KOOTENAI RIVER ECOSYSTEM FUNCTION RESTORATION FLOW PLAN
May 5, 2005

Introduction

The Proposed Action contained in the Supplemental BA included Libby Dam operations to support spawning, incubation and rearing of Kootenai River white sturgeon (sturgeon). The Corps and BPA, in conjunction with the Service and state and tribal biologists, have further refined the Proposed Action, in part by developing this flow plan. The objective of this plan, in conjunction with the concurrent habitat placement plan, is to restore ecosystem function in support of Kootenai River white sturgeon recovery consistent with the Corps responsibilities to provide for flood control, in order to avoid jeopardizing the likelihood of the continued existence of sturgeon. The plan embraces functional "normative"[1] river concepts while continuing to support salmon flow augmentation in the mainstem Columbia River.

The flow plan sets forth guidelines to utilize existing or increased sturgeon "tier" volumes during late May and June, creating a rise, or "freshet" from Libby Dam, followed by a gradually declining, or rescinding, limb of the hydrograph into July (normative shape). These guidelines provide the flexibility to augment peak local inflows at Bonners Ferry with up to 35 kcfs from Libby Dam to 1) create attraction flows, 2) stimulate spawning behavior, and 3) enhance velocity for egg incubation, should successful spawning occur (i.e. embryos attached to appropriate substrates).

Reaching full- or nearing full-powerhouse flow each spring is ecologically important for the aquatic and riparian ecosystems immediately downstream of the dam, as flushing flows serve to clean and re-sort gravels, and inundate the functional floodplain. The rescinding limb of the hydrograph, when extended, allows the river to gradually warm as local runoff temperatures increase, and serves to allow for a quasi-normative thermograph, which is an ecologically important component of a normative hydrograph.

Flow augmentation each year is intended to provide normative conditions for testing adaptive management treatments in the mainstem of the Kootenai River. Among these treatments are projects that add appropriate substrate to the river channel, projects to release gametes and larvae

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[1] *"Normative" is defined as the condition where natural flood plain functions and channel maintenance can occur. This includes a reduction in the width of the varial zone (that becomes biologically unproductive), removing unseasonable flow fluctuations (natural day to day fluctuations vary by 5% during basal conditions and 10% during spring runoff), restoring a natural spring freshet (runoff occurs in late May or early June, followed by a stable, low basal flow period), periodic channel maintenance flows (a bankfull flow for at least 48 hours on a periodicity of 2.5 years, or every second or third year, or 3 out of 10), stable summertime flows that are constant or gradually reducing after spring runoff (this can include a sliding scale to respond to varying water availability). The condition allows the river to flush fine sediments into the channel margins during runoff (cleaning fines from interstitial spaces in river cobbles creating insect habitat). As flows decline from the spring peak, terrestrial vegetation can invade the margins and as flows stabilize (riparian can establish including willows, cottonwood, grasses and sedges), roots prevent fines from being swept back into the channel (preventing embeddedness and siltation). Rivers that maintain normative functions have stabile banks, slow channel migrations, maintain low width/depth ratios, and high pool/length ratios. (Kootenai Tribe of Idaho and Montana Fish, Wildlife & Parks 2004). A normative thermograph mimics the natural temperature variations present in the river in its pre-dam state.*

into the river, nutrient addition experiments, Kokanee stock restoration, and ongoing conservation aquaculture larvae and juvenile releases. In addition to these biological objectives, providing a normative hydrograph will allow for thorough monitoring of the introduction of coarse substrate to the river channel.

The Corps and BPA believe better information needs to be developed in order to determine how best to implement actions that will benefit listed sturgeon and bull trout. The flow plan discussed below is designed to work in conjunction with mainstem treatments to gather additional information and use adaptive principles to make constructive management decisions for the listed species.

BACKGROUND and NEW INFORMATION

The Kootenai River population of white sturgeon has been declining for at least four decades and recruitment has been insignificant since 1974. The last successful sturgeon recruitment of over 20 fish is believed to have occurred in 1974, despite considerable efforts by the Kootenai River White Sturgeon Recovery Team (KRWSRT) to implement actions to assist with population recovery. Biologists have acquired considerable new information regarding life history requirements of the species since the 2000 Biological Opinion was implemented – the population continues to decline. This plan incorporates the current new information and allows for implementation of strategies resulting from the adaptive experimentation scheme contained in this document, as well as new information attained during implementation of the plan.

Status

The following excerpt from Paragamian et al. (*In Review* at Transactions of the American Fisheries Society), a study undertaken to determine the current status, population dynamics, and future prospects of Kootenai River white sturgeon, is the best available current information.

> Synthesis of sampling data from 1977 through 2001, including extensive mark-recapture data, provided a comprehensive and current picture of the status, population dynamics, and future prospects of the endangered Kootenai River white sturgeon. At the current mortality rate of 9% per year, fewer than 500 adults will remain by year 2005, and fewer than 50 adults will remain by year 2030. Based on current growth and maturity rates, hatchery fish being released since 1992 will begin recruiting to the adult population around year 2020 for females. Population projections describe a significant bottleneck in spawner numbers as the wild population declines but hatchery fish are not yet mature.
>
> Mark-recapture data for wild fish were available for 22 of 25 years between 1977 and 2001 (Figure 1). Annual catches ranged from 2 to 258 fish. Recaptures comprised a steadily-increasing percentage of the catch and most fish in the population have now (*as of 2000*) been caught at least once. Capture probabilities ranged from <1% to 22% as sampling effort varied substantially among years and probabilities have averaged 10-15% over the last 8 years (Figure 1). Wild population size was estimated to be 760 fish in 2000 based on a Jolly-Seber model assuming no significant wild recruitment. This population size is about half of the 1,470 estimated in 1996 and less than 10% of numbers estimated for the late 1970s (Figure 1). Large numbers of recaptures and multiple

recaptures from the aging cohort of long-lived fish resulted in precise population estimates in recent years.

With the almost complete failure of natural recruitment, the model sturgeon population declined by almost 90% from 6,800 fish in 1980 to 640 in 2002 (Figure 2). Initial population length and the declining trajectory were consistent with estimates based on mark-recapture data for the same period (Figure 1). Current data indicate that the population declines by half every 7.4 years. Fewer than 500 adults from the existing wild population will remain by year 2005 and fewer than 50 adult fish by year 2030. Total biomass has declined by about 75% from 80 to 20 metric tons from 1980 to present (Figure 2). Annual numbers of female spawners have declined from 270 per year in 1980 to about 77 in 2002. Fewer than 30 females will be spawning annually after year 2015 (Figure 2).

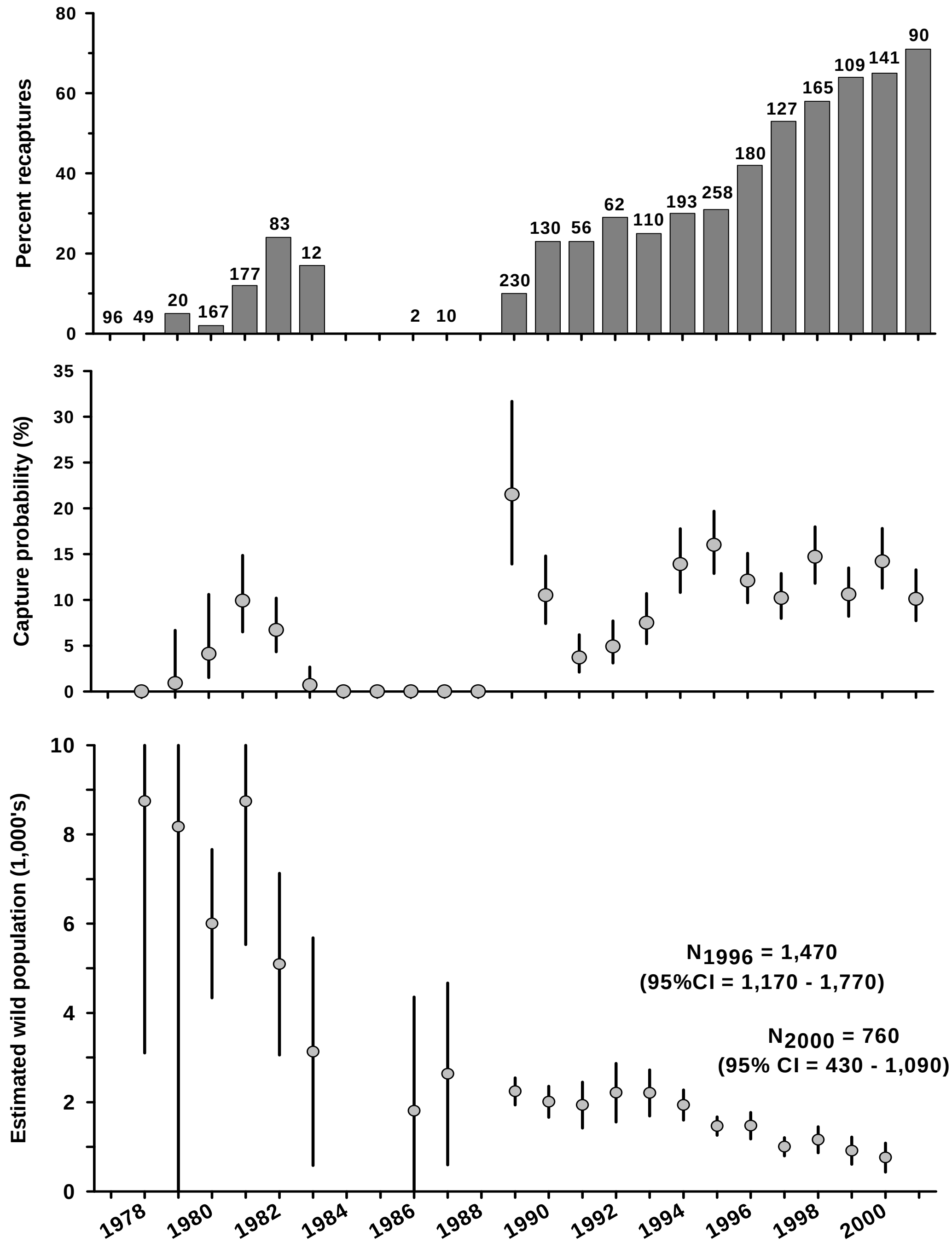


Figure 1. Percent of the annual catch that were recaptures of previously-tagged fish, estimated proportion of the population captured each year, and estimated abundance of wild white sturgeon, 1997-2001. Histogram labels are total catch in a year, and error bars represent 95% confidence intervals (Paragamian et al. *In Review*).

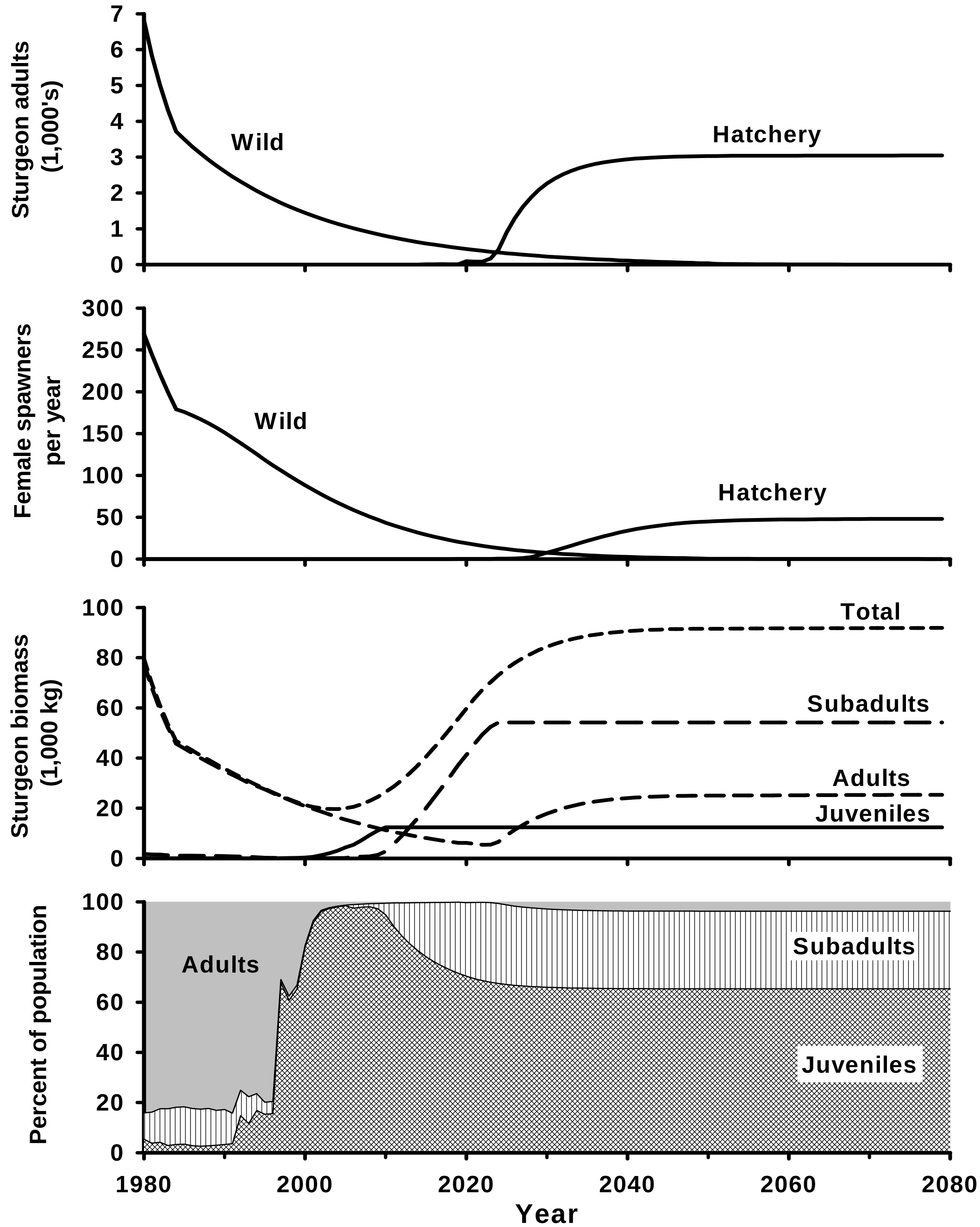


Figure 2. Simulated population size, female spawner number, total population biomass by life history stage, and size composition for Kootenai River white sturgeon from 1980-2080 (Paragamian et al. *In Review*).

Model predictions were extremely sensitive to estimates of annual survival rate. For instance, changes of just ± 3% in annual survival of subadults and adults change the projected years to fewer than 50 fish from 17 to 48 years (Figure 3). Projected numbers of hatchery adults at equilibrium change approximately ± 50%.

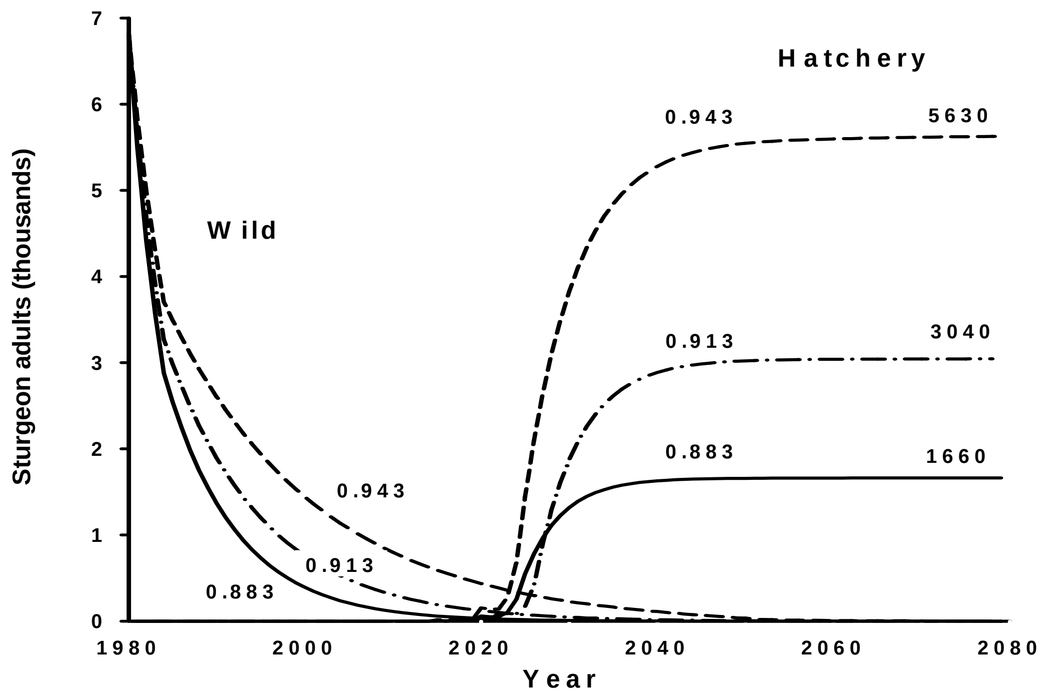


Figure 3. Sensitivity of wild and hatchery-origin adult numbers to annual mortality rate in model projections for 1980-2080 *(Paragamian et al.* In Review*).*

The above discussion indicates that the population of Kootenai River white sturgeon is experiencing rapid accretion, and that the population is composed entirely of sexually mature adults. There has not been a significant year class produced naturally since 1974, and the first year class produced by the conservation aquaculture facility will not become sexually mature until at least 2020. In order to determine what is required for successful wild recruitment biologists must incorporate adaptive management principles, and water management agencies must work with biologists to implement adaptive flow experimentation.

Hydrograph

Before the construction and operation of Libby Dam in the early 1970's, the natural hydrograph of the Kootenai River downstream of the dam consisted of a spring freshet with high peak flows, followed by a rapid drop in flows into August (Figure 4). Since the construction and operation of Libby Dam, the hydrograph has changed, with curtailment of the peak flows during the spring freshet (Figure 4).

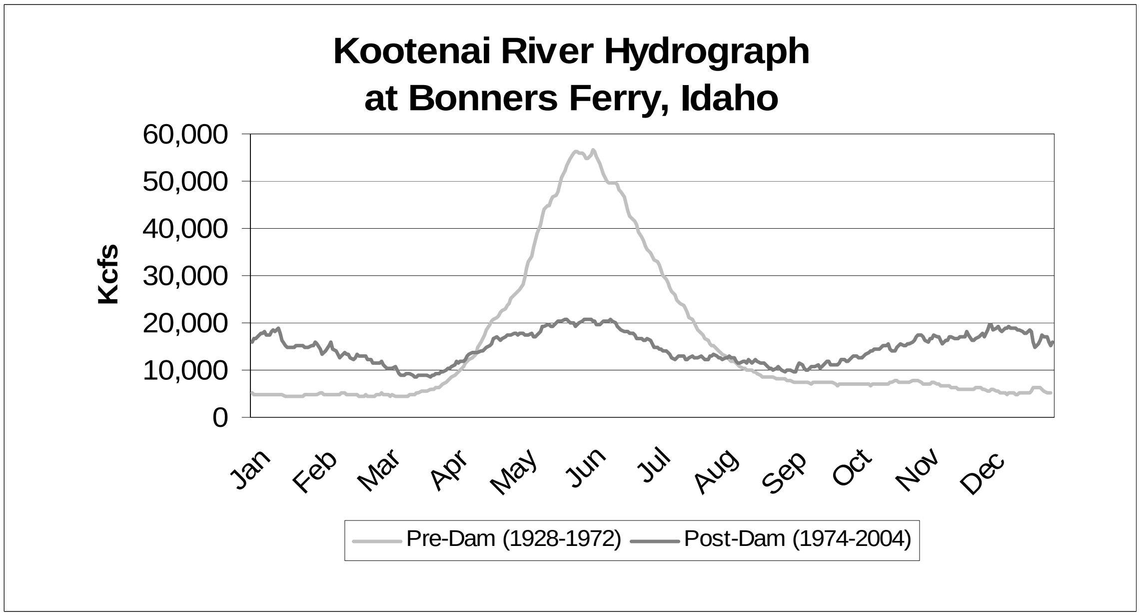


Figure 4. Annual hydrograph at Bonners Ferry, Idaho (1928 through 2004).

The average pre-dam hydrograph indicates that, in general, flow peaked in early to mid-June after increasing in mid- to late May, and then gradually descended during July. The 1995 BiOp recommended flow that approached pre-dam conditions, which resulted in a shape more closely resembling the pre-dam hydrograph (Figure 5); however, the actual volume of these freshets is relatively insignificant when compared to the magnitude of the natural pre-dam freshet.

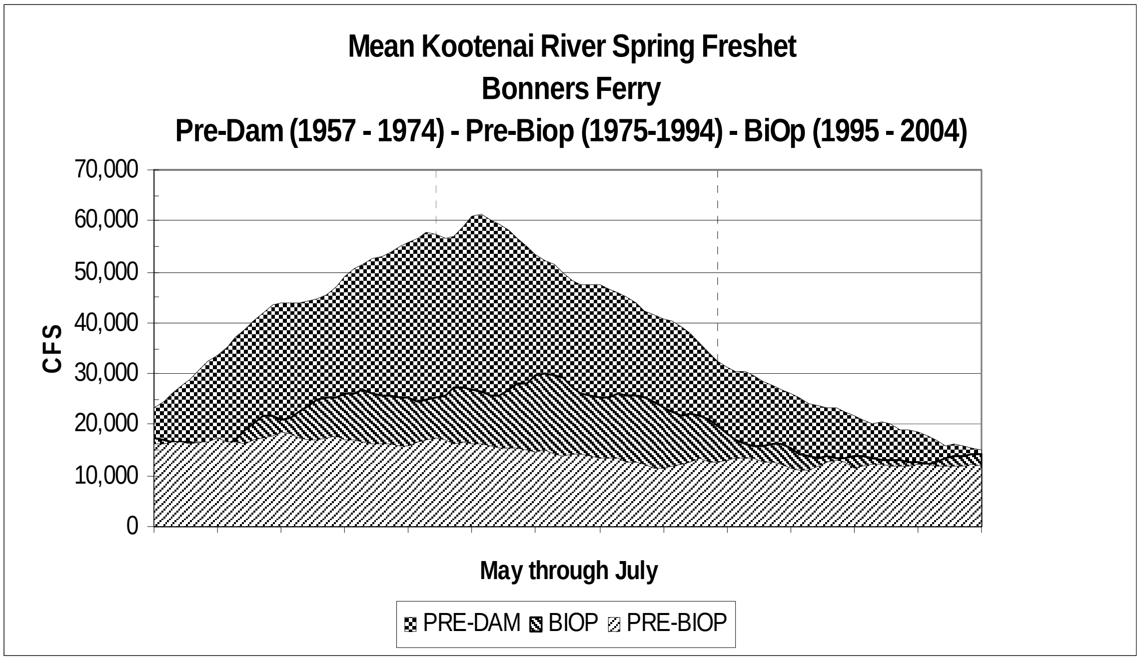


Figure 5. Mean seasonal (May through July) hydrograph (calculated[1]; Bonners Ferry) for pre-dam (1957 – 1974), pre-BiOp (1975-1994), and BiOp (1995-2004).

