Stuart-Takla
Fish-Forestry Interaction Project




1990 – 2008

Introduction

The Stuart-Takla Fish-Forestry Interaction Project (STFFIP) was initiated in 1990 from the recognition that our knowledge of the interactions between forest harvesting and aquatic habitats was very limited for the interior of British Columbia. At the time, forestry guidelines and regulations for the protection of fish and fish habitat were largely based on research conducted in coastal watersheds. This research significantly improved both our scientific knowledge and our management capability for mitigating the effects of logging activities on aquatic habitats. However, there are significant differences in physical and biological aspects between coastal and interior watersheds that could affect the functional relationships between forestry and fisheries and their responses to logging disturbances. This uncertainty about the applicability of coastal forest management practices to interior forests was one of the primary driving forces behind the creation of the STFFIP.

Figure 1: General views of the landscape surrounding the STFFIP watersheds.

The STFFIP was sited in the northernmost watersheds of the Fraser River basin in north-central British Columbia. Initially, four similar salmon-bearing tributaries and their watersheds were selected for the study. These were subsequently complemented by the addition of headwater streams (bankfull width < 1.5 m) to the study. Small streams received little riparian buffer protection under British Columbia forest practices legislation and little was known about the ecological roles of headwater streams in British Columbia. Variable-retention riparian buffer strips had been used in the forest harvesting industry; however, their efficacy for maintaining natural stream and riparian functions had not been well documented.

As an interdisciplinary study, the STFFIP incorporated hydrology, forestry, fisheries science, and aquatic ecology expertise. Research activities included monitoring and assessment of stream and groundwater hydrology and thermal dynamics, streambed composition and mobilization, water quality, suspended sediment dynamics, local meteorology, incubation environments, predator-prey interactions, primary productivity, invertebrate production and patterns, large woody debris (LWD) surveys, and the distribution, movement, growth, and habitat use of resident and migratory salmonids.

Due to its multidisciplinary design, the STFFIP involved numerous researchers from various organizations including the Canadian Department of Fisheries and Oceans (lead agency), the B.C. Ministry of Forests and Range, the B.C. Ministry of Environment, Environment Canada, the Canadian Wildlife Service, the University of Northern British Columbia, the University of British Columbia, and Simon Fraser University. Collaboration of a forest industry partner (Canadian Forest Products Limited) was an important component of the study. The early involvement of the local First Nations bands in the STFFIP was also imperative. The study watersheds are part of the traditional territories of the Tl'azt'en Nation. Tl'azt'en band members, as well as members from other First Nations bands of the Carrier Sekani Tribal Council, were involved in many areas of the research.

Figure 2: One of the four main study streams of the STFFIP, together with spawning Sockeye salmon.

Figure 3: Logging operations in watersheds surrounding the Stuart-Takla area.

Study Site Description

The four spawning creeks (Bivouac, Forfar, Gluskie and O'Ne-ell Creeks) are fourth-order and arise in the Hogem Range of the Omineca Mountains within British Columbia's Sub-boreal Spruce (SBS) biogeoclimatic zone. They are tributary to the Stuart-Takla system, which comprises Takla, Trembleur and Stuart Lakes. The surrounding mature forests are comprised primarily of hybrid white spruce (*Picea glauca X engelmannii*), subalpine fir (*Abies lasiocarpa*) and lodgepole pine (*Pinus contorta*).

The study stream watersheds are largely undisturbed; Gluskie and Bivouac had minimal harvesting to control a beetle outbreak, and a logging road intersects each stream 500 to 1700 m upstream of their mouths. The four streams flow northeast into Takla Lake or its outflow, Middle River, at an elevation of 700 m. Watershed areas range from 36 to 75 km2 with main channel lengths of 15-20 km and stream bankfull widths of 9-15 m. The lower 3-4 km of the watersheds are low-gradient (0.5-2%), with large alluvial fans near their mouths.

