Response to ISRP Comments for Project 35044

Determine the Effects of Contaminants on White Sturgeon Reproduction and Parental Transfer of Contaminants to Embryos in the Columbia River Basin
Principal Investigator: Molly A.H. Webb

ISRP Comment: Give more convincing evidence from existing literature that contaminants and recruitment are geographically-linked.

The ISRP reviewer's stated that "one might suspect that the contaminant loading of the Columbia River basin would be the reverse (of recruitment), that is, more contaminants in the lower river than in the upper reaches". This is not the case for many contaminants, such as dioxins, furans, and heavy metals. Significant contamination of the upper Columbia River and the Kootenai River has occurred. The Columbia River system below Keenleyside Dam (B.C., Canada) receives effluent from two primary industrial facilities, Celgar Pulp Company and Cominco, and a number of municipal waste discharges. The Kootenai River has had significant contaminant loading as a result of mining, lumber and pulp production, and agriculture. A detailed description of the point-source discharges has been described by the Columbia River Integrated Environmental Monitoring Program (CRIEMP, 1994). Agriculture increases as one moves downstream in the Columbia River basin resulting in an increase in chlorinated pesticides that are not present in the upper reaches of the Columbia River (J. Beatty, pers. comm., Head of Environmental Assessment Section, Ministry of Water, Land and Air Protection, B.C.). PCBs appear to be ubiquitous throughout the basin, potentially a result of the presence of dams. Because of the persistent nature of these bioaccumulating contaminants, previous releases and spills result in their presence in the environment and food chain long after effluents meet water quality standards.

The ISRP's understanding of recruitment of white sturgeon throughout the basin is correct in that recruitment decreases in an upstream trend. Natural recruitment in the lower Columbia River (unimpounded section to McNary Dam) does occur. However, the upstream trend still applies to this section of the river (Beamesderfer et al., 1995). Recruitment is greatest in the unimpounded section of the river and decreases throughout the reservoirs. Within the reservoirs, recruitment is greater in Bonneville Reservoir which is greater than in The Dalles Reservoir which is greater than in John Day Reservoir (Beamesderfer et al., 1995). Recruitment in the middle Columbia River (McNary Dam to Grand Coulee Dam) and Kootenai River populations is poor to non-existent. Though a significant adult population exists between Grand Coulee and Keenleyside Dams (adult population resides in upper Lake Roosevelt and spawns in the Waneta area; two proposed sampling sites), natural recruitment has failed in this subpopulation.

The following are some specific details about each section of the river:

<u>Upper Columbia River (upstream of Grand Coulee Dam)</u>

Celgar Pulp Company began operations in 1961 and was the first bleached kraft mill in the interior of B.C. In 1989, Celgar announced its intention to replace the original bleached kraft

pulp mill with a new mill. From 1992 to 1994, various components of the new mill were brought into operation. During the CRIEMP sampling period (1991-1993), Celgar's effluent was acutely toxic to rainbow trout (CRIEMP, 1994). Chlorinated dioxins and furans, although not detectable in the water column, were present in sediments from all stations below Celgar at concentrations that exceeded the Sediment Quality Objectives established for the Columbia River (Butcher, 1992). The effluent of Celgar now meets the B.C. Ministry of Environment, Lands and Parks permit requirements and complies with federal dioxin and furan regulations.

Cominco has been operating since 1906 (MacDonald Environmental Sciences Ltd. 1997). This facility was a copper and gold smelter at the turn-of-the-century, and since the early 1990s, the metallurgical operation produces primarily zinc and lead. Over the past 25 years, the industry has initiated a long-term program to modernize and expand its operations at the Trail plant reducing the loading of metals into the Columbia River. However, elevated levels of trace metals have frequently exceeded the water quality standards for the Columbia River, and evaluation of the most recent data indicates that a number of water quality concerns still exist (MacDonald Environmental Sciences Ltd., 1997). Frequent accidental discharges of contaminants into the river have occurred. Between January 1987 and January 1993, there were a total of 56 spills from Cominco into the upper Columbia River. These spills released multiple tons of compounds containing sulphuric and phosphoric acid, zinc (various forms), gypsum, mercury, copper sulphate, ammonia, coal dust, furnace and compressor oils, sodium bisulphite, phosphate, ammonium sulphate, arsenic, cadmium oxide, chlorine, lead, slag, oxide dust, and various undetermined solutions. As well, studies conducted by the Department of Fisheries and Oceans have shown that slag released by Cominco was acutely toxic to five species of aquatic organisms, including rainbow trout (Nener, 1992). The toxicity of slag to white sturgeon has not been evaluated.