[1] *Flows at Bonners Ferry recorded or calculated according to the following:*

1 May 1928 to 30 Sep 1960 → USGS gage station
1 Oct 1960 to 31 December 1971 → Unregulated data
1 January 1972 to 31 December 1973 → Amended SSARR, HEB (Delaney)
1 January 1974 to 27 Sept 2003 → Leonia + 1.25 Yaak, USGS flows

Based on the most complete set of sturgeon recruitment data (Idaho Department of Fish and Game), and the consensus of members of the Kootenai River White Sturgeon Recovery Team, the year classes most represented in the most complete database available are 1961 and 1974. Peak flow at Bonners Ferry during each of these years exceeded 40 Kcfs (Figure 6; flow exceeded 40 Kcfs for 44 days in 1961, and for 23 days in 1974); flow at Bonners Ferry has not exceeded 40 Kcfs for more than 2 days since dam construction was completed except in 1997 (22 days) and 2002 (14 days). Prior to commencement of reservoir filling (1957 - 1973), flow exceeded 40 Kcfs for at least 25 days during the spring freshet each year except 1973, and exceeded 60 Kcfs during the spring freshet each year except 1972 and 1973.

The Corps currently operates Libby Dam to not exceed 1,764 MSL at Bonners Ferry, the flood stage designated by the National Weather Service for the purposes of flood protection, though flood stage can be exceeded due to unexpected increased inflow to Libby Dam or due to tributary flows downstream of Libby Dam. Bonners Ferry stage exceeded 1,764 MSL in both 1961 and 1974 (Figure 7). River stage 1,780 MSL at Bonners Ferry (117,000+ cfs, Figure 6) was contained within the newly reconstructed levees during the peak runoff event in 1961.

Kootenay Lake stage, which in conjunction with river flow and stage, influences the locale of the lake/river delineation point (backwater effect), exceeded 1,760 MSL in 1961, and approached

1,755 in 1974 (Figure 8).   In 1961 the backwater interface reached to about RM 161, and in 1974 it reached to about RM 159 (Figure 9). Backwater interface location has not reached upstream of approximately RM159 since 1974 (through 1999 – Figure 9).

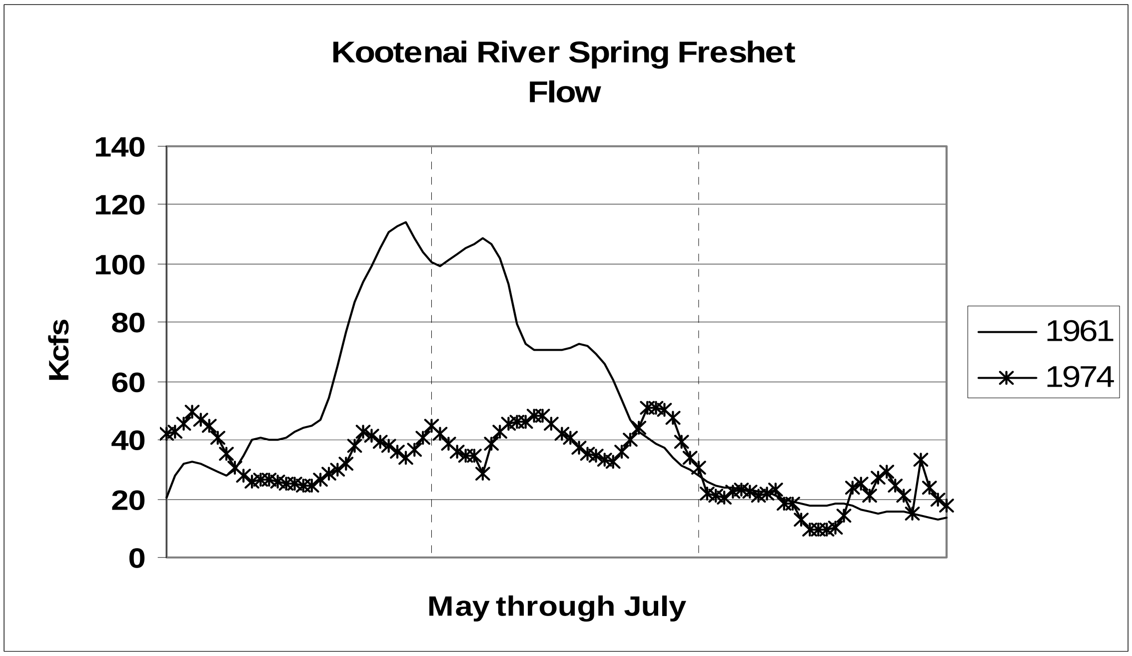


Figure 6. Kootenai River flow (Kcfs) at Bonners Ferry, Idaho, during sturgeon spawning season in selected years.

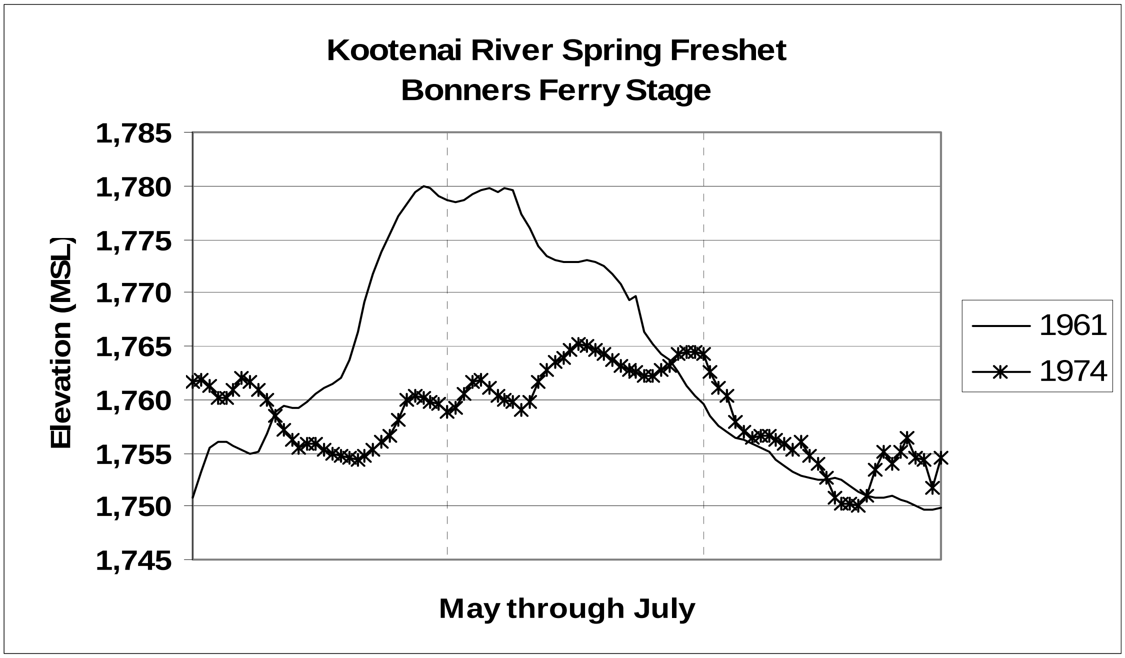


Figure 7. Kootenai River stage (MSL) at Bonners Ferry, Idaho, during sturgeon spawning season in selected years.

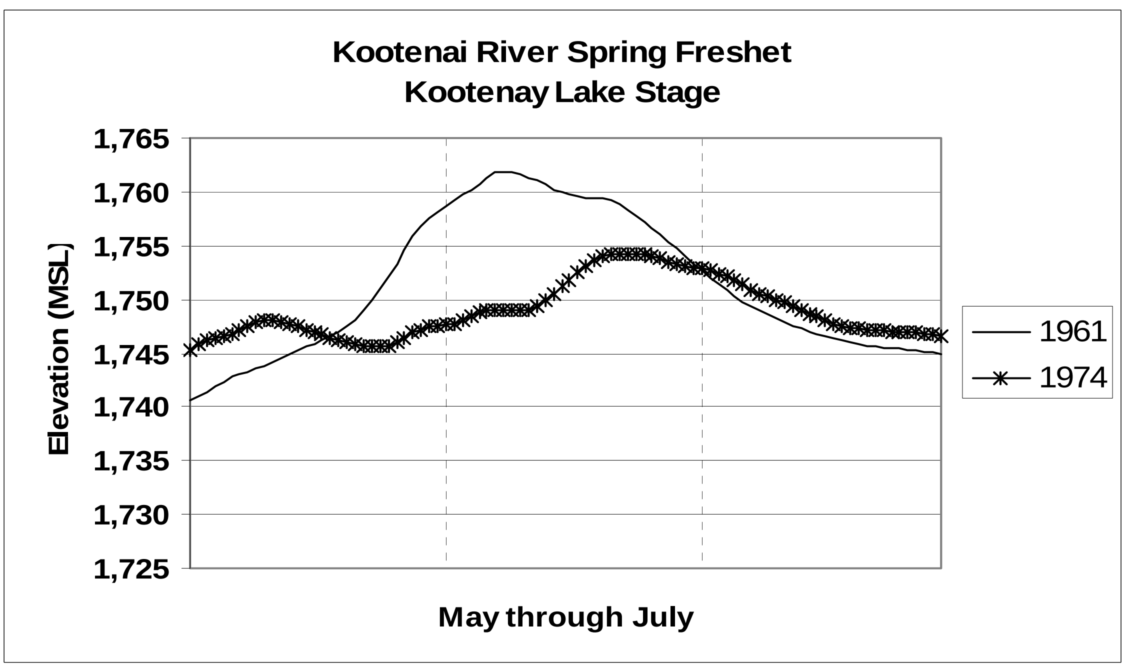


Figure 8. Kootenay Lake stage (MSL) during sturgeon spawning season in selected years.

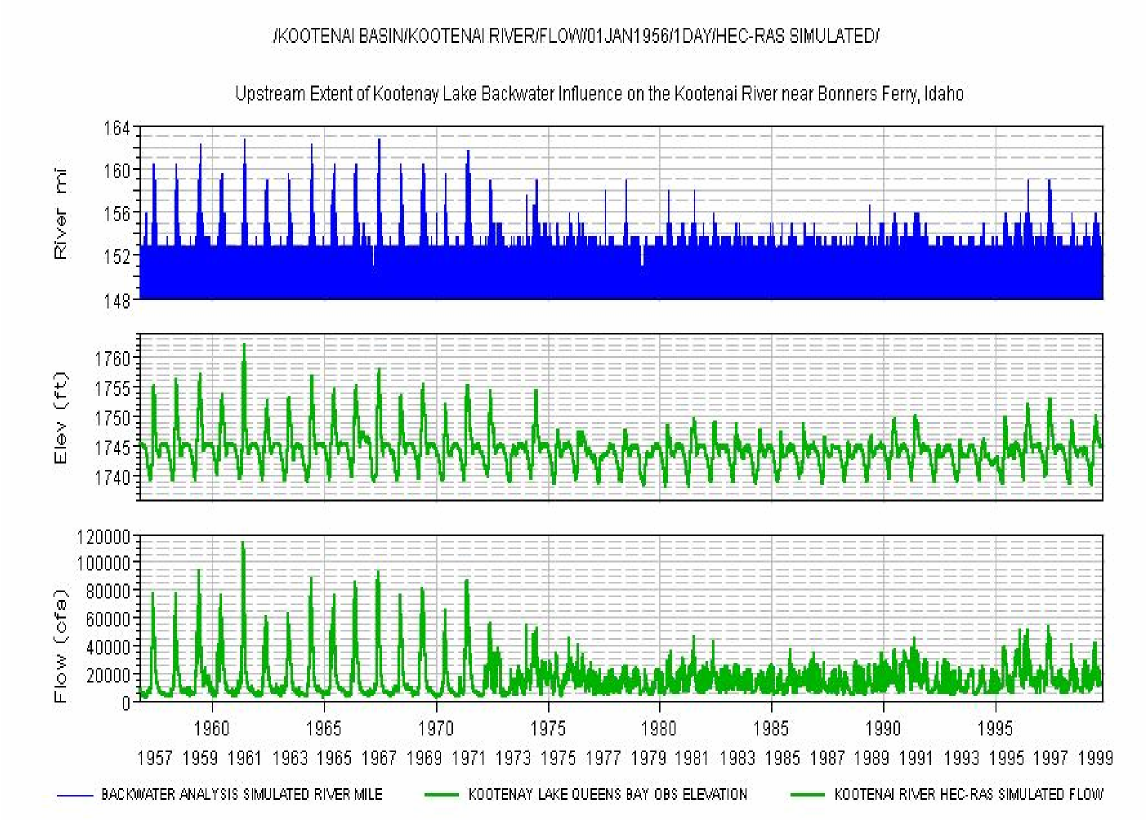


Figure 9. Approximate Kootenai River / Kootenay Lake interface locations 1957 through 1999 (numerically modeled data).

The tiered sturgeon releases have not yet addressed the apparent relation between freshet shape, duration, temperature, and temporality, location of the backwater interface, and sturgeon recruitment. Under existing regulation of both the Kootenai River and Kootenay Lake, the relationships of these covariates and alignment of them, if possible, may be crucial in promoting natural recruitment. The proposed flow plan would allow for further evaluation of the significance of these covariates, and may include flows of up to 10,000 cfs above existing powerhouse capacity if experiments within powerhouse capacity both fail to produce a year class *and* indicate that additional flow is necessary to spur successful recruitment.

Thermograph

Average water temperatures in the Kootenai River are typically warmer in the winter and colder in the summer than they were prior to the construction of Libby Dam.
Current average spring temperatures tend to be cooler than under pre-dam conditions (Figure 10), and the differences may be increased even more when large flow from Libby Dam dominates the total river flow. These temperature alterations may also affect the rates of maturation and spawning behavior of sturgeon.

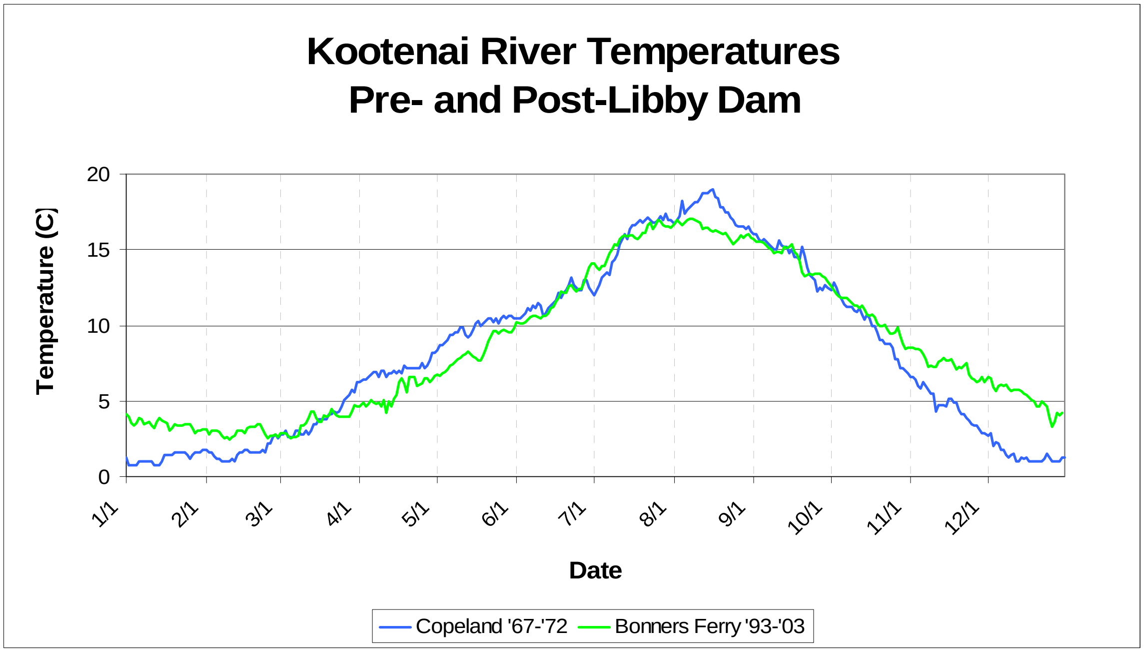


Figure 10. Mean Kootenai River thermograph (1967 through 1972 at Copeland and 1993 through 2003 at Bonners Ferry).

Turbidity

Suspended sediment levels in the Kootenai River have decreased substantially since the construction of Libby Dam. During the period of suspended-sediment record for the Libby Dam era (Figures 11 and 12), the only notable multi-week suspended sediment transport event with streamflow that approached pre-Libby Dam conditions took place from April 24 to July 5, 1974, during the white sturgeon spawning season (Barton 2004). Suspended sediment and turbidity may be a critical component of flow that allows sturgeon egg and larvae survival; the last known year-class recruitment to the Kootenai River white sturgeon population occurred in 1974.

Gadomski and Parsley (2005) found that significantly more white sturgeon larvae were eaten by prickly sculpins *Cottus asper* at lower turbidity levels (*P*, 0.01) in a controlled laboratory experiment. This may suggest that lower turbidity levels now present in the Kootenai River, as a covariate with other alterations to the river as a result of environmental alterations, may result in increased predation on white sturgeon larvae.

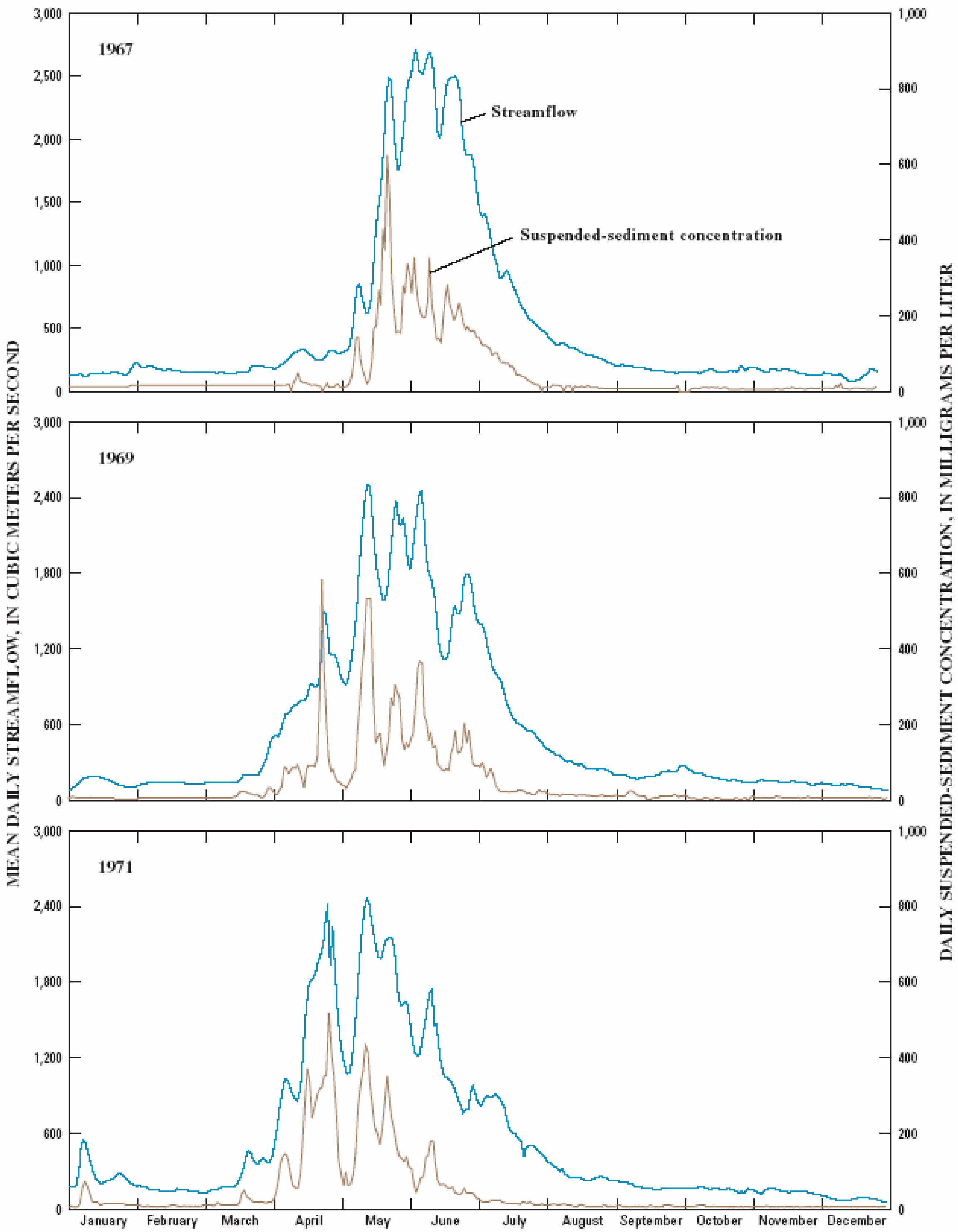


Figure 11. Daily suspended-sediment concentration and mean daily streamflow at U.S. Geological Survey streamflow gaging station 12318500 on the Kootenai River at Copeland, Idaho, during the pre-Libby Dam era.

