration	Restore connectivity	Habitat Acquisition	Habitat Stewardship	Monitoring & Evaluation	Priority in the Species Plan
Burbot (Kootenay Lake)	BEN	-	2	-	1	-	-	2	2	2	-	-	2	Focal
Burbot (Other)	BEN	-	2	-	-	-	-	2	2	2	2	-	1	Focal
Rainbow Trout (insectivorous-LL)	INS	-	-	-	-	-	-	-	1	-	-	-	2	Focal
Bull Trout	PIS	2	1	-	2	-	-	2	1	-	-	-	2	Focal
Rainbow Trout (piscivorous-LL)	PIS	2	1	-	-	-	-	2	1	-	-	-	2	Focal
Kokanee	PLK	-	2	-	-	-	2	-	1	-	-	-	2	Focal
Pygmy Whitefish	WFI	1	-	-	-	-	-	-	-	-	-	-	-	Inventory
Bald Eagle	RAP	-	-	-	-	-	-	-	-	-	-	2	1	Inventory
Common Tern	SHO	1	-	-	-	-	-	-	-	-	-	-	-	Inventory
Killdeer	SHO	1	-	2	-	-	-	-	-	-	-	2	-	Inventory
Greater Scaup	WAT	1	-	2	-	-	-	-	-	-	-	-	-	Inventory

* Priority wetland species - *Canadian Intermountain Joint Venture*
** Priority landbird - *Northern Rockies Bird Conservation Region (Partners in Flight)*

1 = First Priority Action
2 = Second Priority Action(s)

I: Indicator sp

Species Associated with Large Lakes as Supporting Habitat

The following species use large lakes as a “supporting” habitat; that is, these species occur in large lakes, but they occur more often or are more dependent on one or more other habitat types (see FWCP: Columbia Species of Interest Plan). For example, large lakes often provide wetland and riparian habitat features adjacent to the lake and species that use wetlands and riparian will show a secondary association with large lakes. Habitat-based actions taken on large lakes may benefit these species, but actions on their primary habitat are likely to provide greater benefit. Such species and the actions to support them are discussed in greater detail within other ecosystem-based action plans, and it is expected that most habitat-based actions of benefit for species in this list will be addressed in these other plans. That said, these species do use large lakes, and some portion of their habitat requirements may be addressed in this Large Lakes Action Plan. The preliminary recommended actions and their priority (1 = first, 2 = second) are identified for each species.

Table B2. Output from the Species Rating and Database Tool (FWCP 2011b). This table identifies species of regional conservation concern whose secondary habitat is large lakes. First and second order priority actions are listed in twelve categories.

		Research & Information Acquisition			Species-Based Actions			Habitat-Based Actions			Land Securement			
Species	Guild	Inventory	Assessment (e.g., targets)	Integrated habitat planning	Translocate / Reintroduce	Alternate Predator Prey Man	Other	Habitat Creation	Hagitat restoration	Restore connectivity	Habitat Acquisition	Habitat Stewardship	Monitoring & Evaluation	Priority in the Species Plan
White Sturgeon	BEN	-	-	-	1	-	-	-	2	2	-	-	2	Recovery
Torrent sculpin	SCL	1	-	-	-	-	-	-	-	-	-	-	-	Inventory
Cliff Swallow	AER	1	-	2	-	-	-	-	-	-	-	2	-	Inventory
Northern Rough-winged Swallow **	AER	1	-	-	-	-	-	-	-	-	-	2	-	Inventory
Tree Swallow	AER	1	-	-	-	-	-	-	-	-	-	2	-	Inventory
Osprey	RAP	-	-	-	-	-	-	-	-	-	-	1	2	Focal
Herring Gull	SHO	1	-	-	-	-	-	-	-	-	-	-	-	Inventory
Semi-palmated Sandpiper	SHO	1	-	-	-	-	-	2	-	-	-	2	-	Inventory
Western Sandpiper	SHO	1	-	-	-	-	-	2	-	-	-	2	-	Inventory
Great Blue Heron *	WAD	2	-	2	-	2	-	-	2	-	2	1	2	Focal
Barrow's Goldeneye *	WAT	1	-	-	-	-	-	2	-	-	2	2	-	Inventory
Bufflehead *	WAT	-	-	-	-	-	-	2	-	-	-	-	1	Inventory
Common Goldeneye	WAT	1	-	-	-	-	-	-	-	-	-	-	-	Inventory
Common Loon *	WAT	2	-	-	-	-	-	2	-	-	-	1	2	Focal
Blue-winged Teal	WAT	1	-	2	-	-	-	-	2	-	-	2	-	Inventory
Canvasback	WAT	1	-	2	-	-	-	-	2	-	-	2	-	Inventory
Hooded Merganser *	WAT	-	-	-	-	-	-	1	-	-	-	-	-	Inventory
Lesser Scaup *	WAT	1	-	2	-	-	-	-	-	-	-	2	-	Inventory
Northern Pintail	WAT	1	-	2	-	-	-	-	-	-	-	2	-	Inventory
Redhead *	WAT	1	-	2	-	-	-	-	2	-	-	2	-	Inventory
Ring-necked Duck *	WAT	-	-	-	-	-	-	-	-	-	-	-	1	Inventory
Wood Duck	WAT	1	-	-	-	-	-	2	-	-	-	-	I	Inventory
Western Grebe *	WAT	2	-	2	-	-	-	-	1	-	-	-	2	Focal
Long-eared Myotis	BAT	1	-	-	-	-	-	-	-	-	-	-	-	Inventory
Long-legged Myotis	BAT	1	-	-	-	-	-	-	-	-	-	-	-	Inventory
Northern Myotis	BAT	-	-	-	-	-	-	-	-	-	2	-	2	Focal
Silver-haired Bat	BAT	2	-	2	-	-	-	-	1	-	-	2	2	Focal
Grizzly Bear	CAR	2	-	2	-	2	-	-	2	1	2	2	2	Focal
Northern River Otter	CAR	1	-	-	-	-	-	-	-	2	-	-	I	Inventory

* Priority wetland species - *Canadian Intermountain Joint Venture*
** Priority landbird - *Northern Rockies Bird Conservation Region (Partners in Flight)*

1 = First Priority Action
2 = Second Priority Action(s)

I: Indicator sp