Contaminant loads in white sturgeon from the Canadian portion of the Columbia River are unknown due to a decision by B.C. Environment not to sacrifice sturgeon for contaminant analysis. Below Celgar, sediments have been found to contain dioxins and furans, and lake whitefish were found to have 0.007 and 0.010 ppb (wet weight) of total dioxins and 0.647 and 0.908 ppb (wet weight) of total furans in muscle tissue (Mah et al., 1989). In Lake Roosevelt, downstream of Celgar and Cominco, the Washington Department of Ecology found concentrations of 0.002 ppb dioxins and 0.147 ppb furans in muscle tissue of four white sturgeon (Johnson et al., 1991). The toxicity of dioxins and furans in this study was evaluated using a set of toxicity equivalency factors to convert concentrations of congeners to equivalent concentrations of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin. The toxicity equivalent (TEQ) for white sturgeon was 17 ppt. It was reported that TEQs of 1 to 65 ppt in fish tissue had effects ranging from increased activity of detoxifying liver enzymes to significant mortalities of eggs and fry (Johnson et al., 1991). In terms of TEQs in fish muscle, the highest concentrations have been found below Celgar to Lake Roosevelt (between Keenleyside and Grand Coulee Dams) (Serdar et al., 1991).

Kootenai River (Tributary of Columbia River)

Contaminant loading in the Kootenai River has occurred as a result of many activities, including hydroelectric development, mining, lumber and pulp production, and agriculture (Kootenai River Network, 2000). Poor water quality in the 1950s and 1960s from industrial and mine development most likely affected white sturgeon reproduction and recruitment prior to the completion of Libby Dam in 1974 (Graham, 1981). Detectable levels of heavy metals, PCBs, and chlorinated pesticides have been found in white sturgeon eggs (Apperson, 1991; Kruse, 2000). These results were described in the proposal.

Middle Columbia River (Grand Coulee Dam to McNary Dam)

There appears to be a trend of declining TEQs for dioxins and furans in fish muscle from Celgar to Priest Rapids Dam, with elevated TEQs found in McNary Reservoir (Serdar et al., 1991). Dioxin concentrations of 0.002 ppb were detected in white sturgeon fillets (Keenan et al., 1990) and 0.92-2.10 ppt in white sturgeon muscle (Beak Consultants Inc., 1989) in McNary Reservoir. The EPA report (EPA, 2002) discussed in the proposal revealed the highest concentrations of DDE in white sturgeon in the middle Columbia River (1.3-1.4 ppm in fillet). The PCB Arochlors 1254 and 1260 were highest in white sturgeon fillets from the Hanford Reach of the middle Columbia River (Arochlor 1254 0.17-0.21 ppm and Arochlor 1260 0.19-0.21 ppm) (EPA, 2002).

Lower Columbia River (McNary Dam to the Estuary)