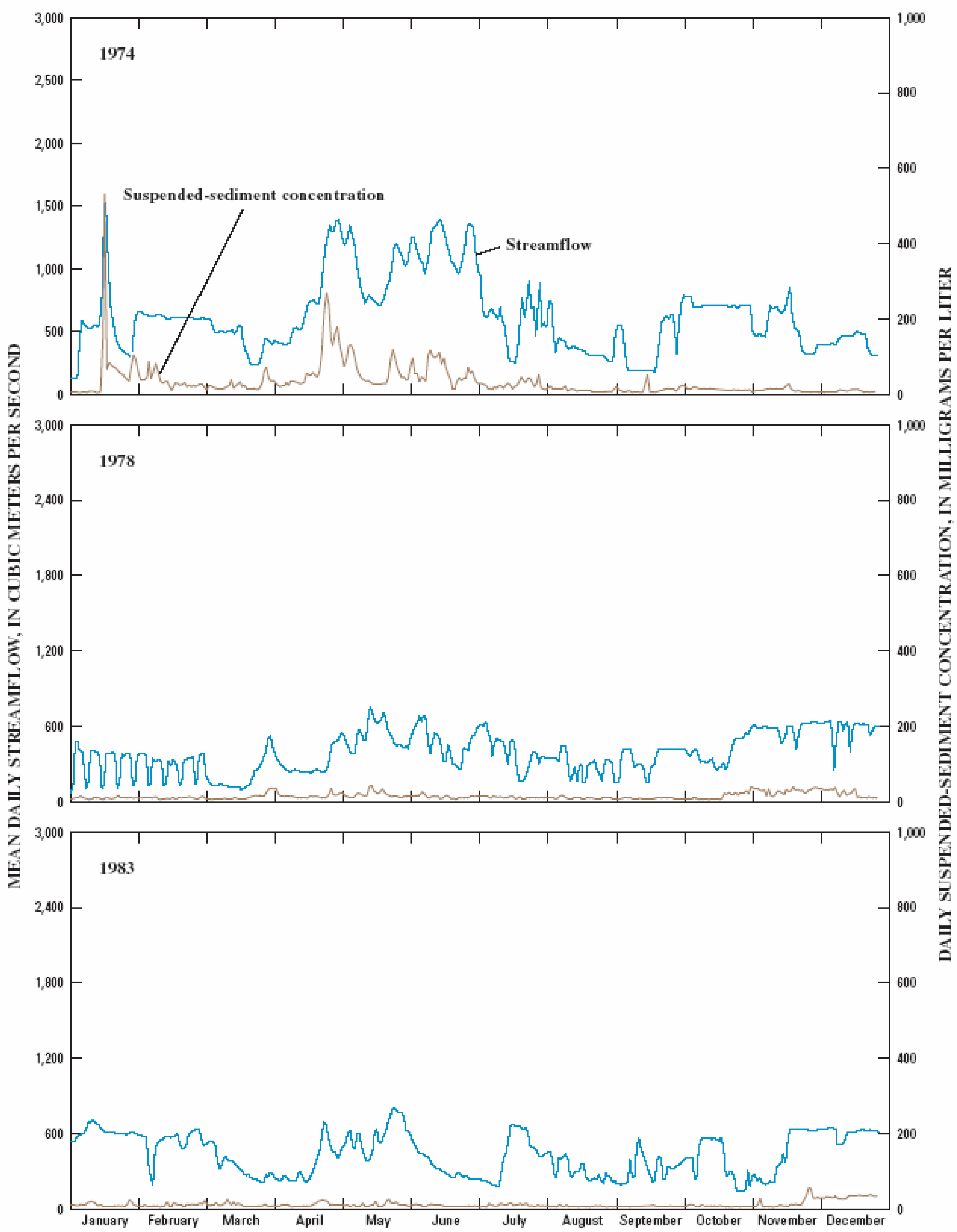


Figure 12. Daily suspended-sediment concentration and mean daily streamflow at U.S. Geological Survey streamflow aging station 12318500 on the Kootenai River at Copeland, Idaho, during the Libby Dam era.

Flow Information

The 2000 USFWS Biological Opinion included a Reasonable and Prudent Alternative, (RPA) based on the assumption that increased flows from Libby Dam correlated with increased velocities in the critical sturgeon spawning habitat (Figure 13) below Bonners Ferry, Idaho. The assumed increased velocities were hypothesized to be sufficient enough to transport sediment from and through the spawning areas, thus making appropriate adherence substrates available for fertilized egg attachment and development. It was also hypothesized that the resulting increased velocities would deter predation upon eggs, embryos, and larvae.

As part of the 2000 BiOp, the Service recommended study of the channel hydraulics and sediment transport capabilities of the Kootenai River. These studies have recently indicated that there is very little appropriate spawning substrate in the thalweg available in the lower reaches of listed critical habitat in the river, and that historically these areas had substrates composed primarily of sand and clay (USGS, personal communication, 2004). Only the upper ~ 1km of critical habitat contains thalweg substrate considered suitable for successful spawning. The studies have also indicated that the change in gradient in the Kootenai River near Bonners Ferry likely prevents a change in river flow from maintaining velocities sufficient enough to transport sediment from these lower reaches. In addition, the studies have indicated that changes in flow to levels up to approximately 50,000 cfs have a very small effect on resulting velocities in the straight reach below Bonners Ferry (Figure 14, Table 1). Results from similar modeling exercises in the upper critical habitat reach are pending (USGS), though it is postulated that velocity is more responsive to changes in river flow in this reach due to the relative gradient in the section of the channel.

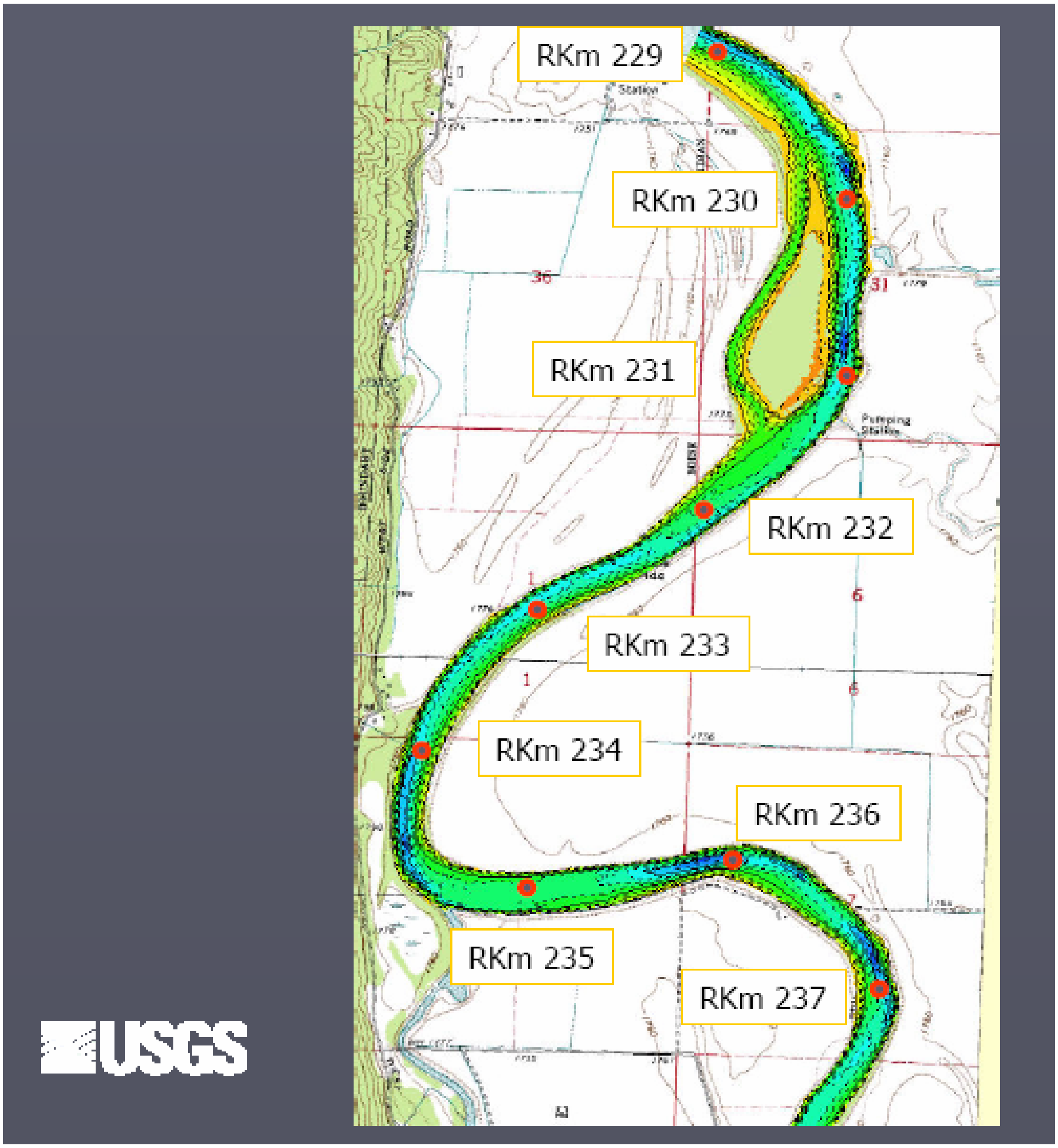


Figure 13. Kootenai River in Bonners Ferry, Idaho, vicinity. RKm 235 is near Myrtle Creek; RKm 230-231 is near Shorty's Island.

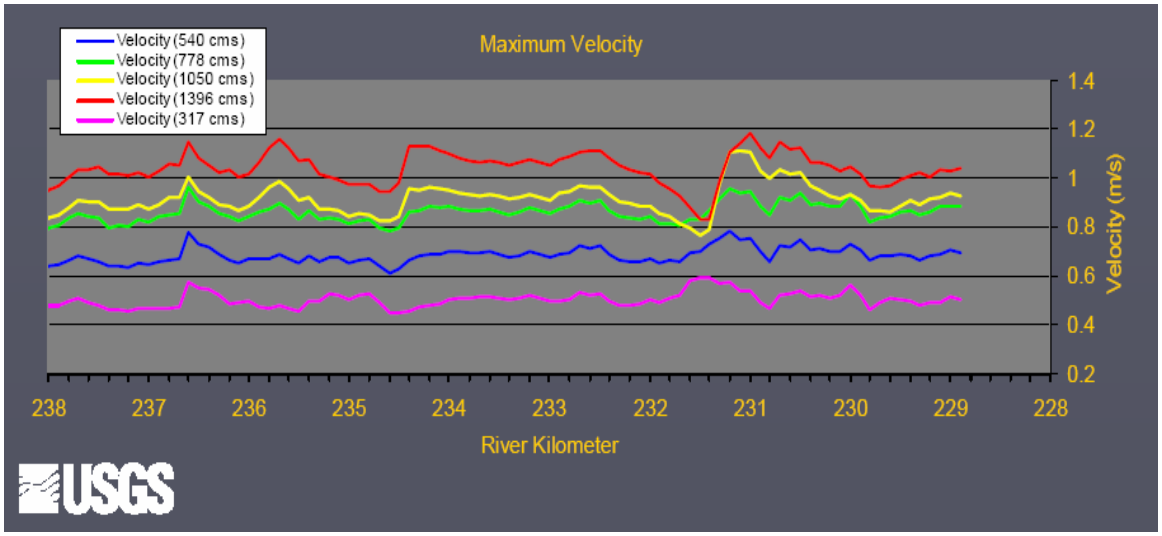


Figure 14. Maximum Kootenai River velocity (V) at various flows (Q) in critical sturgeon habitat (River Kilometers 228 – 238), as modeled by USGS.

Table 1. Metric to English conversions for Figure 14.

RIVER DISTANCE		**FLOW (Q)**		**VELOCITY (V)**	
Kilometer	**Mile**	**Cubic Meters / Second (cms)**	**Cubic Feet / Second (cfs)**	**Meters / Second (m/s)**	**Feet / Second (f/s)**
228	**141.7**	**317**	**11,195**	**0.2**	**0.66**
229	**142.3**	**540**	**19,070**	**0.4**	**1.31**
230	**142.9**	**778**	**24,475**	**0.6**	**1.97**
231	**143.5**	**1050**	**37,080**	**0.8**	**2.63**
232	**144.2**	**1396**	**49,299**	**1.0**	**3.28**
233	**144.8**			**1.2**	**3.94**
234	**145.4**				
235	**146.0**				
236	**146.6**				
237	**147.3**				
238	**147.9**				

The results of the USGS modeling suggest that creation of appropriate spawning conditions, including velocities of 1.5 m/s or greater, is not likely in the Shorty's Island reach of the Kootenai River. Sturgeon have and will continue to spawn in that location regardless of flow, but survival of fertilized eggs has never been documented. Substrate placement in this reach may enable egg attachment, however. Experimentation with increased velocity conditions should occur upstream of this reach, where gradient and substrates are more conducive to successful egg attachment and survival.

RECOMMENDED ACTIONS

The following discussion sets forth the general flow plan guidelines the Corps proposes to utilize in making operational decisions at Libby Dam in support of the functional normative river concept, and to implement adaptive management flow experiments to further define sturgeon early life history requirements in the Kootenai River.

10 Year Aquatic Ecosystem Management Experimental Hydrograph

- Based on April-August inflow forecast (final May forecast), commence a freshet operation on or about 15 May*, depending on water temperature, targeting use of 45% of the tiered volume until 01 June. Maximum discharge (full powerhouse- or up to 35 Kcfs if operationally possible) should occur during the last week in May and the first week in June. Duration of tiered discharge at full capacity should be limited to 2 weeks, but should occur for at least 48 hours each year regardless of tier (including Tier 1). Actual timing and duration of augmentation volumes can be adjusted to allow for real-time water management.

  * *If possible, increasing flows from Libby Dam should be delayed until doing so would not result in substantially decreased river temperatures downstream of the dam, preferably until water temperature in the top 20 feet of the forebay is within 2 degrees Celsius of river temperature at Bonners Ferry. Operations for natural sturgeon spawning, as well as for KTOI conservation aquaculture operations, should* ***attempt*** *to optimize the thermal effects of increased flow when implementing the flow plan. If additional flow is necessary prior to the alignment of temperatures for flood control purposes, and that early release is necessary to use 45% of the tiered volume prior to 01 June, then the shape of the release should incrementally approach full capacity as smoothly as possible.*

- The remaining volume will be shaped over June (45%) and July (10%), targeting a final ramp down to reach at least minimum bull trout flows by 15 July. Shaping of the volume will be dependent upon bull trout minimum target flow and flood control requirements, and should attempt to minimize the "double peak," which may occur when providing sturgeon operations and operating to refill Libby Dam to have water available for salmon flow augmentation, in accordance with the Action Agencies Updated Proposed Action confirmed in the 2004 NOAA BiOp. This operation was also recommended in the 2003 NPCC Mainstem Amendments (Appendix I-a, I-b, I-c).

- Higher tier years will have a more gradual ramp-down from powerhouse capacity (consistent with ramping rates); lower tiers will have a more pronounced rise in May towards a peak, and a more sigmoidal shape to the descending limb of the hydrograph (Figure 15). The peak of this generally shaped flow scenario may vary by as much as three weeks to address the natural runoff augmentation opportunities or responses by sturgeon believed to be spawning in a given year, or both.

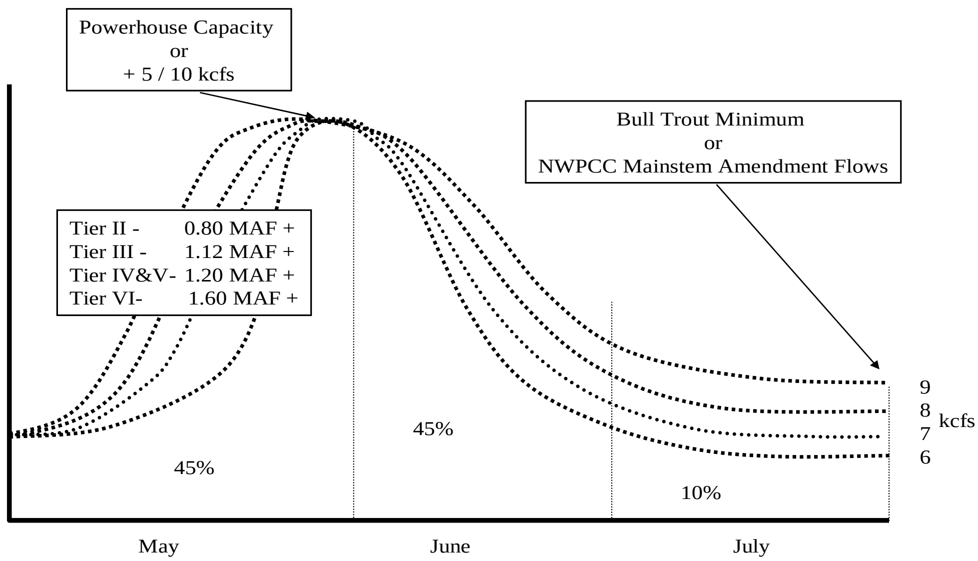


Figure 15. Schematic depiction of a functionally "normative" spring freshet hydrograph from Libby Dam (not to scale).

- Libby flow may be curtailed for flood control purposes, thus extending the duration of higher flows, to not exceed Bonners Ferry flood stage elevation.

- The specific flows to be used to shape the normative hydrograph are based on the given tiered volumes (Figure 16 and Table 2) and the historic hydrograph shapes of 1961 and 1974 (Figure 6).

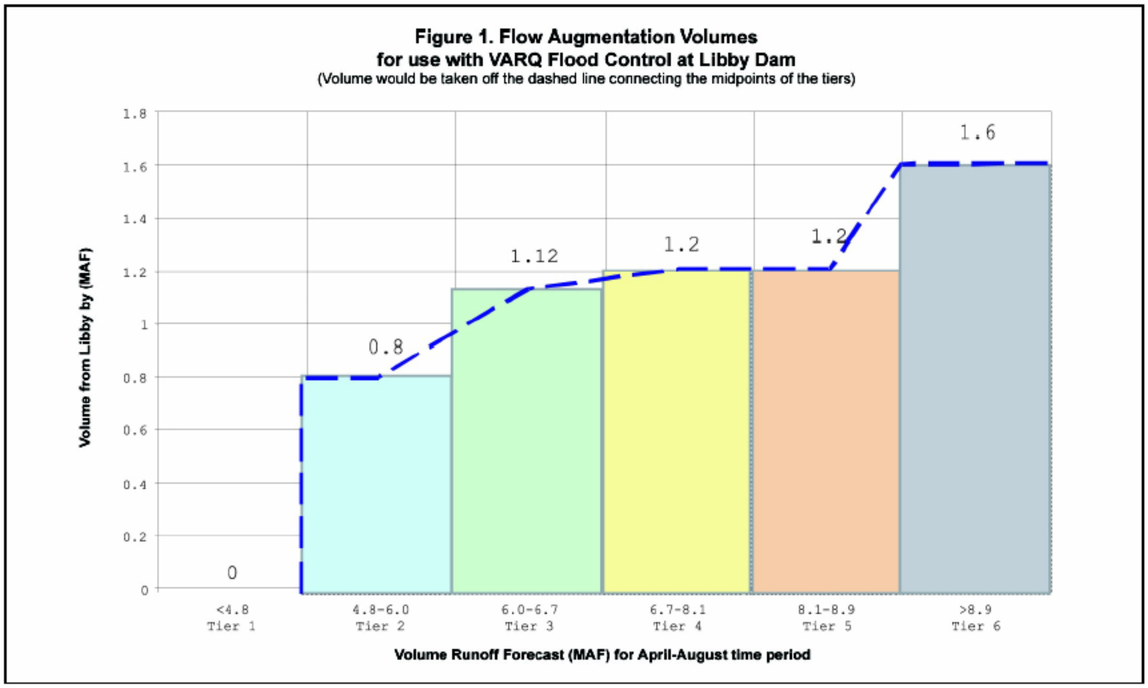


Figure 16. The "tiered" flow strategy for Kootenai River white sturgeon flow augmentation. During a March 25-26, 2002, meeting with the U.S. Army Corps of Engineers, the Recovery Team determined that some problems could be corrected by establishing a new calculation for sturgeon flows. Release volumes are still based on water availability, but the volumes to be released are calculated over the entire range of possible inflows (dashed line) rather than grouped into the original six tiers.

Table 2. VARQ "tiered" volumes of water (MAF – million acre feet) for sturgeon flow enhancement and bull trout base flow to be provided from Libby Dam according to the April - August volume runoff forecast at Libby.

Final May Forecast Runoff Volume at Libby (MAF)	Sturgeon Volume from Libby Dam (MAF)	Minimum Bull Trout Flow May 15– September 30 (CFS)
0.00 to 4.80	NA	6,000
4.80 to 6.00	0.80	7,000
6.00 to 6.70	1.12	8,000
6.70 to 8.10	1.20	9,000
8.10 to 8.90	1.20	9,000
> 8.90	1.60	9,000

The following lays out the steps the Corps proposes, using adaptive management principles, to implement and test the 10 year aquatic ecosystem management experimental hydrograph.

- Year 1

  Target is fertilized egg release experiment. Flows should last 21+ days (depending on tier) following the last fertilized egg release with a target 1.5 mps or greater at the release site. (*See* Kootenai River Sturgeon Egg Release Study)

- Years 2-10

  Powerhouse capacity ~ possible repeat(s) of egg release experiment at Hemlock Bar and/or created habitats at Shorty's Island, Straight Reach, or Braided Reach to benefit natural spawners or placed gametes. Main intent is to provide a normative hydrograph for habitat placements and experiments with those projects based on tiered flow volumes and start dates.

  In water years during which optimal conditions are present, operational flexibility should target powerhouse flows in addition to local freshet peaks in order to create the highest possible velocities (within operational constraints) over the existing habitat (i.e. straight reach w/ substrates), and to further define biological parameters required for sturgeon migration and spawning site selection. If artificially placed habitat structures are available, the same defined parameters should be monitored at those locations.

  The thresholds to trigger this action include: 1) the ability to create the greatest brief peak flow/stage and backwater extent possible - in excess of 55,000 cfs at Bonners Ferry for at least 2 days and backwater to within 2 miles of Bonners Ferry; within operational constraints and consistent with authorities; 2) presence of radio tagged sturgeon expected to spawn; and, 3) at the earliest point in the year when water temperatures can be maintained near 10 degrees C at Bonners Ferry.