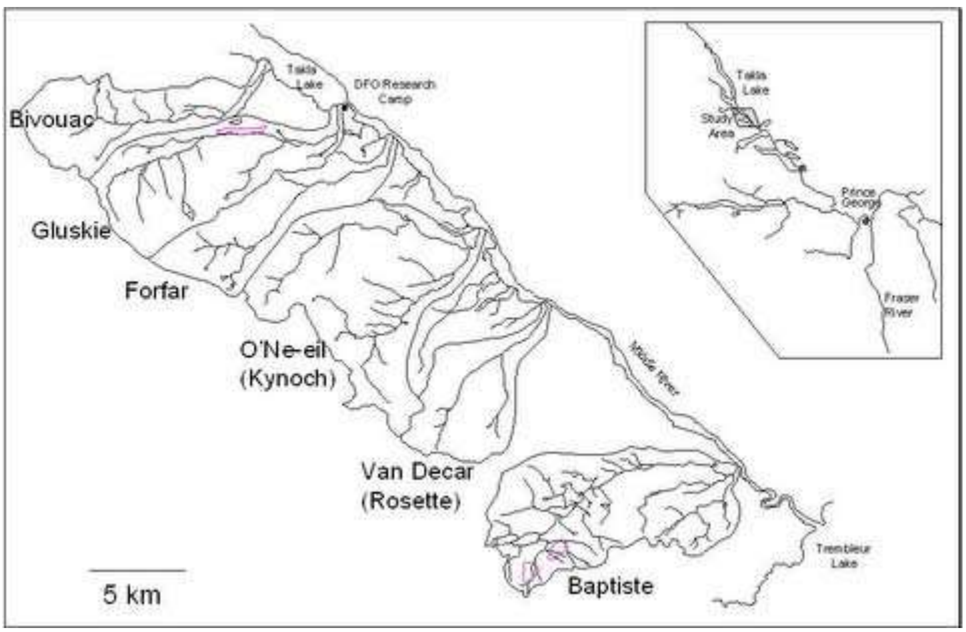

Figure 4: The general location of the study watersheds of the STFFIP.

The Stuart-Takla watershed supports both early- and late-run sockeye salmon (*Oncorhynchus nerka*), together with a distinct race of kokanee and other species of salmonids (e.g., lake, rainbow and bull trout, and whitefish) and non-salmonids (e.g., burbot, peamouth chub, pike minnow, sculpin and shiners).

The creeks are spawning grounds for Early Stuart sockeye salmon, which have the earliest river entry and one of the longest sockeye migrations runs in the Fraser River system. Stuart sockeye salmon enter the Fraser River in June and migrate ~ 1200 km in about 24 days to reach their spawning grounds.

Headwater studies were located in the upper watersheds of Baptiste and Gluskie Creeks at an elevation of approximately 900 m. Some of the Baptiste streams had rainbow trout in their lower reaches. Variable-retention riparian treatments were prescribed to test the efficacy of current British Columbia legislation that allowed for varying amounts of riparian retention as best management practices for the management of windthrow.

Figure 5: Small streams of the type monitored as part of the Baptiste Creek study.

Figure 6: Landscape of the Baptiste watershed following logging operations.

Study Design

For the spawning creeks, 1990-1994 were devoted to collecting baseline and pre-harvest data on natural physical, chemical and biological processes thought to be sensitive to forest harvesting effects. In the original study design, most streamside forest harvesting activities were to have been initiated in the autumn of 1994, with road building and logging in the Gluskie and O'Ne-ell watersheds. Logging was to have begun in the lower portions of each watershed, progressing upstream with time, and using Forfar Creek as a non-harvested control for the duration of the project.

Figure 7: DFO and First Nations personnel conducting sampling in the Stuart-Takla study streams.

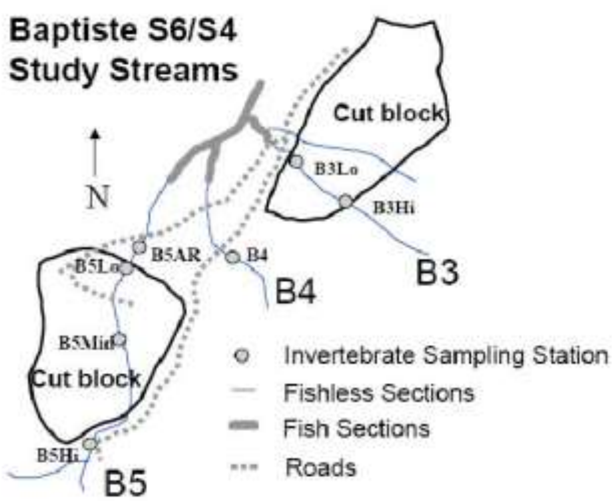

Figure 8: Map and general overview of the Baptiste study streams.

Figure 9: Riparian treatments at the Baptiste study site. The buffer strip in the foreground is the high retention treatment (B3 watershed), the buffer strip in the far cutblock is the low retention treatment (B5 watershed) and the unlogged section between the two cutblocks (upper side of road) is the control watershed (B4watershed). The photo looks west.