Downstream of McNary Dam, reduced concentrations of dioxins and furans compared to the middle and upper Columbia River were found in fish muscle (Beak Consultants Inc., 1989; Serdar et al., 1991), though dioxin concentrations found in white sturgeon fillets and muscle from fish caught in Bonneville Reservoir were 1.09 ppt (Serdar et al., 1991) and non-detectable to 2.10 ppt in muscle (Beak Consultants Inc., 1989). Concentrations of dioxins and furans in fish muscle in the unimpounded section of the Columbia River were low to non-detectable (Beak Consultants Inc., 1989; Serdar et al., 1991), with dioxin concentrations in white sturgeon fillets found to be 0.09-0.12 ppt (Keenan et al., 1990) and non-detectable to 0.24 ppt in muscle (Beak Consultants Inc., 1989). Chlorinated pesticide and PCB concentrations in immature white sturgeon livers in the lower Columbia River were shown in the proposal (Figure 2). The concentrations of contaminants in immature white sturgeon gonad tissue collected in 2000 and 2001 in our study from the estuary to John Day Reservoir were as follows: 0.02-7.42 ppm DDE, 0.02-9.06 ppm total pesticides, and 0.00-0.79 ppm PCBs (White Sturgeon Contaminant & Reproductive Physiology Research Group, unpublished). Bosley and Gately (1991) reported concentrations of PCBs and pesticides in white sturgeon eggs for one female below Bonneville Reservoir (0.16 ppm PCBs, 0.07 ppm DDE) and one female in Bonneville Reservoir (1.45 ppm PCBs, 1.75 ppm DDE).

ISRP Question: Are the contaminant levels found in sturgeon within ranges believed to be biologically significant (for any species)?

The biological significance of contaminant levels in fish tissues has been a challenging question for researchers over the decades. Physiological response thresholds differ for a variety of species (Kime, 1998), and the duration of exposure to the toxicant appears to affect the

response threshold (Giesy et al., 2002). The response thresholds for sturgeon are unknown, though the long lives of sturgeon, their lack of movement between reservoirs, and their close association with the sediments increases their exposure time and rate to contaminants.

Little data exists with regard to contaminant concentrations in white sturgeon gonadal tissue in the Columbia River Basin (Table 1). Our results from the White Sturgeon Contaminant & Reproductive Physiology Research Group (WSCRPRG) suggest a link between contaminants, growth, and reproduction (Foster et al., 2001a and b; WSCRPRG, unpublished). The negative correlation between plasma androgens in immature males and liver DDE concentrations indicates endocrine disruption in wild white sturgeon in the Columbia River and may result in delayed maturity (Foster et al., 2001a and b).

Table 1. Contaminant concentrations in gonadal tissue of white sturgeon in the Columbia River Basin. Data are ranges of wet weight where more than one fish was sampled (ppm).

Site	PCBs	DDT	DDE
Below Bonneville Dam (eggs) (Bosley and Gately, 1991)	0.16	-	0.07
Bonneville Reservoir (eggs) (Bosley and Gately, 1981)	1.45	0.47	1.75
Lower Columbia (immature males and females) (WSCRPRG, unpublished)	0.00-0.79	0.00-0.610	0.02-7.42
Kootenai River (maturing females) (Kruse, 2000)	0.16-1.30	0.02-0.08	0.05-1.80

Based on work conducted with other fish species, the concentration range of PCBs and DDE (Table 1) and dioxins and furans (Table 2) detected in white sturgeon tissue is biologically significant. In charr, 5-75% mortality was reported in eggs with concentrations of 0.10-0.50 ppm PCBs and 0.04-0.17 ppm DDT derivatives (Monod, 1985). In flounder eggs with $\geq$ 0.12 ppm PCBs, viability was below 50%, and hatch success was below 50% among eggs from ovaries that contained 0.010-0.12 ppm PCBs and 0.003-0.092 ppm DDT (von Westernhagen et al., 1981). A 75% mortality rate in rainbow trout 30 days posthatch was reported for females that had PCB and DDT levels in eggs at 2.70 ppm and 0.09 ppm, respectively (Hogan and Brauhn, 1975). Cameron et al. (1988) reported mortalities of $\geq$ 50% among embryos of whiting that contained gonadal concentrations of 0.10-85.00 ppm of PCBs (lipid normalized) and up to 2 ppm DDE.