  Monitoring of the biological and hydrological effects of this action will determine if additional flow from Libby Dam is required to fulfill biological objectives of the experiment. If successful recruitment is observed under the tested conditions, implementation of additional operations of similar parameter should be undertaken as often as possible.

  If successful recruitment is not documented under the tested conditions, and it is determined that additional flow would provide conditions likely to ensure successful recruitment, the following action should be implemented to provide flows in excess of powerhouse capacity.

  Powerhouse capacity + 10,000 cfs ~ The thresholds to trigger release of flows greater than powerhouse capacity include, in addition to the conditions listed above: 1) the ability to augment powerhouse flows with additional flows of up to 10,000 cfs without significant biological harm to downstream biota (e.g. as a result of increased levels of

TDG); and 2) when incubation flows can then be sustained at no less than 40,000 cfs for no less than 21 days and up to 42 days. These conditions are intended to mimic, at the earliest opportunity, the lower thresholds of pre-Libby conditions when sturgeon are believed to have recruited naturally. (Note: These thresholds may be modified after USGS provides modeling results to questions posed by the Service.)

This action depends on the ability to provide 10,000 cfs in addition to powerhouse capacity. The Corps and BPA have investigated options for structural modifications that would accommodate the additional releases and minimize elevated TDG levels. Such options included additional generating units requiring construction of transmission lines, spillway modifications, and other gas abatement measures. The Corps and BPA have concluded that adding generating units and the associated transmission is not a reasonable or economically prudent near term option.

In the near-term, testing the biological effects of providing additional flow augmentation volume will require spilling up to 10,000 cfs in addition to powerhouse capacity. This action will increase total dissolved gas levels, therefore, the Corps and BPA, in conjunction with the Service, will discuss the anticipated biological basis for testing the increased flow augmentation with the Montana Department of Environmental Quality and Montana Fish, Wildlife & Parks.

Longer-term options to provide this additional flow, if it is found to provide biological benefits, may include the use of the three existing penstocks, 6, 7, or 8. The Corps and BPA will continue investigating possible long-term options to provide the additional flow augmentation volume if biologically supportable.

Flow Test Decision Guidelines

In order to test hypotheses regarding the importance of flow in causing volitional movement of spawning condition adult sturgeon in the Kootenai River, and thus the importance of the implementation of structural changes at Libby Dam for that purpose, this plan proposes to set hydrologic and biological criteria that will determine when these tests are appropriate, and would have reasonable potential for scientist to determine whether or not flow was a significant variable. The criteria to be considered and met when planning for these flow tests are river temperature conditions, location of the river/lake backwater interface as it relates to Kootenay Lake elevation and Kootenai River flow.

Pre-dam conditions are assumed to have provided conditions appropriate for successful spawning and recruitment.

- Prior to Libby Dam regulating the Kootenai River, the thermal regime of the river can be considered to have been normal.

- Corra Linn Dam began regulating Kootenay Lake in 1931, thus reducing the extent of the backwater effect beginning at that time due to the spring lowering of lake elevation;

however, successful recruitment still occurred up until the time of installation of Libby Dam.

It is likely that the combination of the effects of regulation of these two variables has caused the greatest effect on both the timing and the location of sturgeon spawning. It is also evident that the combined effect of these two variables as cues for migration and spawning has been so disrupted that sturgeon now spawn over substrates that are not suitable for egg attachment and survival. Historically, temperature of the Kootenai River increased incrementally in parallel with increase in backwater location from flow and Kootenay Lake elevation (Appendix II). This general pattern has been disrupted with the construction and operation of Libby Dam, with temperatures generally not warming until later in the spring, and backwater elevations being regulated for flood control at Kootenay Lake and near Bonners Ferry (Figures 17-26).

Evidence suggested by the data indicate that although appropriate temperature conditions are currently reached during the spawning period, the onset of those temperatures is delayed by several weeks, on average (Figure 17). Operation of the selective withdrawal system at Libby Dam has been sporadic, and has not targeted temperatures for sturgeon spawning in most years prior to 2003.

Data also indicate that backwater locations, at times, reach above areas of the Kootenai River thought to be favorable for successful sturgeon spawning (Figure 18). Egg collection data indicate that currently sturgeon consistently spawn 10-20 km downstream of the backwater interface in lower water years (i.e. Shorty's Island, the area with the greatest velocity and turbulence in the lower river). In higher water years sturgeon spawned nearer the backwater interface, perhaps indicating that the higher stage and flows associated with those conditions cause areas upstream to be more turbulent, and thus more attractive for spawning adults (Figures 19-27).

Historically, sturgeon in the Kootenai likely spawned during the receding limb of the hydrograph, as has been documented in other sturgeon populations (e.g. Waneta Dam on the Columbia River)), as temperatures and day length were increasing. In order to provide similar temperature conditions in the present Kootenai River, it is imperative to maximize thermal conditions at Libby Dam through use of the selective withdrawal system. To provide hydraulic conditions thought cue sturgeon migration and create conditions thought to attract spawning fish, it will be necessary to time releases from Libby Dam to be maximally additive to the peak of the local freshet. If possible, Kootenay Lake elevations should be optimized, perhaps by delaying the spring freshet and lowering formula through agreement with Canada.

The specific conditions that will be cause for implementing a full powerhouse or a full powerhouse plus test event are:

Powerhouse capacity ~

1. The ability to create the greatest brief peak flow/stage in excess of 55,000 cfs at Bonners Ferry for at least 2 days;
2. Backwater reaching to or above Bonners Ferry (within operational constraints and consistent with authorities);
3. Presence of radio tagged sturgeon expected to spawn; and,
4. At the earliest point in the year when water temperatures can be maintained near 10 degrees C at Bonners Ferry.

Powerhouse capacity + 10,000 cfs ~

1. The ability to create the greatest brief peak flow/stage in excess of 55,000 cfs at Bonners Ferry for at least 2 days;
2. Backwater reaching to or above Bonners Ferry (within operational constraints and consistent with authorities);
3. Presence of radio tagged sturgeon expected to spawn;
4. At the earliest point in the year when water temperatures can be maintained near 10 degrees C at Bonners Ferry;
5. The ability to augment powerhouse flows with additional flows of up to 10,000 cfs without significant biological harm to downstream biota (e.g. as a result of increased levels of TDG);
6. When incubation flows can then be sustained at no less than 40,000 cfs for no less than 21 days and up to 42 days.

This action depends on the ability to provide 10,000 cfs in addition to powerhouse capacity, which relates to a reservoir elevation of at least 1302 MSL.

Figure 17. Kootenai River white sturgeon documented spawning location and timing (egg collection) in 1994.

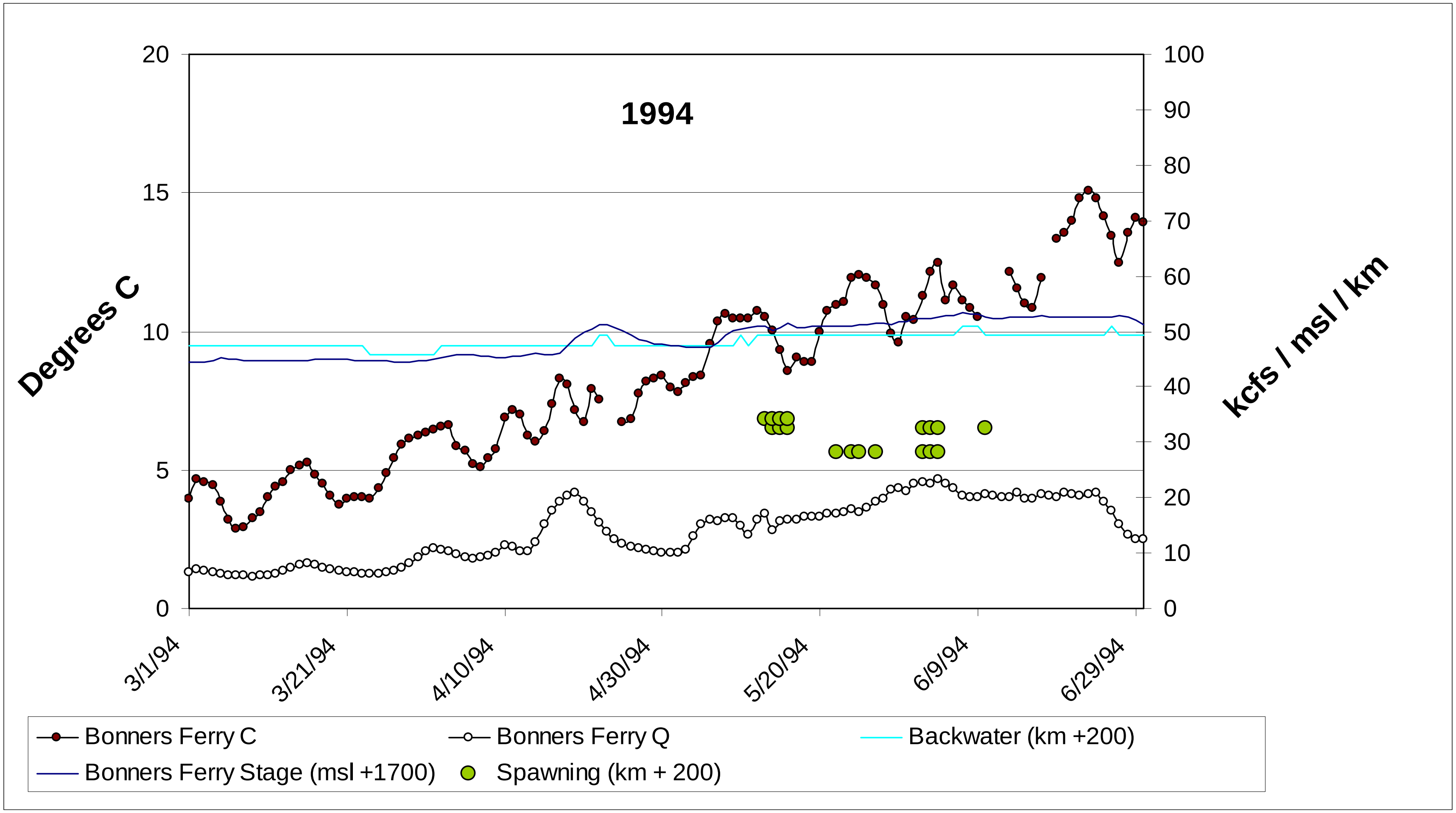


Figure 18. Kootenai River white sturgeon documented spawning location and timing (egg collection) in 1995.

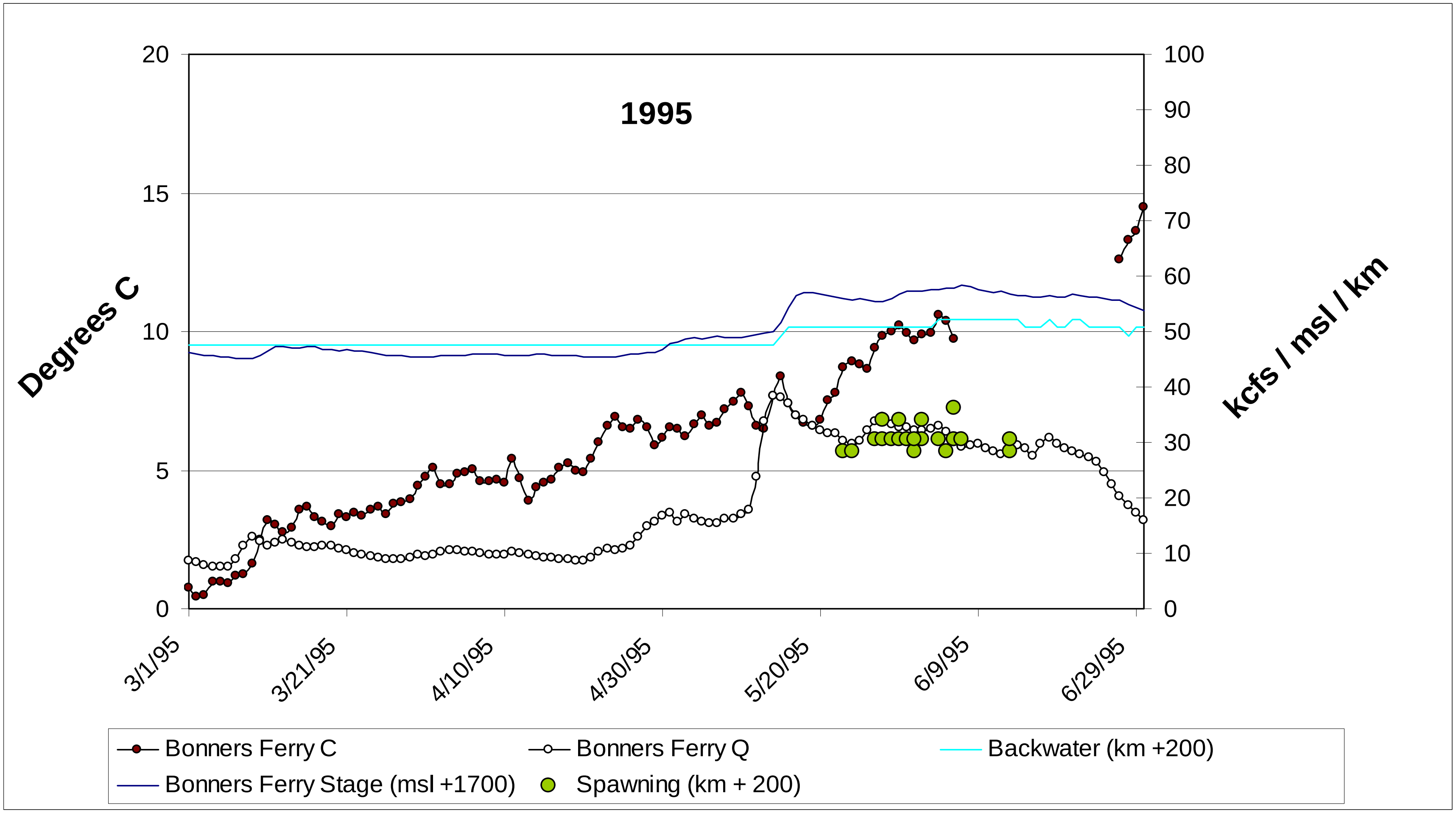


Figure 19. Kootenai River white sturgeon documented spawning location and timing (egg collection) in 1996.

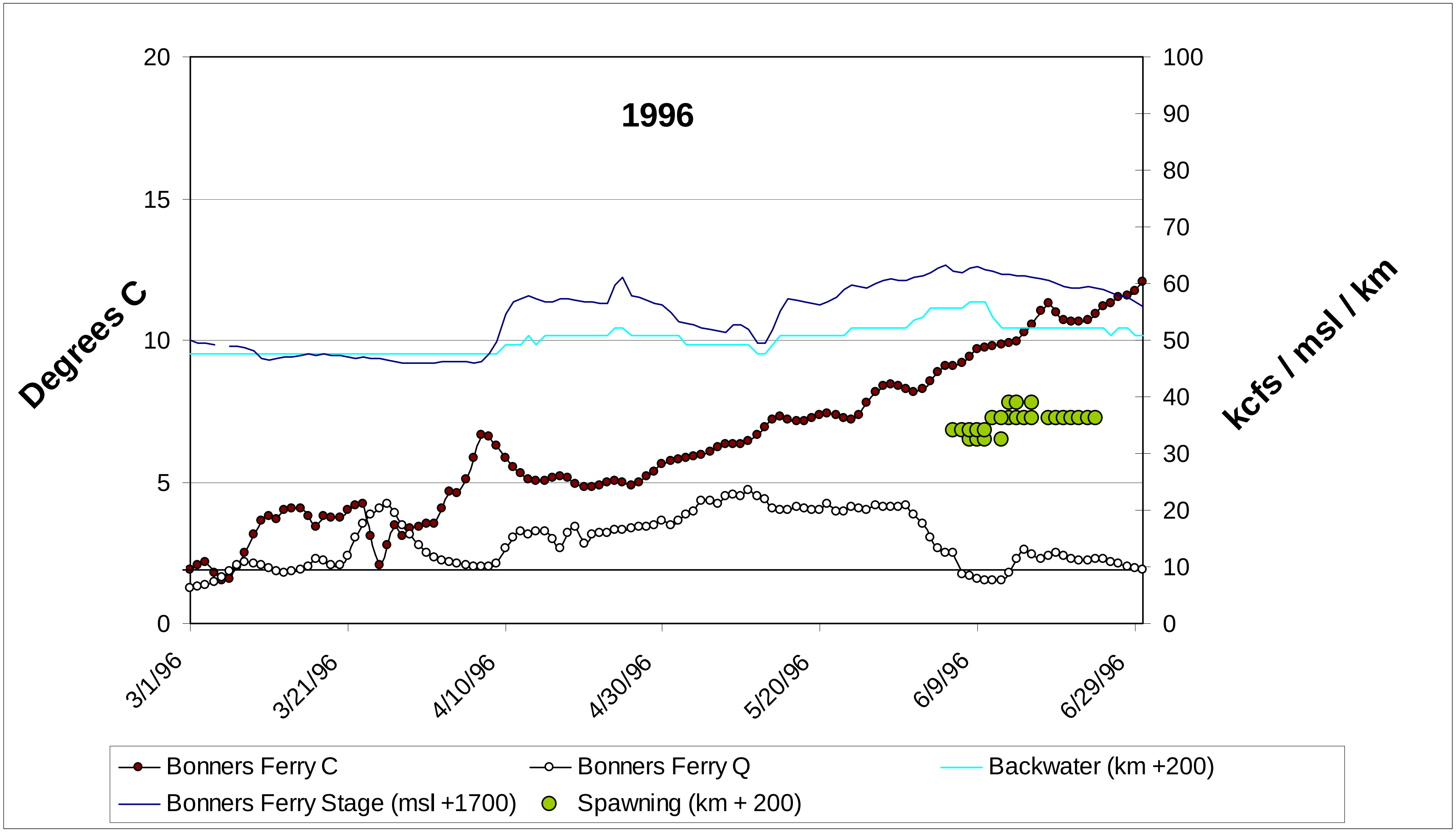


Figure 20. Kootenai River white sturgeon documented spawning location and timing (egg collection) in 1997.

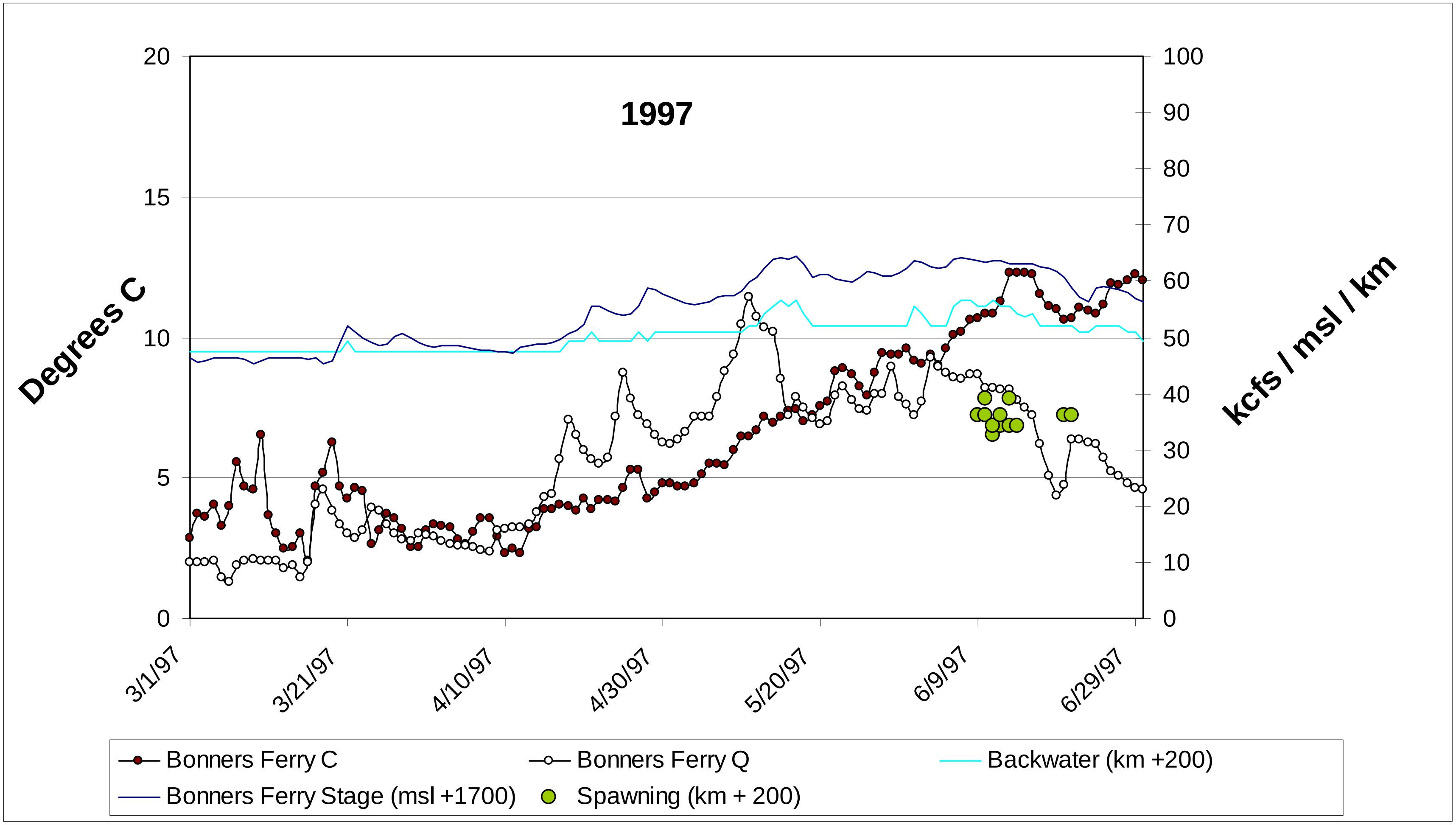


Figure 21. Kootenai River white sturgeon documented spawning location and timing (egg collection) in 1998.