However, to date forest harvesting has been limited to small parts of the upper Gluskie Creek watershed and the lower O'Ne-ell Creek watershed. Economic changes in the forest industry in the mid-1990s and a re-distribution of local logging tenures from CanFor to the small business sector altered logging plans and the economics of harvesting in the watersheds. The Early Stuart sockeye also suffered a recent downturn in abundance that raised sensitivity to any extensive logging in the watersheds of these culturally and economically important sockeye salmon populations.

Nevertheless, the baseline data amassed is an invaluable assessment of the natural variations and functions of north-central salmon-bearing streams spawning many scientific publications, The STFFIP significantly improved our knowledge of the natural processes that make interior watersheds and aquatic ecosystems different from coastal systems. Baseline data collection for most parameters continued until 2000 and some hydrologic/climatic data are still collected.

For the headwater studies in the Baptiste and upper Gluskie watersheds, pre-harvest monitoring began in the fall of 1995, incorporating both temporal and spatial controls. Measurements included discharge, suspended sediment, stream and groundwater temperature, nutrients, invertebrates, and sediment geochemistry. Clearcut forest harvesting began in January 1997 using fellerbunchers. Variable-retention buffer strips (20 m wide) were left on the treatment streams. Depending on the parameter, up to four riparian treatments were investigated: clearcut, patchcut, low retention (all merchantable timber removed), and high retention (all timber > 30 cm dbh removed). Intensive post-harvesting monitoring continued until 2000 and some parameters continue to be measured.

Figure 10: Sampling for bedload transport and spawning sockeye salmon.

Summary of Main Findings

Salmon Spawning Creeks

Hydrology

- The hydrograph of the streams is snowmelt driven, with freshet occurring in the spring.
- The snow water equivalent at peak of snow accumulation was 51% higher in clearcuts relative to the adjacent forest.

Stream thermal dynamics

- The annual pattern of stream temperatures is typical of northern interior streams. Stream temperatures usually remain < 1° C from November to April, showing little diurnal variation. Summer stream temperatures are between 8 and 16° C with diurnal ranges of 1-4° C. Annual maximums occur during August when sockeye salmon enter and spawn in the study streams.

Stream morphology

- Each of the study streams has many distinctly different types of channels. The general progression is from downstream low-gradient (< 2%) channels characterized by pool-riffle morphologies to mid-stream pool-riffle-bar morphologies with gravel and cobble-sized bed materials, abundant Large Woody Debris (LWD), and gradients < 4% to steep (> 7%), narrow, and boulder-bedded upstream channels.
- The study streams are strongly influenced by in-stream LWD, which appears to control specific channel shapes, sediment patterns, and streamflow characteristics.


Figure 11: Sampling efforts in the Stuart-Takla study streams.


Figure 12: Sampling for invertebrates in the main study streams.

Suspended & gravel-stored sediments

- Suspended sediment concentration typically increases with increasing stream discharge in the study streams, with annual peaks in sediment concentrations occurring during the spring snowmelt.
- Fine-grained sediment in suspension moves not only as single-grained particles but also as aggregates of fines that are held together by physical, chemical, and biological forces. The aggregates have different settling properties than do individual clay and silt particles, and they can potentially be stored in channels, on the bed surface, and within the gravel matrix.

Riparian litterfall inputs, storage & processing

- Deciduous trees and shrubs within 5 m of the bank edge are the major sources of direct litterfall to the streams, while over 90% of the in-channel LWD is derived from the conifer overstorey.

Nutrients & periphyton accrual

- The nutrient levels in these interior streams are low relative to coastal systems. Periphyton productivity in the STFFIP streams is nutrient limited; increased periphyton accrual coincided with increased nitrogen and phosphorous levels derived from spawning salmon.

Figure 13: Winter sampling and measuring stream discharge

Figure 14: Low-level air photograph of O'Ne-ell Creek taken at an altitude of 100 m (left), together with a close-up view of large woody debris (right).

Invertebrates

- Insect drift in the study creeks is comprised primarily of dipterans, ephemeropterans, and plecopterans. Dipteran Chironomid larvae were the most predominant invertebrate during sockeye fry outmigration and constituted the majority of fry prey items.
- Insect drift density was highest in July, whereas the period of lowest density coincided with the highest water levels (May-June).