The data available for dioxins and furans in white sturgeon is muscle, fillet, or whole body concentrations (Table 2). In rainbow trout, Giesy et al. (2002) found the dietary lowest observable effect level for dioxin (2,3,7,8-tetrachlorodibenzo-*p*-dioxin) was 1.80 ppt which was equivalent to 0.043 ppt dioxin in muscle, 0.43 ppt dioxin in liver, and 1 ppt dioxin in whole body. The effects seen were increased mortality of adult female rainbow trout and decreased survival of eggs from females exposed to dioxin. Because of the higher lipid content of eggs compared to muscle or fillet, it is highly plausible that the concentration of dioxins and furans in white sturgeon eggs would be significantly higher than that detected in muscle or fillet. Lake trout eggs containing 0.23 ppb of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin had decreased hatch rate with the greatest mortality seen at the sac fry stage, and the lowest observable adverse effect level for mortality was 0.055 µg/kg egg (ppb) (Walker et al., 1991).

Table 2. Dioxin and furan concentrations (mean or ranges; ppt wet weight) in tissue of white sturgeon in the Columbia River Basin. Total dioxins and furans were reported in EPA (2002); ND=non-detectable.

Site / Tissue Type	Dioxins	Furans	Total Dioxins and Furans
Lake Roosevelt / Muscle (Johnson et al., 1991)	2.40	147.00	-
McNary Reservoir / Muscle (Beak Consultants Inc., 1989)	0.92-2.10	37.00-73.00	-
McNary Reservoir / Fillet (Keenan et al., 1990)	1.68	-	-
John Day Reservoir / Muscle (Beak Consultants Inc., 1989)	0.56-1.50	9.60-32.00	-
John Day Reservoir / Fillet (Keenan et al., 1990)	0.88	-	-
Bonneville Reservoir / Muscle (Beak Consultants Inc., 1989)	ND-2.10	19.00-60.00	-
Bonneville Reservoir / Fillet (Keenan et al., 1990)	1.09	-	-
Below Bonneville Dam / Muscle (Beak Consultants Inc., 1989)	0.22-0.28	2.60-3.70	-
Basin-Wide / Fillet (EPA, 2002)	-	-	20,000

Basin-Wide / Whole Body (EPA, 2002)	-	30,000

This information suggests that the concentrations of contaminants detected in sturgeon tissues are biologically relevant. The purpose of the proposed research is to determine the concentrations of these contaminants in sturgeon gametes at several sites throughout the basin and the effect of parentally derived contaminants on offspring viability. Due to the difficulties in examining cause-and-effect relations for a specific chemical in wild gametes because of the presence of other chemicals, the laboratory experiments described in Objective 5 will assess the impact of single contaminants and determine the response thresholds in white sturgeon embryos.

ISRP Question: How can we know that the site a fish is captured in and the toxin location are the same?

The dams have created functionally discrete populations of sturgeon (North et al. 1993). The stock assessments in the lower Columbia River have revealed that the majority of sturgeon in Zone 6 (Bonneville Reservoir, The Dalles Reservoir, John Day Reservoir) and McNary Reservoir have been recaptured in the reservoir in which they were originally marked (C. Kern, 2001 ODFW Annual Report for BPA Project 198605000, unpublished). Of 4,113 fish, 96.57% were recaptured in the same reservoir, 0.12% of the fish were recaptured in an upstream reservoir, and 3.31% of the fish were recaptured in a downstream reservoir. Based on this information, our assumption will be that fish captured in a given reservoir were spawned in that reservoir. Because sturgeon do move around a lot within the reservoir in which they reside, we will not be able to make conclusions at a finer scale than that of a specific reservoir.

In the upper Columbia River, little information is available regarding the percentage of fish that pass downstream through Keenleyside Dam or upstream through Grand Coulee Dam (samples collected from Lake Roosevelt and the Waneta area). There is a possibility that sturgeon may pass through Keenleyside Dam via a boat lock, however based on reports by lock operators, this appears to occur infrequently (UCRWSRMP, 2002).

Given the geographic isolation of the Kootenai River white sturgeon population, the contaminant information for this population will be reflective of Kootenay Lake to Libby Dam. Because of the old age of the Kootenai River sturgeon population and the completion date of Libby Dam (1974), the contaminant load in adults may still be reflective of pre-impoundment water quality and sediment conditions.

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