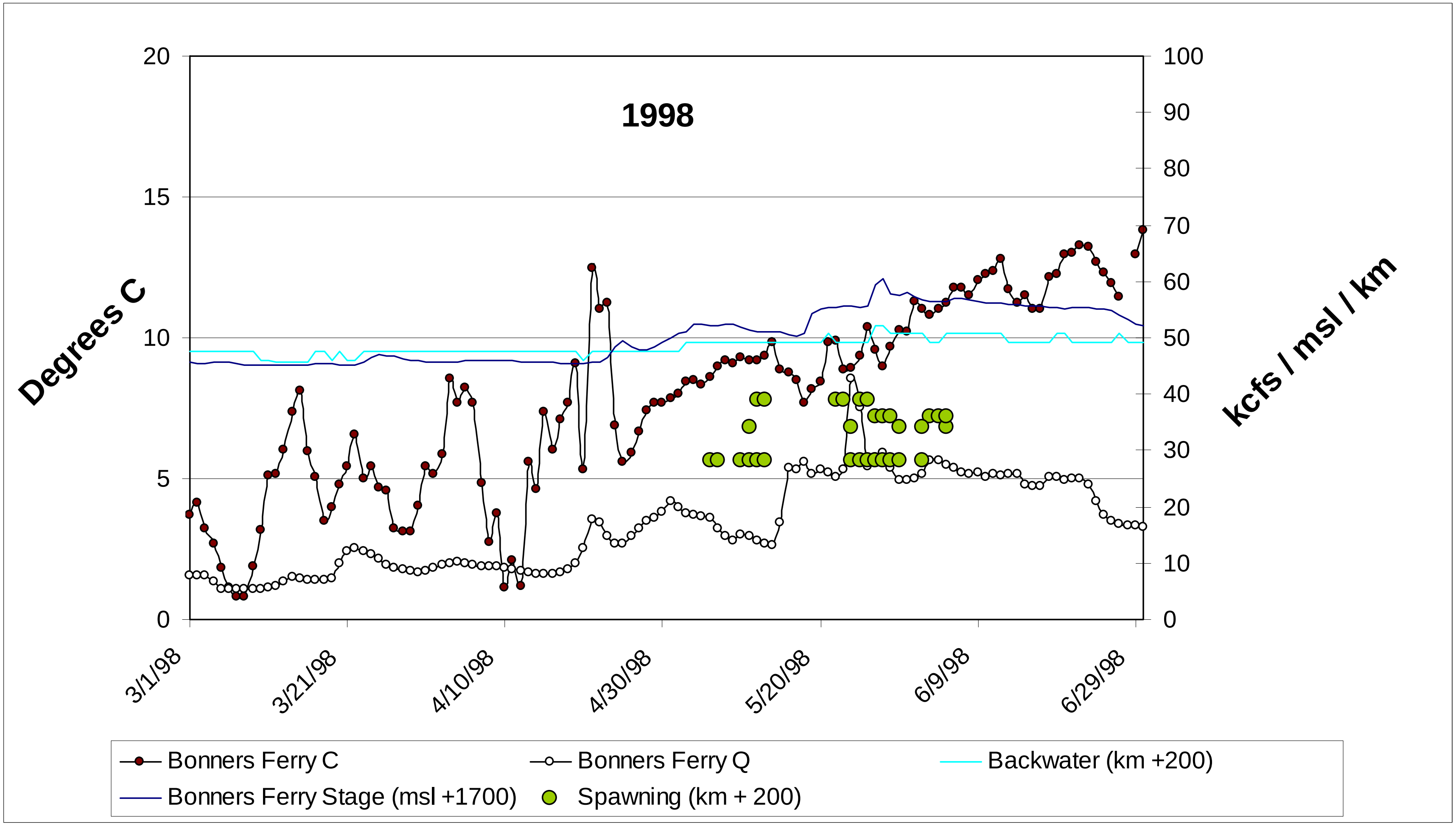


Figure 22. Kootenai River white sturgeon documented spawning location and timing (egg collection) in 1999.

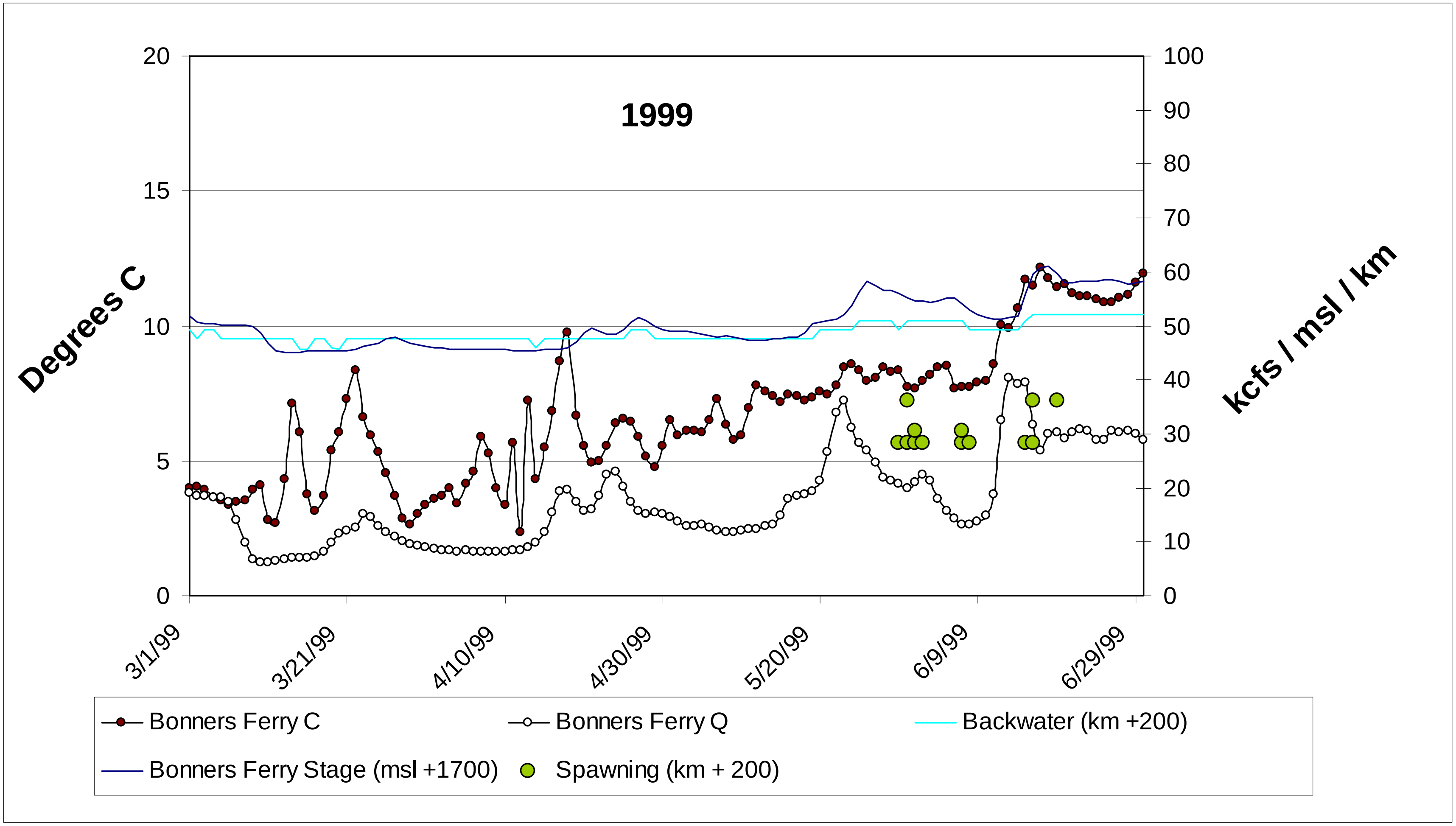


Figure 23. Kootenai River white sturgeon documented spawning location and timing (egg collection) in 2000.

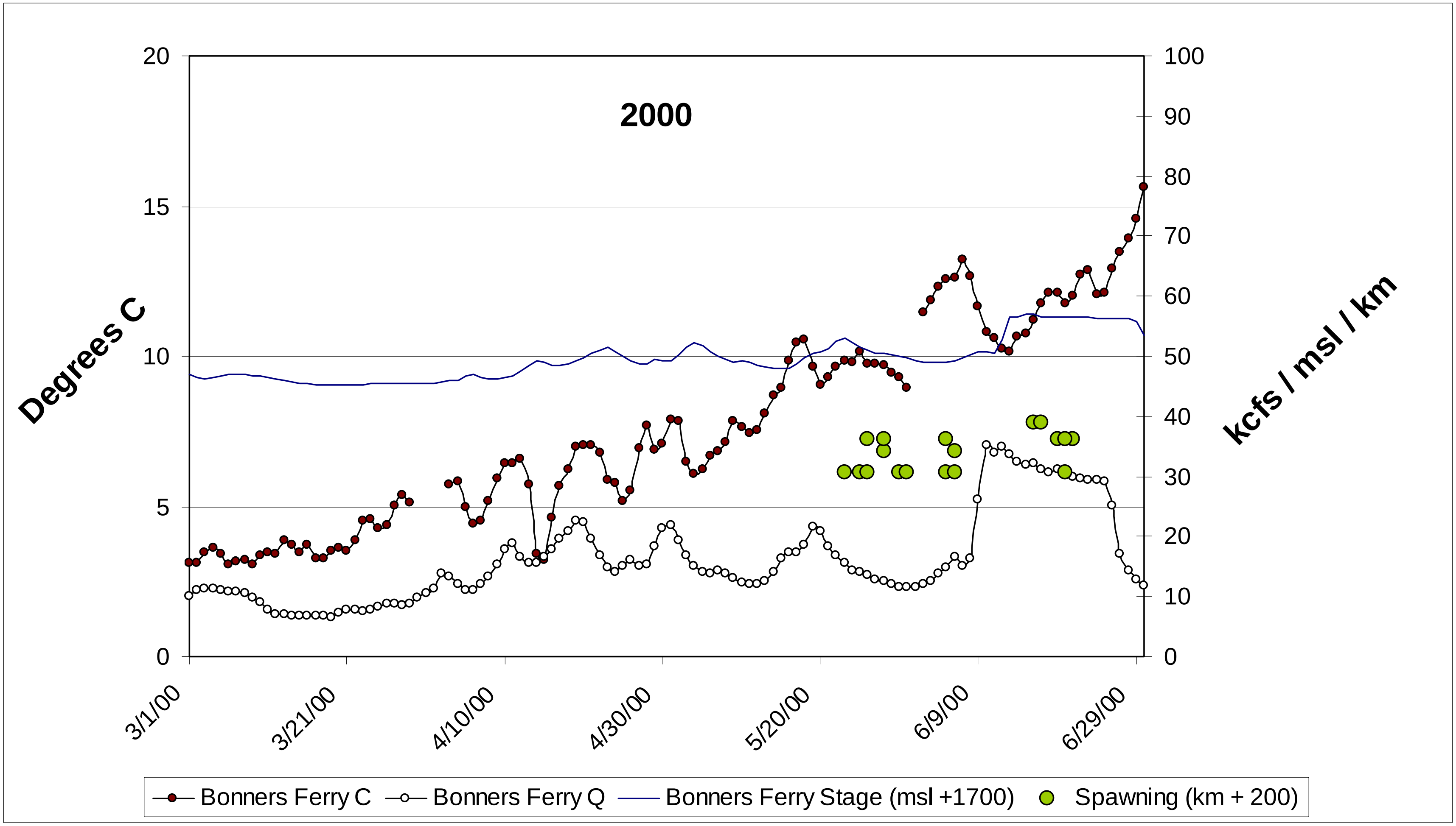


Figure 24. Kootenai River white sturgeon documented spawning location and timing (egg collection) in 2001.

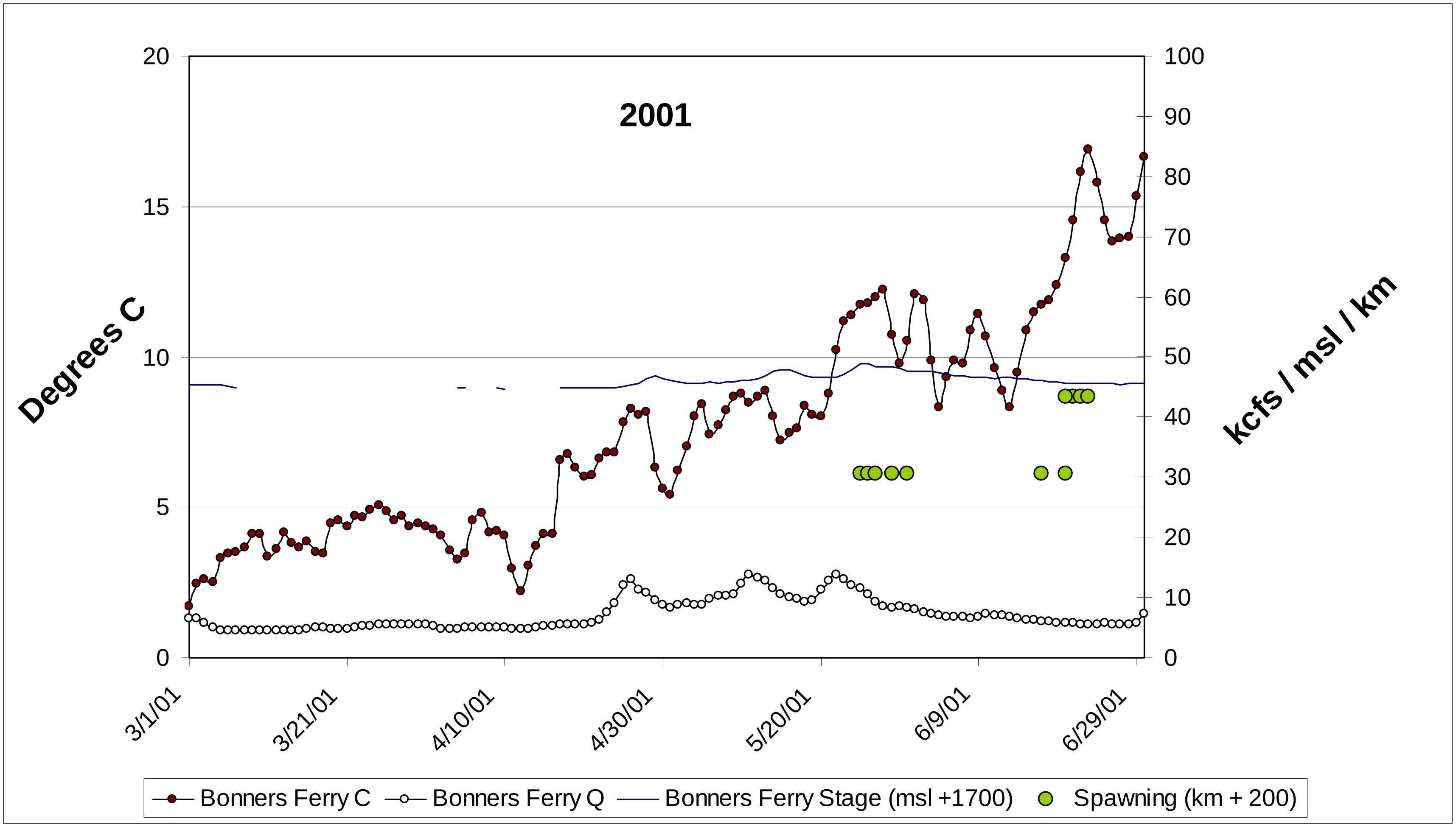


Figure 25. Kootenai River white sturgeon documented spawning location and timing (egg collection) in 2002.

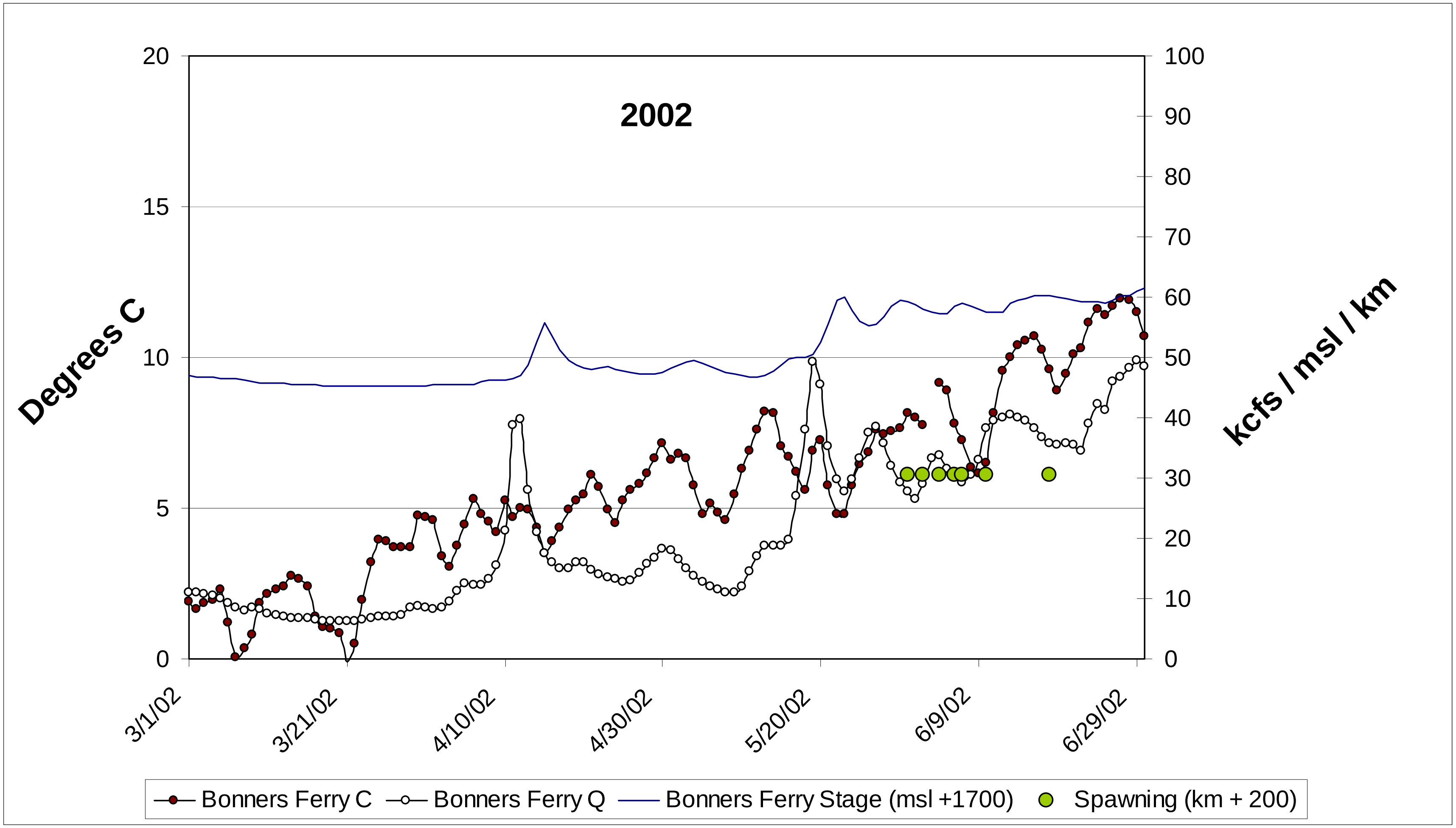


Figure 26. Kootenai River thermographs for pre- (1967 through 1974) and post-(1994 through 2002) Libby Dam periods during April through June (sturgeon spawning timeframe).