Sockeye salmon spawning, incubation & outmigration

- Adult sockeye escapements have fluctuated between 475 and 12530, 436 and 13200, and 713 and 17000 for Gluskie, Forfar, and O'Ne-ell Creeks, respectively, in the 1990s.
- Eggs hatch in November and the alevins reside in the intragravel environment until spring when thermal and hydrologic cues initiate an outmigration to Middle River and Takla Lake.
- Egg-to-fry survival averages about 30%, which is relatively high, indicating good incubation conditions.
- Spawner longitudinal distribution was not density dependent or limited spatially in any of the study streams. Overall, spawner distribution showed no general pattern relative to variations in-stream depths and velocities.

Figure 15: Spawning salmon in Forfar Creek

Spawning sockeye salmon contributions to bedload & sediment transport

- Activity of mass spawning salmon moved an average of almost half of the annual bedload yield. Spawning-generated changes in bed surface topography persisted from August through May, defining the bed surface morphology for most of the year. Hence, salmon-driven bedload transport can substantially influence total sediment transport rates, and alters typical alluvial reach morphology.
- The size composition of bedload materials collected during flood and winter events were similar, but samples of material collected during spawning were composed of larger material.

Figure 16: General view of one of the Baptiste study streams (left) and the installation of a weir (middle), together with sampling for invertebrates in the Stuart-Takla drainage (right).

Headwater Studies

Creek thermal dynamics

- Increases in stream temperatures (up to 5° C daily average) were related to the amount of merchantable timber retained within the buffer strip. A clearcut treatment had the largest effect, followed by patchcut, low-retention, and high-retention treatments. Seven years after harvesting, none of the treatments showed temporal recovery in stream temperatures. Initially, the high-retention treatment acted to mitigate the temperature effects of the harvesting, but 3 successive years of windthrow reduced canopy density, which caused subsequent temperature increases.
- Temperature recovery occurred in the treatment streams as they flowed back into a forested area.
- Downstream cooling of mean daily temperatures ranged up to 3.7° C 170 m within the recovery area.
- Road rights-of-way contributed to thermal increases; impacts were commensurate with right-of-way width.

Snowmelt discharge & suspended sediment

- An increase in peak snowmelt and total freshet discharge occurred in the second spring following harvest in both the high- and low-retention treatments and remained above predicted in all subsequent years.
- Suspended sediment also increased during freshet following harvest but returned to levels at or below pre-harvest predictions within 3 years.

Geochemical fingerprinting

- New sediment sources (in this case related to construction of logging roads and installation of culverts) changed the multi-element geochemical fingerprint of stream sediments even though the original stream sediment and the new sediment source are derived from the same or similar parent materials.

Figure 17: View of the steep, unstable cutbanks left after the removal of a culvert (site is located approximately 200m upstream of the B5 monitoring site), together with sediment from a road crossing being introduced into a stream following a rain storm.

Water chemistry

- Stream water chemistry changed in all treatments. Significant increases in total dissolved phosphorous (TDP) and nitrate (NO3) were observed, but similar increases in conductivity were not found. Lack of correlation with treatment type suggests that watershed-scale processes, and not riparian processes, are largely responsible for water chemistry changes.

Invertebrates

- At the top of a clearcut, exposure to UV radiation may have had an effect on invertebrates, while at the bottom of the clearcut, UV radiation had no observable impact immediately after harvesting. A 4 mg/L increase in dissolved organic carbon (DOC) between the top and bottom of the clearcut may have sufficiently shielded invertebrates from potentially deleterious effects of UV radiation.
- Long-term benthic invertebrate abundance and biomass changed in the high-retention buffer only. A response in the low-retention buffer may have been masked by high sedimentation in the first two post-harvest years.

Application of Results & Future Directions

In summary, at this time, there has been limited forest harvesting in spawning creek watersheds but the STFFIP has already significantly improved our knowledge of the natural processes that make interior watersheds and aquatic ecosystems different from coastal systems.

The STFFIP is also one of the first studies to begin looking at variable-retention riparian management on headwater streams. While offering some mitigation, variable-retention buffers do not appear to fully protect headwater streams from changes to thermal regimes, discharge, water chemistry, and invertebrate communities.

Although the science is of paramount importance, one of the great legacies of the STFFIP is the determination and effort of a diverse group of researchers and resource managers from universities, industry, government agencies, and the private sector to collaborate and address important resource management issues that affect all British Columbia stakeholders.