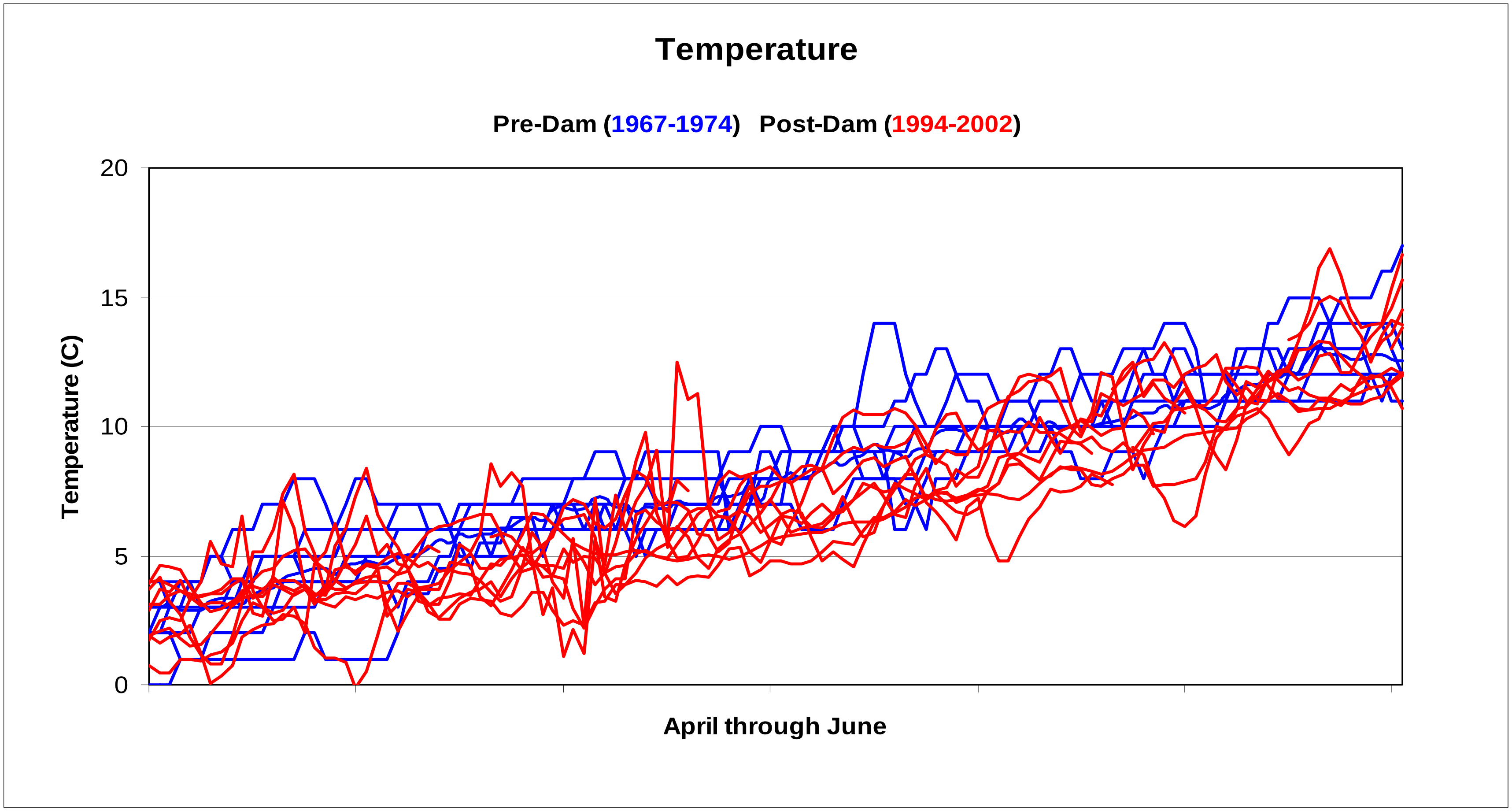
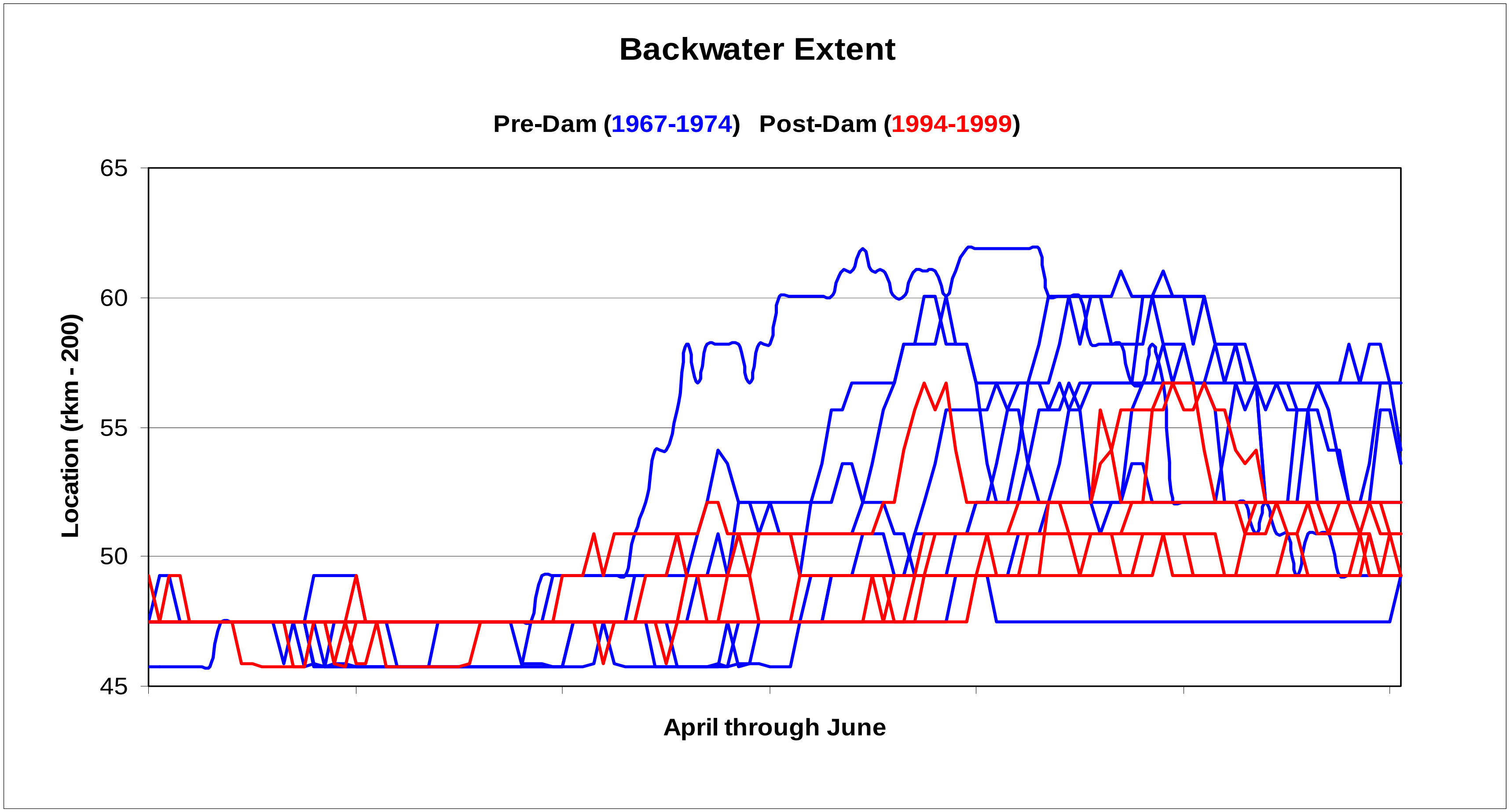


Figure 27. Kootenai River backwater locations for pre- (1967 through 1974) and post-(1994 through 1999) Libby Dam periods during April through June (sturgeon spawning timeframe).



IMPLEMENTATION OF PROPOSED LIBBY DAM OPERATIONS

Flow Recommendations

Ramping Rates and Daily Shaping

The recommended ramp rates (Table 3) will be followed except if the recommended ramp rate causes a unit(s) to operate in the rough zone, a zone of chaotic flow in which all parts of a unit are subject to increased vibration and cavitation that could result in premature wear or failure of the units. In this case the project will utilize a ramp rate that allows all units to operate outside the rough zone. Ramping rates will be followed to the extent possible during flood control operations, power emergencies, and other project operations beneficial to fish and wildlife resources. Daily shaping is defined as ramping up and down by more than 1 unit in a 24 hour period.

Table 3. 2004 Proposed daily and hourly maximum ramp up rates for Libby Dam (as measured by daily flows, not daily averages, restricted by hourly rates).

		Summer (05/01 - 09/31)	
		Hourly	Daily
Ramp Up	4-6 kcfs	2500 cfs	1 unit
	6-9 kcfs	2500 cfs	1 unit
	9-16 kcfs	2500 cfs	2 units
	16-QPHC	5000 cfs	2 units
Ramp Down	4-6 kcfs	500 cfs	500 cfs
	6-9 kcfs	500 cfs	1000 cfs
	9-16 kcfs	1000 cfs	2000 cfs
	16-QPHC	3500 cfs	1 unit
		Winter (10/01 - 04/30)	
		Hourly	Daily
Ramp Up	4-6 kcfs	2000 cfs	1 unit
	6-9 kcfs	2000 cfs	1 unit
	9-16 kcfs	3500 cfs	2 units
	16-QPHC	7000 cfs	2 units
Ramp Down	4-6 kcfs	500 cfs	1000 cfs
	6-9 kcfs	500 cfs	2500 cfs
	9-16 kcfs	1000 cfs	1 unit
	16-QPHC	3500 cfs	1 unit

- It is important to maximize river productivity during the summer months leading into the fall ramp-down. Maximizing productivity during this time would offset the biological impacts from the load shaping operations during the winter months.

- Daily load shaping during October through February above 6 Kcfs, within the ramping rate constraints, provides protection for aquatic biota inhabiting the primary river channel (base flow) below 6 Kcfs. However, it is critical to minimize flow fluctuation in the wetted perimeter below 9 Kcfs, as the area inundated between 6 and 9 Kcfs encompasses the greatest wetted perimeter in the Kootenai River channel, and is thus the most biologically important.

Minimum Flows

The action agencies will continue to provide the following minimum flows from Libby Dam (measured at USGS Gauge on the Kootenai River below Libby Dam), and will attempt to :

- Maintain existing year-round instantaneous minimum flow of 4,000 cfs.

- Provide a minimum flow of 6,000 cfs from May 15 through September 30. Provide minimum bull trout flows as per Table 2 from May 15 through September 30. Extending a minimum discharge requirement of 6 Kcfs through into May and through September will protect the channel inundated at this flow during the most biologically productive period of the year.

    - Note: In order to minimize loss of river productivity in river varial zones in October, a period of declining but substantial biological production, river elevations should gradually decrease from the preceding September elevations towards the target base flow. If September flows are at the bull trout minimum (6,000 cfs), then following the recommended general ramping rates is acceptable. However, if flows are more than the minimum bull trout flows, and reduction to minimum powerhouse capacity is desired, then a slower ramping, discussed through the Technical Management Team (TMT), should be considered.

    - Note: The zone of productivity within the wetted perimeter of the Kootenai River is re-delineated when flows are reduced after an extended period of inundation, resulting in desiccation of that zone. Summer "double peak" operation increases the area of desiccation by creating reduced flows between sturgeon augmentation and salmon augmentation. The effect of this action is the establishment of productivity in a varial zone during sturgeon operations, followed by immediate desiccation of this zone (total loss of productivity within 4 days) for the period through the commencement of salmon augmentation operations, during which the varial zone becomes productive once again (fully recovered in approximately 35 days). If the salmon augmentation is followed by another reduction in flow, a similar biological response is experienced in the desiccated zone.

Sturgeon and Bull Trout Volumes

The action agencies will store and supply, at minimum, water volumes based upon water availability or "tiered" approach as defined in Figure 13. The probability for each tier occurring is shown in Table 4. The action agencies will re-examine these minimum volumes in order to potentially provide more water for the "normative" freshet in tiers 2, 3, and 4.

This water is available for use in May, June and July, and is measured as a volume out of Libby Dam above minimum flow of 4,000 cfs. Accounting of these total tiered volumes occurs according to the experimental hydrograph plan outline. Actual flow releases would be shaped based on seasonal requests from the Service and coordination with the Technical Management Team. Use of this water is subject to flood control constraints, including the Bonners Ferry 1764 ft flood stage, the requirements of the International Joint Commission 1938 Order on Kootenay Lake, and water quality, specifically total dissolved gas supersaturation.

Bull trout minimum flows will be in effect from May 15 through September 30, as described previously. Volume to sustain basal flow of 6,000 cfs from May 15 through May 31 will be accounted for with sturgeon volumes, and in the fall should be drawn from the autumn flood control draft.

Table 4. Probability of occurrence of specific sturgeon tiers for the period of record 1929 – 2004.

	Period of Record (1929 through 2004)	
Sturgeon Tier	**Years of Occurrence**	**Probability of Occurrence**
1 (0 MAF)	9	0.12
2 (0.8 MAF)	23	0.30
3 (1.12 MAF)	11	0.14
4 (1.2 MAF)	25	0.33
5 (1.2 MAF)	5	0.07
6 (1.6 MAF)	3	0.04

Temperature

Paragamian et al (2002) recorded temperatures during 87 spawning events in the Kootenai River from 1994 through 2000. Approximately 60% of those observations occurred when temperature was between 9.6 and 11.6 C; approximately 30% of the observations were made at temperatures from 7.6 to 9.5 C; the remaining observations were made at temperatures between 11.6 and 14.5 C. Historically, the minimum threshold for temperature, approximately 8 C, was reached in early May; since 1995 that temperature is not reached until late May (Figure 7).

- Availability of warmer water in Koocanusa Reservoir is limited during the early spring months. Libby Dam should be operated to pass the warmest water available as the spring freshet commences via the selective withdrawal gate system.

- A selective withdrawal model is in preparation by the Corps, which will allow prediction of release temperature based on the forebay temperature gradient and the gate configuration.

- Libby Dam operations for natural sturgeon spawning, as well as for KTOI conservation aquaculture operations, should ***attempt*** to optimize the thermal effects of increased flow when implementing the flow plan. If possible, flows from Libby Dam should be delayed until doing so would not result in substantially decreased river temperatures downstream of the dam.

- The action agencies will examine the potential modifications to the selective withdrawal system to control vortexing, air entrainment, and cavitation that would allow withdrawal of warmer surface water.

Turbidity experiments ~ Work with KRWSRT to incorporate turbidity additions during flow events and document the effects via adaptive monitoring and evaluation (M&E). The purpose of this study is to determine if localized addition of turbidity will allow or cause sturgeon spawners to enter and remain in the now relatively shallow waters at and upstream of Bonners Ferry to spawn during the descending limb of the hydrograph. This river reach is believed to be substantially shallower during the sturgeon spawning /incubation period generally during the descending limb of the hydrograph in response to 1) gravel aggradation in the channel through lost stream energy, 2) the reduced backwater effect from the operations of Kootenay Lake made possible because of the regulating effects of Libby Dam, and 3) shallower waters simply because of flow restrictions imposed by Libby Dam.

Velocity enhancement experiments ~ Work with USGS to place velocity enhancement mechanisms (e.g. eductors) in areas thought to be advantageous to sturgeon egg attachment and development. Consider channel constriction in these areas to increase water velocity and stream energy for site maintenance and predator avoidance.

Research, Monitoring and Evaluation

The success of the proposed actions may be documented by detection of 1) free embryos, 2) free swimming larvae, or 3) subsequent detection of juveniles of any year-class attributable to the experimental flow or experimental flow with habitat placements. Monitoring for detection of these occurrences will be accomplished via current and planned activities, as outlined below.

1. *Direct observations of placed habitat features via SCUBA, underwater video, and submersed capture nets to collect fry.*
2. *Direct measurements of velocity near habitat features.*
3. *Continued temperature monitoring at the dam and at Bonners Ferry.*
4. *Kootenai River White Sturgeon Recovery Implementation* Plan *(Appendix II)*
5. *NWPCC Mainstem Amendment Research via Montana FWP*
6. *Sub-Basin Management Plan : Research, Monitoring and Evaluation*

ENVIRONMENTAL CONSIDERATIONS

Riparian Consideration

Re-establishment of the riparian floodplain is dependent largely upon flood control and power generating operations at Libby Dam. Cottonwoods and willow seed each spring during the receding limb of the hydrograph, sprout and root during the summer months, and establish in varial zones (Mahoney and Rood 1998). In order for these seedlings to recruit, ensuing river stage during the fall and winter months should not exceed the maximum stage attained during the spring freshet (S. Soults, KTOI, pers. comm. 2004).

Operation of Libby Dam should consider these impacts, and managers should attempt to shape flows to allow for riparian woody species recruitment when monitoring indicates that saplings are present in sufficient quantity to warrant intentional preclusion of excessive flows. Riparian recovery and development in the lower river may be linked to primary and secondary productivity, as well as bank and levee stability.

Burbot Consideration

The ***KVRI Burbot MOU*** provides a framework for planning burbot restoration flows.

Appendix I. SUPPORTING SCIENCE

Appendix I-a.

A Proposed Experimental Design for Long-term Adaptive Management
Of The Kootenai River Ecosystem
Carl Walters and Josh Korman
Fisheries Centre, University of British Columbia and Ecometric Research Inc., Vancouver, B.C.
July 24, 2004

In ecosystem management situations where there is high uncertainty about efficacy of some policy options and where multiple options may be implemented at the same time, adaptive management cannot safely proceed as a simple process of trying options and monitoring whether or not they succeed. Instead, we generally recommend developing a long term plan for implementing options over time in some experimental sequence that will provide deliberate experimental contrast in management "treatments", along with replication, where possible, of treatment versus control or reference policy comparisons. Such designs might involve factorial arrangement of policy treatments (classic experimental design), but it is typically simpler and more effective to use a "titration" approach where treatments are added successively (or are started all at once as a "kitchen sink" approach then deleted successively) until a desired system response is assessed.

At a recent multi-agency adaptive management workshop (July 22-23, 2004), we had an opportunity for multiple scientific and management stakeholders involved with ecosystem management for the Kootenai River to develop such a long term plan. The workshop discussions leading to the plan involved three steps: (1) identification of particular management options that have potential for restoring key functions in the Kootenai River ecosystem, and important attributes of these options (cost, possible negative side effects, monitoring time required for detection of response, etc.); (2) evaluation of alternative plans for applying combinations of these options over the next few decades, so as to identify plans that offer opportunities for contrasting effects of each option along with prudent economic cost trajectories over time; and (3) review of key needs for improvement of monitoring programs so as to insure timely detection of intended immediate effects of each option as well as possible longer-term side effects.

Tables 10.3 and 10.4 describe the basic plan that emerged from the discussions as a clear consensus favorite among the participants. This plan aims to restore a range of critical ecosystem functions in the Kootenai River, through manipulation of productivity, habitat features, and seasonal flow regimes, while utilizing hatchery production systems as a backup to guard against extinction of species that are still declining. The critical components of this plan are (a) a fertilization program to restore basic productivity and carrying capacity for fish of the River, to near historical levels from the Montana border through the South Arm of Kootenay Lake; (b) experimental restoration of hard-bottom features in the river reach where sturgeon now spawn unsuccessfully; (c) experimental manipulation of sturgeon hatchery operations so as to test for possible competitive effects of hatchery releases on wild sturgeon survival and to determine optimum size and location of release for hatchery sturgeon juveniles; (d) development and testing of a plan "aquatic ecosystem management" hydrograph for Libby Dam releases, where this plan hydrograph involves both lower winter flows to provide a more natural ecosystem low-flow" "reset" feature (and more natural conditions for burbot spawning and migration) and also spring-summer peak flows to improve conditions for sturgeon spawning and also restore some sediment transport functions; and (e) opportunistic, small-scale experimentation with localized restoration of connections between the channelized river and its flood plain, in areas where such connections can be restored without serious impact to flood plain land users.

The experimental treatment sequence shown in Table 2 is not ideal from a scientific viewpoint, i.e., effects of fertilization/hydrograph modification options will be partly confounded in the first few years of application. Most options will be implemented as quickly as possible, so the experimental design is a reverse titration or "kitchen sink" structure. Considering response lags in key ecological variables (e.g. sturgeon recruitment), it should be possible to begin reviews of monitoring results after about five years, and these will likely lead to changes in the treatment sequence so as to more clearly separate effects that are confounded in the initial treatment results.

Table 10.3. Characteristics of proposed adaptive management plan activities and potential outcomes.

	River Fertilization	South Arm Fert. & Kokanee Introductions Tributary Enhancement	Hatchery Sturgeon / Burbot	Substrate Modification (Gravel/cobble additions over sand substrate, hydraulics)	Ecosystem Restoration Flows Winter Low, Spring Runoff Peaking, Sediment Augmentation	Flood Plain Reconnection
Target Benefit	Community, increased growth, survival, and biol. condition	Kokanee, burbot, sturgeon,	Addresses potential sturgeon reproductive stock limitation	Increase survival of eggs, larvae	Sturgeon recruitment, cottonwood recruitment, natural processes	Increased surv/growth of larvae, juv for sturgeon, increase productivity for comm.
Potential Negative Effects	Stimulation of non-target species.		Overstocking sturgeon could limiting wild production	Unintended hydraulic consequences	Seepage at higher flows, cooler water temperatures inhibit sturgeon spawning, reduced productivity in reservoir (not refilled)	
Required Time to See Effect	Periphyton =wks, invert=months, fish = 1-5 yrs,	Kokanee =1-3 yrs	Variable dep. on life stage and objective (e.g. 30 to det. spawn)	In-season detection of larvae, 2+ yrs to fully recruit to gill nets	Same as above	
Monitoring Requirements	All taxa responses in Kootenay Lake and lower Kootenai River	All taxa responses in Kootenay Lake	Ongoing	Better definition of spawning and egg deposition areas. Start at small-scale to work-out mechanics, spawning pref. studies	Same as above	Assess nutrient and habitat heterogeneity contribution
Small Scale	No	No	Yes for reduced sturgeon growth due to pot l overstocking	Yes	No	Yes
Pre-Implementation Steps	Mesocosm studies (completed)		Completed population modeling	Small-scale evaluation of predators	Evaluation of flow alteration results	Feasibility Assessments

Table 10.4. Draft 20-Year Multi-agency Adaptive Management Program Framework

	Aquatic							Riparian		Terrestrial		
Year	Kootenai River fertilization	South Arm Fert. and Kok. Introductions / Tributary Enhancement	Sturgeon Conservation Aquaculture	Burbot Conservation Aquaculture	Aquatic system Biomonitoring	Habitat creation , modification, or restoration	Ecosystem function restoration flows (winter low, spring runoff peaking, sediment augmentation)	Flood plain reconnection, wetlands restoration	Terracsosm studies	Terrestrial Invert. surveys	Vegetation surveys	Small mammal surveys
2004	Design	1	1	Evaluate	1	Assess	Hydrograph design	Local, small scale tests	Assess	Assess	1	Assess
2005	1	1	Evaluate	Evaluate	1	Evaluate	1+fry bioassay	as opportunities	Design	Contingent	1	Contingent
2006	1	1	1	Evaluate	1	1	1	arise	1	Contingent	1	Contingent
2007	1	1	Evaluate	Contingent	1	1	1	Including:	1	Contingent	c	Contingent
2008	Review	Review	1	Contingent	1	1	1	restoration,	1	Contingent	c	Contingent
2009	0	Contingent	Evaluate	Contingent	1	Review	1	side channel	Review	Contingent	c	Contingent
2010	0	Contingent	1	Contingent	1	Contingent	1	artificial spawning	Contingent	Contingent	c	Contingent
2011	0	Contingent	Evaluate	Contingent	1	Contingent	Review	channel construction	Contingent	Contingent	c	Contingent
2012	1	Contingent	1	Contingent	1	Contingent	Contingent	Contingent	Contingent	Contingent	c	Contingent
2013	1	Contingent	Evaluate	Contingent	1	Contingent	Contingent	Contingent	Contingent	Contingent	c	Contingent
2014	1	Contingent	Review	Contingent	1	Contingent	Contingent	Contingent	Contingent	Contingent	c	Contingent
.	Contingent	Contingent	Contingent	Contingent	Contingent	Contingent	Contingent	Contingent	Contingent	Contingent	c	Contingent
.	Contingent	Contingent	Contingent	Contingent	Contingent	Contingent	Contingent	Contingent	Contingent	Contingent	c	Contingent
2024	Contingent	Contingent	Contingent	Contingent	Contingent	Contingent	Contingent	Contingent	Contingent	Contingent	c	Contingent

1=Annual implementation and evaluation, 0=No annual implementation but evaluation, "c"=contingent

Aquatic Program Components

1. Kootenai River experimental fertilization – The controlled addition of limiting nutrients to artificially de-nutrified aquatic systems is a well established, rigorous, yet rapidly emerging scientific discipline, with nearly 30 years of empirical history (Stockner 2003). Beginning with North Arm Kootenay Lake fertilization in 1992, the Kootenay Lake system provides a good example of the successes of fertilizing artificially denitrified waters. For example, downstream from Libby and Duncan Dams, Kootenay Lake was experiencing declines in productivity (nutrient levels) and fish populations during the 1980s. In response to these declines, the BC Ministry of Environment and BC Hydro initiated an experimental program to fertilize the North Arm of Kootenay Lake in 1992. By 1998, kokanee numbers in Kootenay Lake had jumped over 800% to 25-30 million. Combined kokanee spawning runs to Meadow Creek Spawning Channel and the Lardeau River increased from 270,000 in 1991 to 2.2 million in 1998. There are currently 30 to 35 million kokanee in Kootenay Lake, due largely to the fertilization program and the presence of suitable kokanee spawning habitat, in the form of engineered habitat channels. The same ecological approach was applied to the South Arm of Kootenay Lake in 2004, and will be applied to the Kootenai River in Idaho, beginning in 2005. (Lead agencies: KTOI, IDFG).

2. South Arm experimental fertilization – Following up on the success of the North Arm Kootenay Lake fertilization program, a fertilization program began in the lake's South Arm to compensate for lost productivity and current ultraoligotrophy imposed by Libby Dam and the loss of the river's historical floodplain (Figures 1 and 2). (Lead agency: BC WLAP).

3. Tributary stream enhancements – High quality tributary stream habitat within the Kootenai River Subbasin are paramount for survival of native resident and adfluvial fishes, riparian biological communities, and their supporting taxa. Consistent with this understanding, several tributary habitat improvement projects supported by BPA and the Bonneville Environmental Foundation funding are ongoing. Project proponents recognize the need to assess and pursue the benefits of expanding the scopes and scales of these and related tributary habitat enhancement projects. (Cooperating agencies: KTOI, IDFG, MFWP, BCWLAP).

4. Conservation aquaculture, white sturgeon – Started in 1989, the white sturgeon conservation aquaculture program is providing reliable annual recruitment, representation of current wild fish genetic diversity for the next generations, and the demographic base to maximize benefits of future mainstem habitat improvements designed to benefit natural spawning and recruitment. Currently, the conservation aquaculture program is the only program successfully contributing to demographic and genetic preservation of this endangered population (Lead agency: KTOI).

5. Conservation aquaculture, burbot – Initial success of experimental burbot conservation aquaculture occurred during the first year (2004) of research to develop techniques and facilities capable of reliably rearing burbot in captivity. (Lead agency: KTOI). (See Section 4.5.1 of the Kootenai Subbasin Assessment for an update on this program.)

6. Aquatic biomonitoring – Agency, tribal, and academic scientists have produced an ongoing biomonitoring program that evaluates water quality, and algal, aquatic insect and fish productivity in the Kootenai River from Kootenay Lake upstream to Wardner, BC. This program has annually documented baseline ecological conditions in the Kootenai River since the mid-1990s, more rigorously during the past four years, and will be used to evaluate experimental river fertilization treatments, relative to prefertilization (baseline) conditions (Lead Agencies: KTOI, IDFG).

7. Habitat creation, modification, or restoration – In response to extensive artificial alteration of the Kootenai ecosystem, innovative sturgeon projects including gravel/cobble additions over sand substrate, hydraulic manipulation structures, and spawning habitat, spawning and early life rearing channels, and natural-engineered hatchery systems are being considered for reestablishment of vital ecosystem functions. An array of additional projects are being currently being assessed to provide benefit for other fish and wildlife communities and the river's required supporting ecological functions (Tables 1 and 2) (Lead Agencies: USACOE, USFWS; cooperating agencies: KTOI, IDFG, MFWP, BCWLAP).

8. Ecosystem restoration (normative) mainstem flows – (All agencies) Libby Dam operation for flood control and power production has reversed the natural (pre-dam) Kootenai River hydrograph and has significantly altered downstream thermographs and water quality parameter values. All collaborators in the lower Kootenai River Subbasin have a vested interest in providing a more natural or normative river downstream from Libby Dam for a variety of ecological, social, cultural, recreational, and economic reasons, while sharing a vested interest in avoiding negative affects on flood control and power production.

Appendix I-b.

NPCC Mainstem Amendments pertaining to Libby Dam

Spring reservoir/flow operations in general

• Refill should be a high priority for spring operations at Hungry Horse, Libby, Grand Coulee, and Dworshak dams so that the reservoirs have the maximum amount of water available during the summer. While on average the target date for refill should be late July for Libby and the end of June for the other projects, the system operators should work to adjust the actual refill date based on reservoir conditions and inflow forecasts.

• Incorporating the 2000 Biological Opinions of NOAA Fisheries and the U.S. Fish and Wildlife Service into this program includes the opinions' approach to spring water management in general, which the Council understands as operating the storage reservoirs to ensure a high probability of water surface elevations within one-half foot of the upper flood control rule curve by April 10 and to refill by June 30 (late July for Libby), otherwise passing the spring runoff through the storage reservoirs. The NOAA Fisheries biological opinion retains the flexibility to allow active flow augmentation to occur in the spring under certain circumstances at the call of the Technical Management Team. The Council calls on the federal agencies not to exercise this flexibility to allow for flow augmentation or additional reservoir drafting in the spring except under extraordinary circumstances and only after consultation with the Council.

Spring operations at Hungry Horse and Libby dams

• VARQ flood control operations and Integrated Rule Curve operations.

At Hungry Horse and Libby dams, continue to implement the VARQ flood control operation called for in the biological opinions and implement the Integrated Rule Curve operations as recommended by the Montana Department of Fish, Wildlife and Parks for the benefit of native resident fish in those reservoirs. Operations should reduce the frequency of refill failure (to within five feet of full pool) at Hungry Horse and Libby reservoirs as compared to historic operation. Implement seasonal flow windows and flow ramping rates in the Flathead and Kootenai rivers downstream of the storage reservoirs, and maintain minimum flows in the Flathead and Kootenai rivers as described by the U.S. Fish and Wildlife Service 2000 Biological Opinion and the Montana Department of Fish, Wildlife and Parks, including the sliding-scale flow strategy for bull trout specified by the biological opinion. Implement VARQ operations in an attempt to avoid the more extreme adverse effects at Grand Coulee that occur in a small percentage of years. The Corps of Engineers should consult with the Council to identify those occurrences and effects and to determine what might be done to minimize or avoid them, and report annually to the Council on VARQ implementation to show that these extreme adverse effects are not occurring. The Corps of Engineers should also place a priority on conducting the further comprehensive review of flood control operations called for in the NOAA Fisheries 2000 Biological Opinion.

• Operations at Libby Dam to benefit Kootenai River white sturgeon.

The U.S. Fish and Wildlife Service's 2000 Biological Opinion concerning hydrosystem operations that affect ESA-listed Kootenai River white sturgeon specifies a "tiered" strategy for flow augmentation from Libby Dam to simulate a natural spring freshet, controlled within flood constraints. Volumes are determined by forecasted water availability so that higher flows are released when ample water is available and minimal flow augmentation occurs during drought. The Council recommends that the average flow augmentation volumes outlined in Figure 1 be used as a guide for sturgeon operations at Libby Dam. These augmentation volumes are not specified volumes and should represent targets for planning purposes. Actual augmentation volumes in any given year will depend on flood control constraints, reservoir refill targets, water availability, and benefits to the Kootenai white sturgeon population. This strategy represents a refinement to volumes specified in the 2000 Biological Opinion.

Summer reservoir operations at Hungry Horse and Libby Dams

• Hungry Horse and Libby Dams:

1) Reduce the frequency of refill failure (to within five feet of full pool) as compared to historic operations; implement seasonal flow windows and flow ramping rates in the Flathead and Kootenai rivers downstream of the storage reservoirs and maintain minimum flows in the Flathead and Kootenai rivers as described by the U.S. Fish and Wildlife Service 2000 Biological Opinion and the Montana Department of Fish, Wildlife and Parks.

2) As an experiment, implement and evaluate an interim summer operation as follows:

- Summer reservoir drafting limits at Hungry Horse and Libby should be 10 feet from full pool by the end of September (elevations 3550 and 2449, respectively) in all years except the lowest 20th percentile water supply (drought years) when the draft could be increased to 20 feet from full pool by the end of September. This would protect fisheries resources in the reservoirs and rivers downstream, while providing additional flow augmentation for fish immediately below the project(s) and in the lower Columbia River.

- Draft each storage reservoir according to elevation limitations that, when combined with projected inflows, result in stable and "flat" or very gradually declining weekly average outflows from July through September. The Council understands that the effect of these operations and summer drafting limits would be to reduce the drafting of these two reservoirs in summer compared to what they would be under ordinary biological opinion operations. The Council believes there is significant flexibility within the biological opinions to implement this operation as an experiment. If there is disagreement on this, the Council calls on the federal operating agencies and federal fish and wildlife agencies to consult on the operation of these two projects in an effort to reach agreement that will allow this operation as an experiment. The agencies should also continue to investigate creative water management actions for summer flows, including what are known as the "Libby-Arrow" and "Libby-Duncan" swaps, although implementation of the summer operations experiment at Hungry Horse and Libby is not to be dependent on these actions.

- Little information exists about the relationship, if any, between levels of flow, flow augmentation and juvenile and adult salmon survival through the lower Columbia hydrosystem reach. Therefore, the focus of the experiment and evaluation to accompany the implementation of these summer operations at Hungry Horse and Libby should be on a) ascertaining the nature, extent of and reasons for a flow-survival relationship through the lower Columbia system, if any exists; b) determining whether flow augmentation from the upper Columbia storage projects has any effect on levels of survival; and c) determining the benefits to resident fish from this operation. The Corps of Engineers and the Bureau of Reclamation should consult with a team formed from the Council, the Independent Scientific Advisory Board, the Montana Department of Fish, Wildlife and Parks, the Confederated Salish-Kootenai Tribes, NOAA Fisheries and the U.S. Fish and Wildlife Service to design a proper experiment and evaluation of this nature to take place during the implementation of these operations. The Council's hypothesis is that the proposed operations will significantly benefit listed and non-listed resident fish in the reservoirs and in the portions of the rivers below the reservoirs without discernible effects on the survival of juvenile and adult anadromous fish when compared to ordinary operations under the biological opinions.

- As the federal operating agencies implement this operation, they should ensure there is no adverse biological impact on Lake Roosevelt fisheries due to changes in reservoir elevations or water retention times. The operating agencies should report annually to the Council on the nature and extent of impacts to Lake Roosevelt from this summer operation at Hungry Horse and Libby. The Council will analyze this information, and if the Council decides the impacts to Lake Roosevelt fisheries are unacceptably adverse, the Council will make additional recommendations on operations to the federal operating agencies.

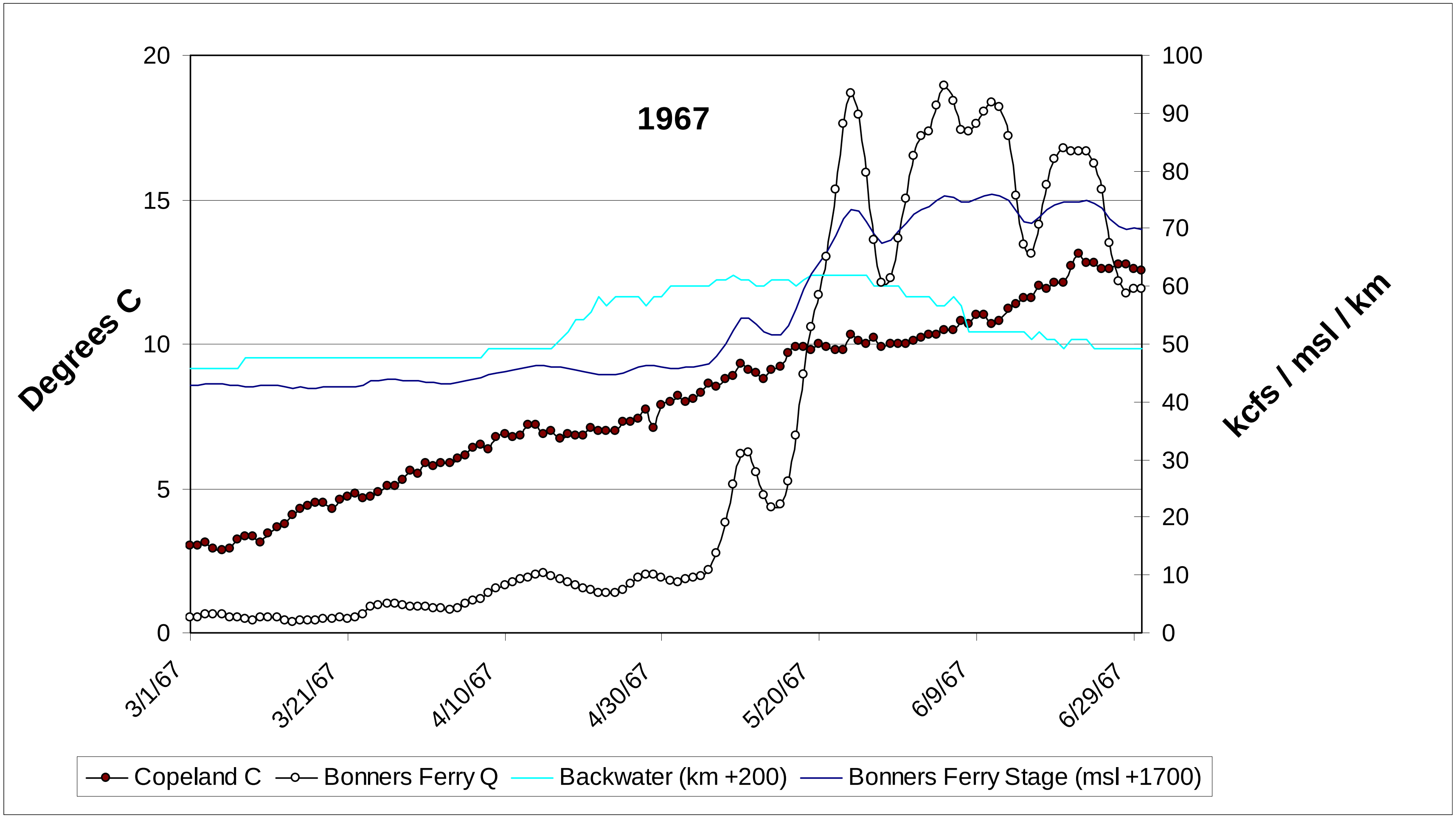
Appendix I-c.

Comparison of recommendations for spring and summer reservoir and river operation of the 2003 Northwest Power and Conservation Council's Mainstem Amendments and the Action Agencies UPA, confirmed in the 2004 NOAA Fisheries' Biological Opinion, at Libby Dam.

2003 NPPC Mainstem Amendments	2004 NOAA Fisheries Biological Opinion
• Refill should be a high priority for spring operations at Libby. While on average the target date for refill should be late July, the system operators should work to adjust the actual refill date based on reservoir conditions and inflow forecasts. Operations should reduce the frequency of refill failure (to within five feet of full pool) at Libby as compared to historic operation.	• Refill by about June 30 each year.
• "Tiered" strategy for flow augmentation from Libby Dam to simulate a natural spring freshet, controlled within flood constraints.	• Operate to provide tiered sturgeon volumes for spawning/recruitment.
• Additional work is required to further refine appropriate sturgeon operations at Libby Dam, and recommends that regional entities continue to work to increase the biological benefits provided by the flow augmentation volumes.	
• Summer reservoir drafting limits at Libby should be 10 feet from full pool by the end of September (elevation 2449) in all years except the lowest 20th percentile water supply (drought years) when the draft could be increased to 20 feet from full pool by the end of September.	• Draft to meet salmon flow objectives during July-August w/draft limit of 2439 ft. by August 31 unless modified to meet the mainstem amendment operation.
• Implement seasonal flow windows, flow ramping rates, and minimum flows in the Kootenai River, including the sliding scale flow strategy for bull trout specified by the biological opinion.	• Operate to provide bull trout minimum flows
• Draft each storage reservoir according to elevation limitations that, when combined with projected inflows, result in stable and "flat" or very gradually declining weekly average outflows from July through September.	• Provide even or gradually- declining flows during summer months (minimize double peak).
• The agencies should also continue to investigate creative water management actions for summer flows, including what are known as the "Libby-Arrow" and "Libby-Duncan" swaps, although implementation of the summer operations experiment at Libby is not to be dependent on these actions.	• Negotiate with Canada annually to try to implement a storage exchange.

Appendix II

Historic Kootenai River and Kootenay Lake conditions 1967 through 1974 during spring sturgeon spawning (April through June).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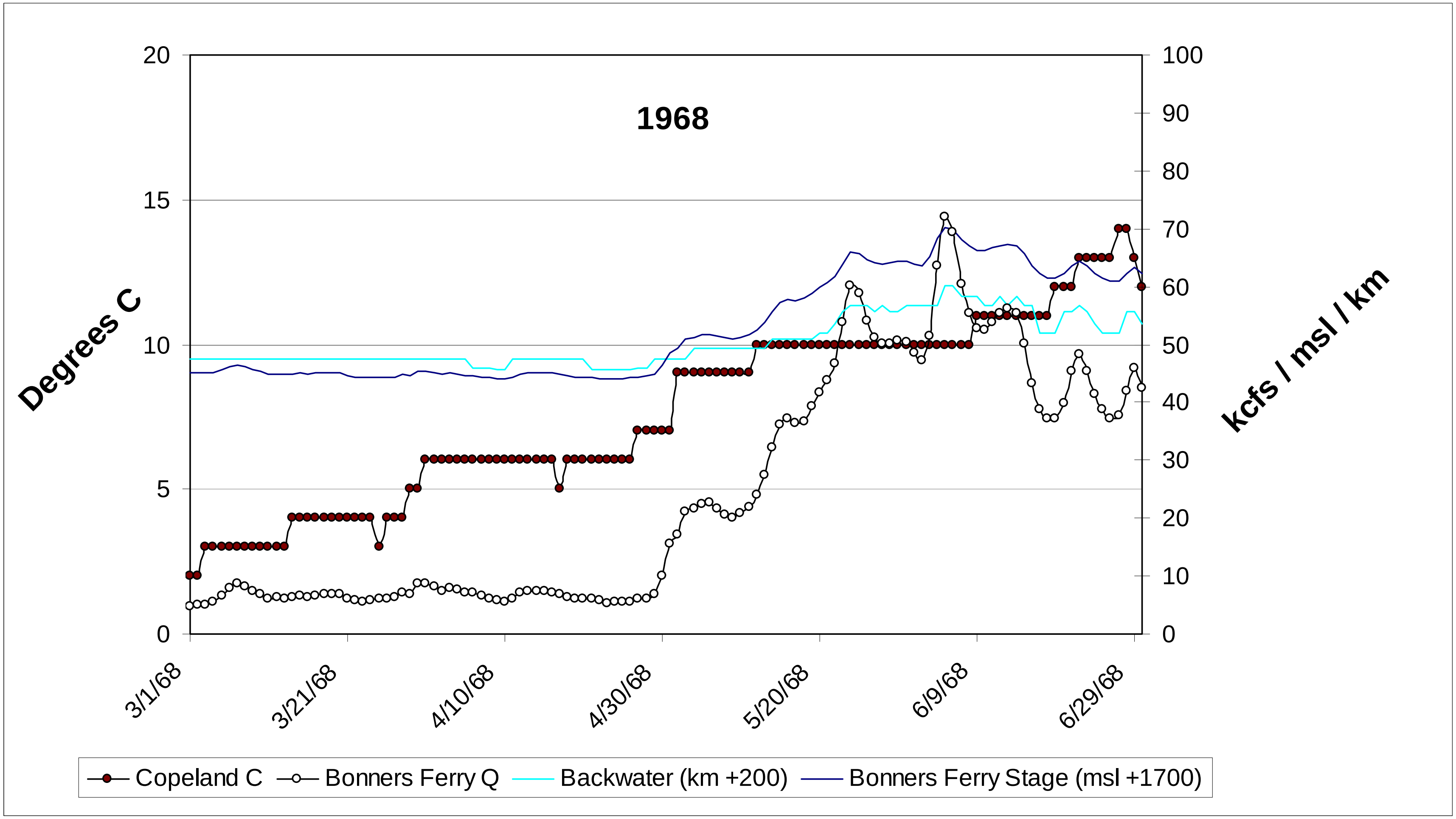
Bonners Ferry Q
Backwater (km +200)
Bonners Ferry Stage (msl +1700)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4/10/68
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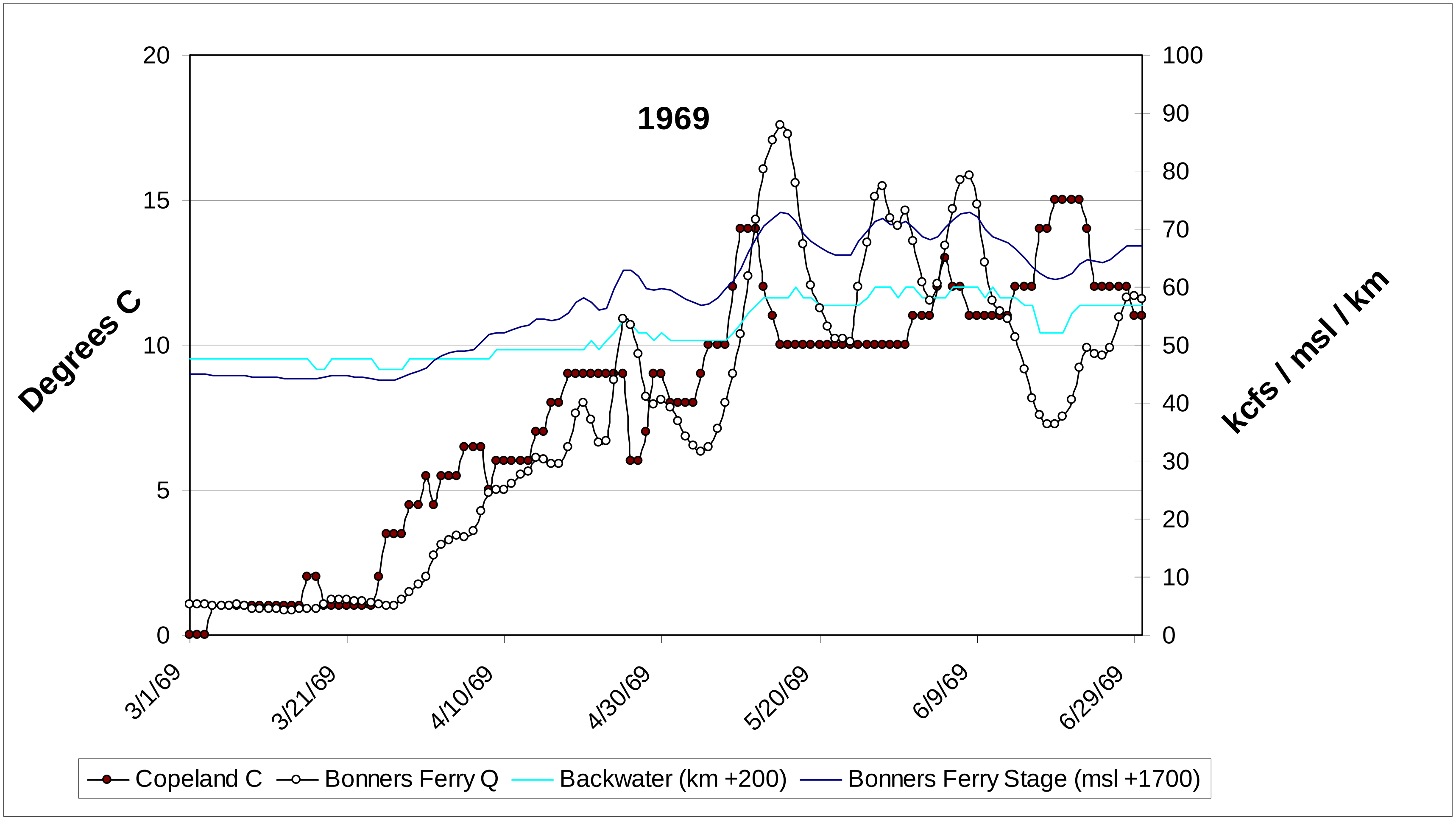
Copeland C
Bonners Ferry Q
Backwater (km +200)
Bonners Ferry Stage (msl +1700)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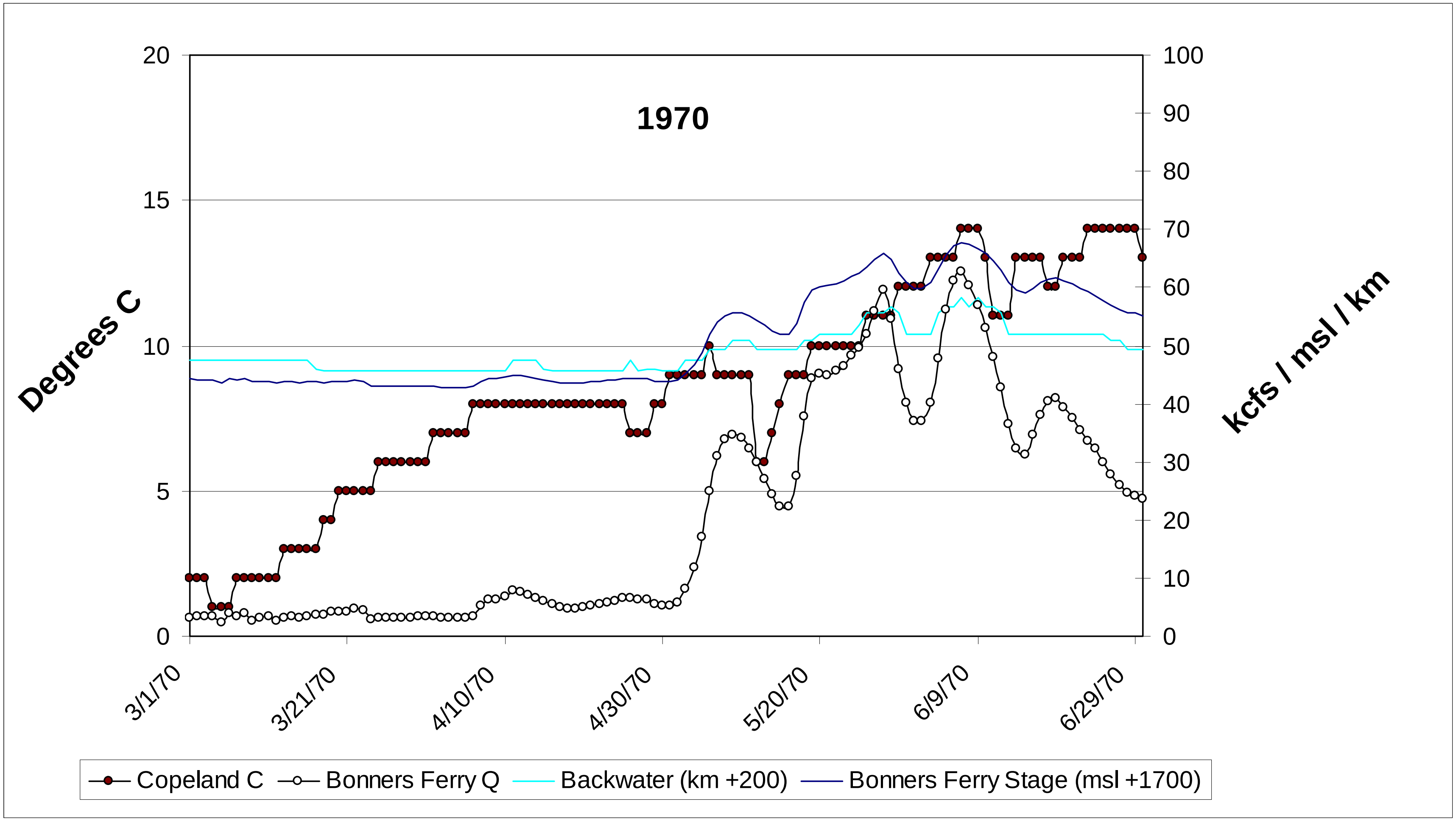
Backwater (km +200)
Bonners Ferry Stage (msl +1700)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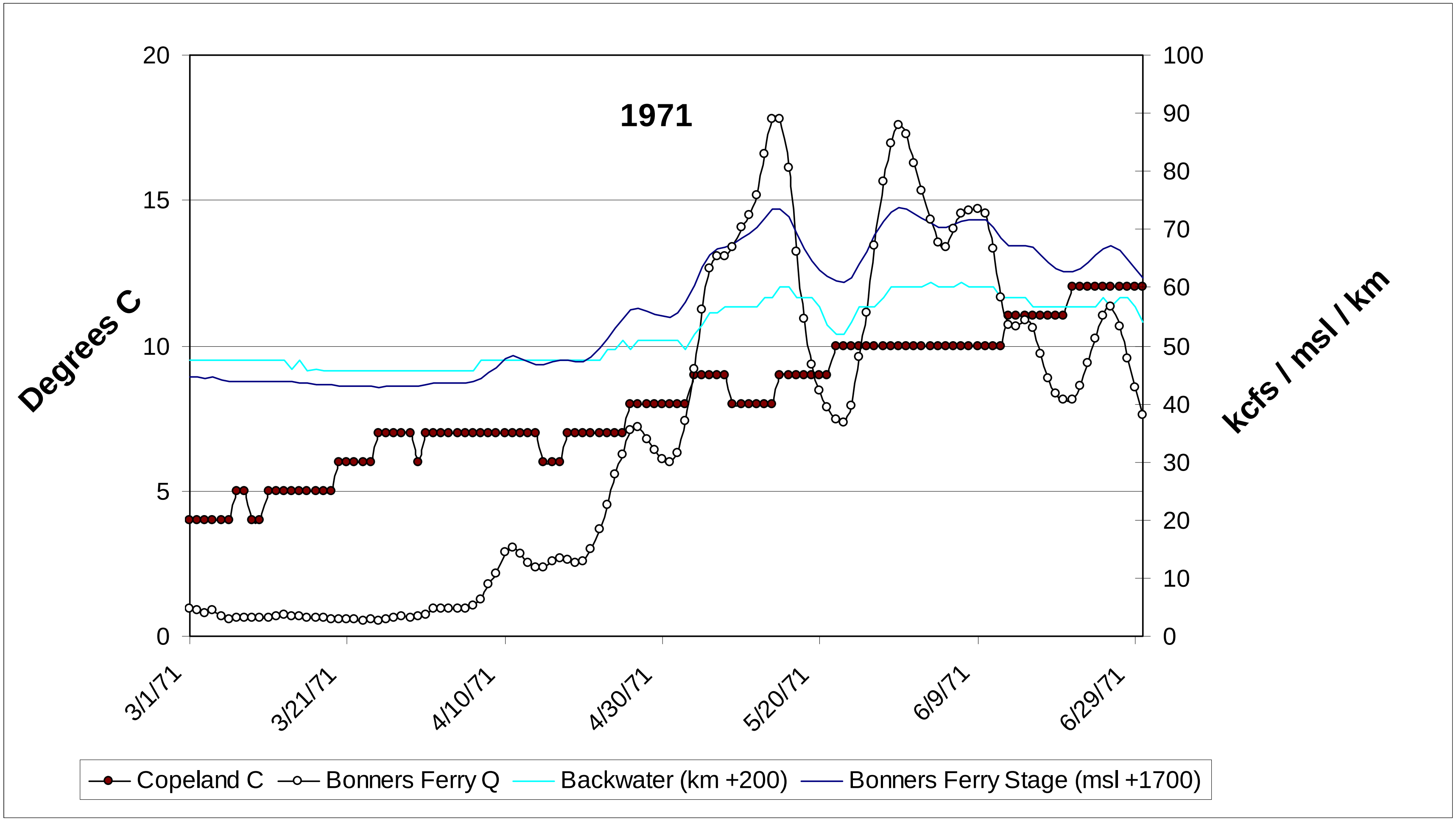
Copeland C
Bonners Ferry Q
Backwater (km +200)
Bonners Ferry Stage (msl +1700)



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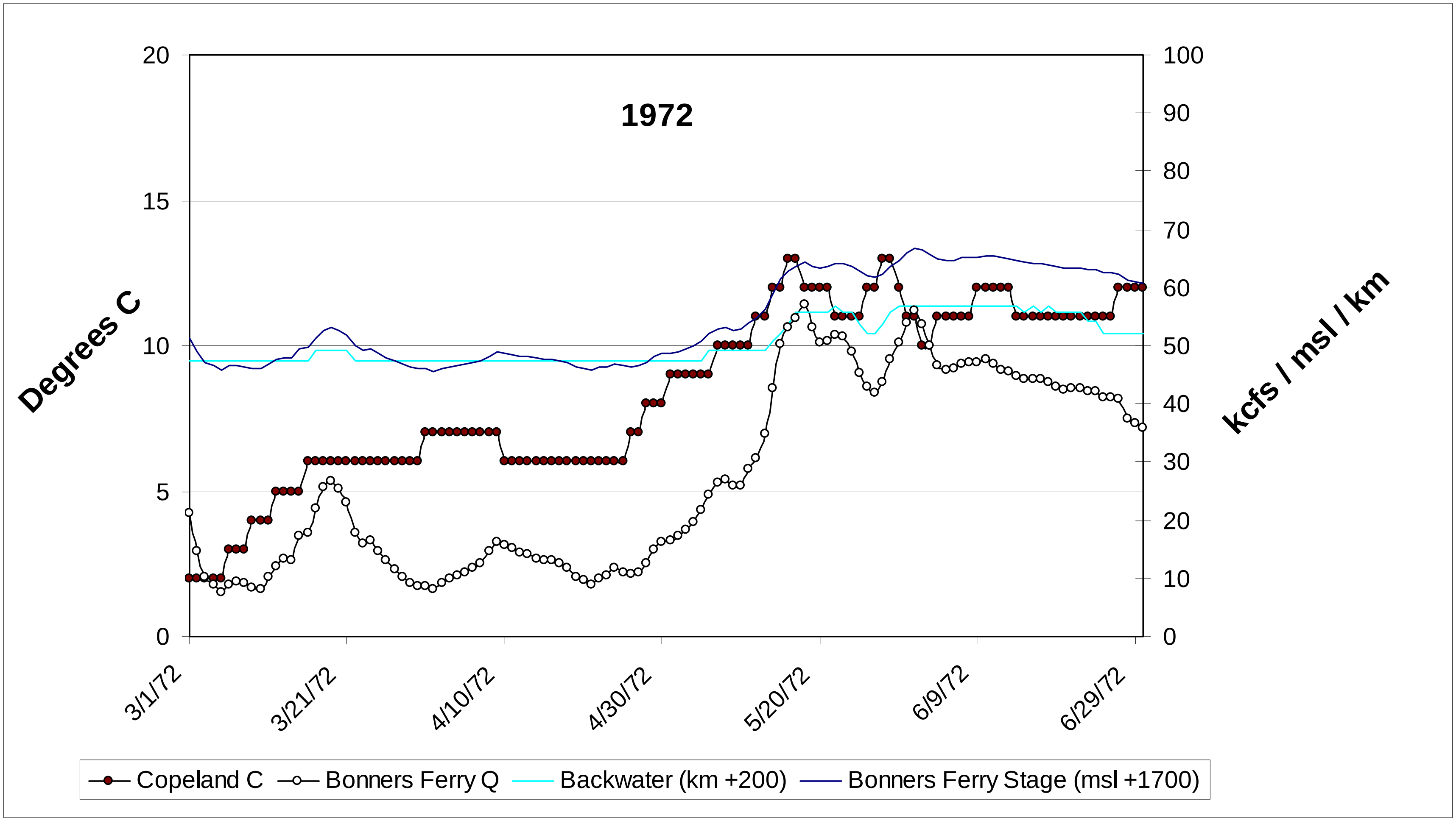
Copeland C
Bonners Ferry Q
Backwater (km +200)
Bonners Ferry Stage (msl +1700)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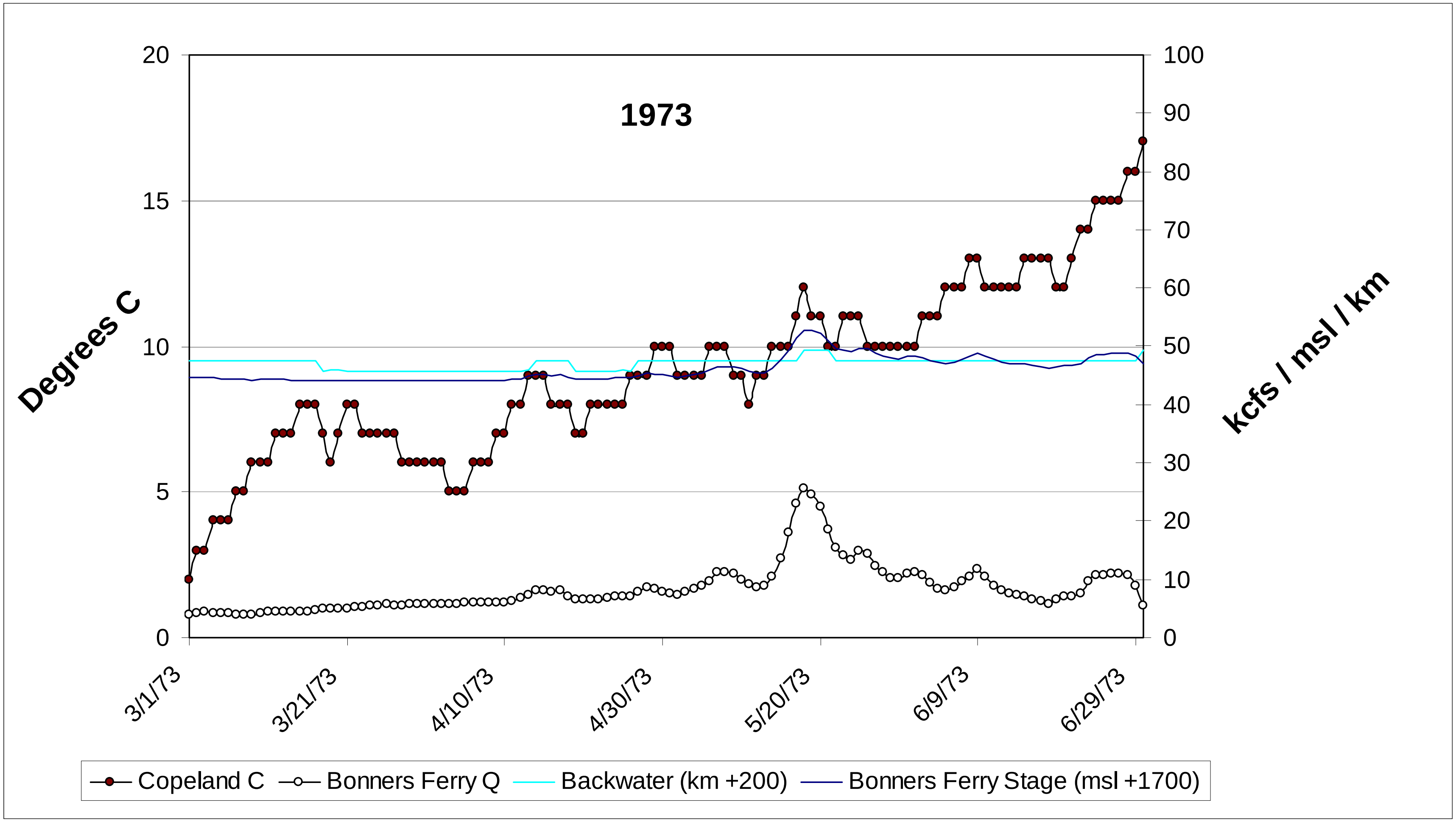
6/9/72
6/29/72
Copeland C
Bonners Ferry Q
Backwater (km +200)
Bonners Ferry Stage (msl +1700)



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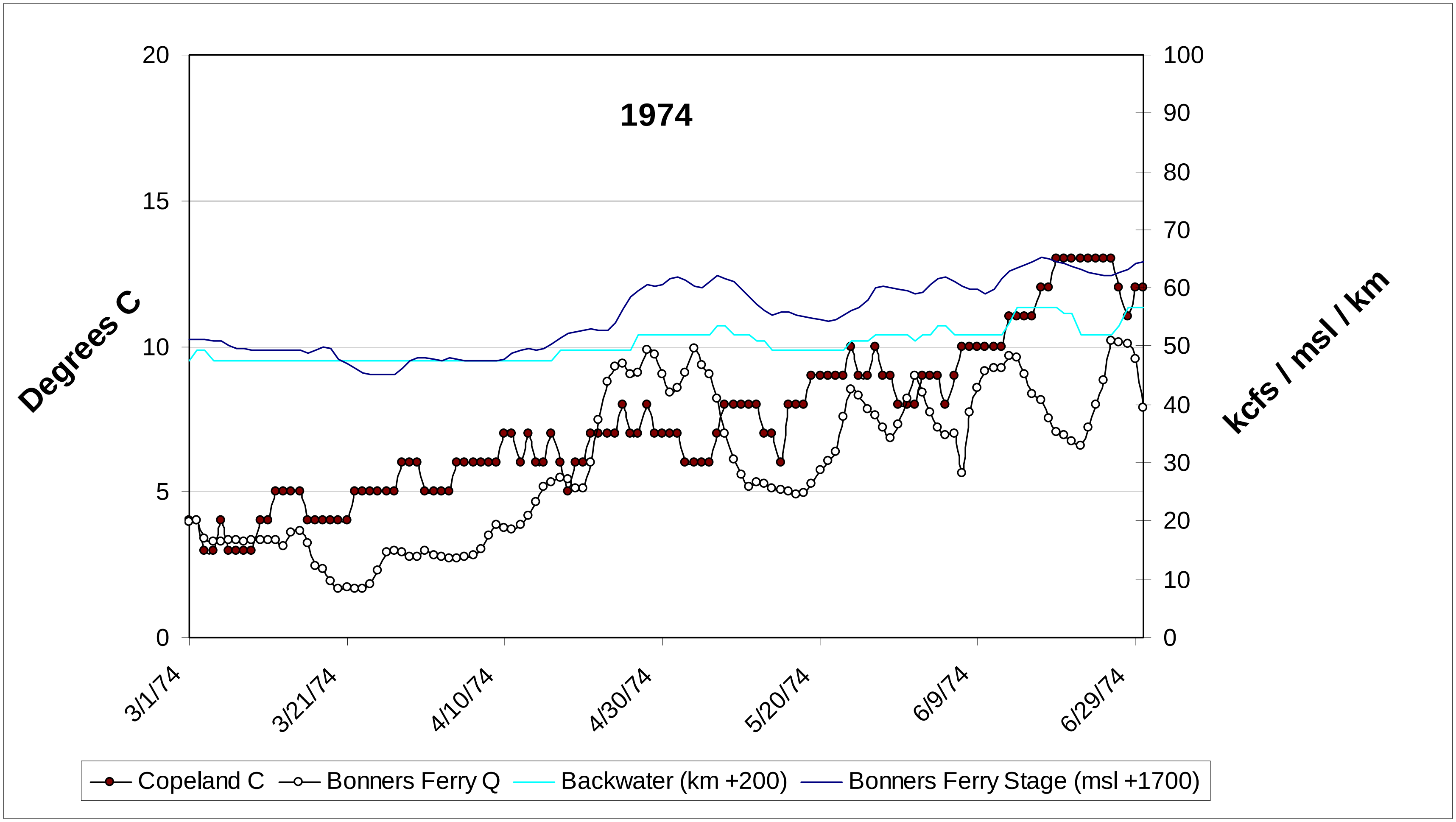
6/9/73
6/29/73
Copeland C
Bonners Ferry Q
Backwater (km +200)
Bonners Ferry Stage (msl +1700)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4/30/74
5/20/74
6/9/74
6/29/74
Copeland C
Bonners Ferry Q
Backwater (km +200)
Bonners Ferry Stage (msl +1700)