Instream Flow Needs for Atlantic salmon - A conceptual approach applied

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Background

The "Instream Flow Needs" framework is an important first principle in the setting of managed flow regimes throughout the world. The framework states that managed flow regimes should consider the natural hydrological variability of a river system, both seasonally and inter-annually, to maintain its ecological integrity.

While valiant, this framework is often in direct conflict with hydropower development and irrigation interests. Therefore, both regulatory agencies and developers are struggling to identify the elements of hydrological variability that are critical to maintain the ecological health of rivers.

Objective

The objective was to develop an idealised flow scenario for Atlantic salmon (*Salmo salar* L.) based on the natural flow paradigm concept.

Methods

Here, we describe flow requirements for different life stages of anadromous Atlantic salmon (Fig.1).

Fig. 1: Atlantic salmon life cycle.

We then explore the potential effects of different flow regime scenarios on a wild Atlantic salmon population, using Harry's River in Western Newfoundland as an example (Fig.2).

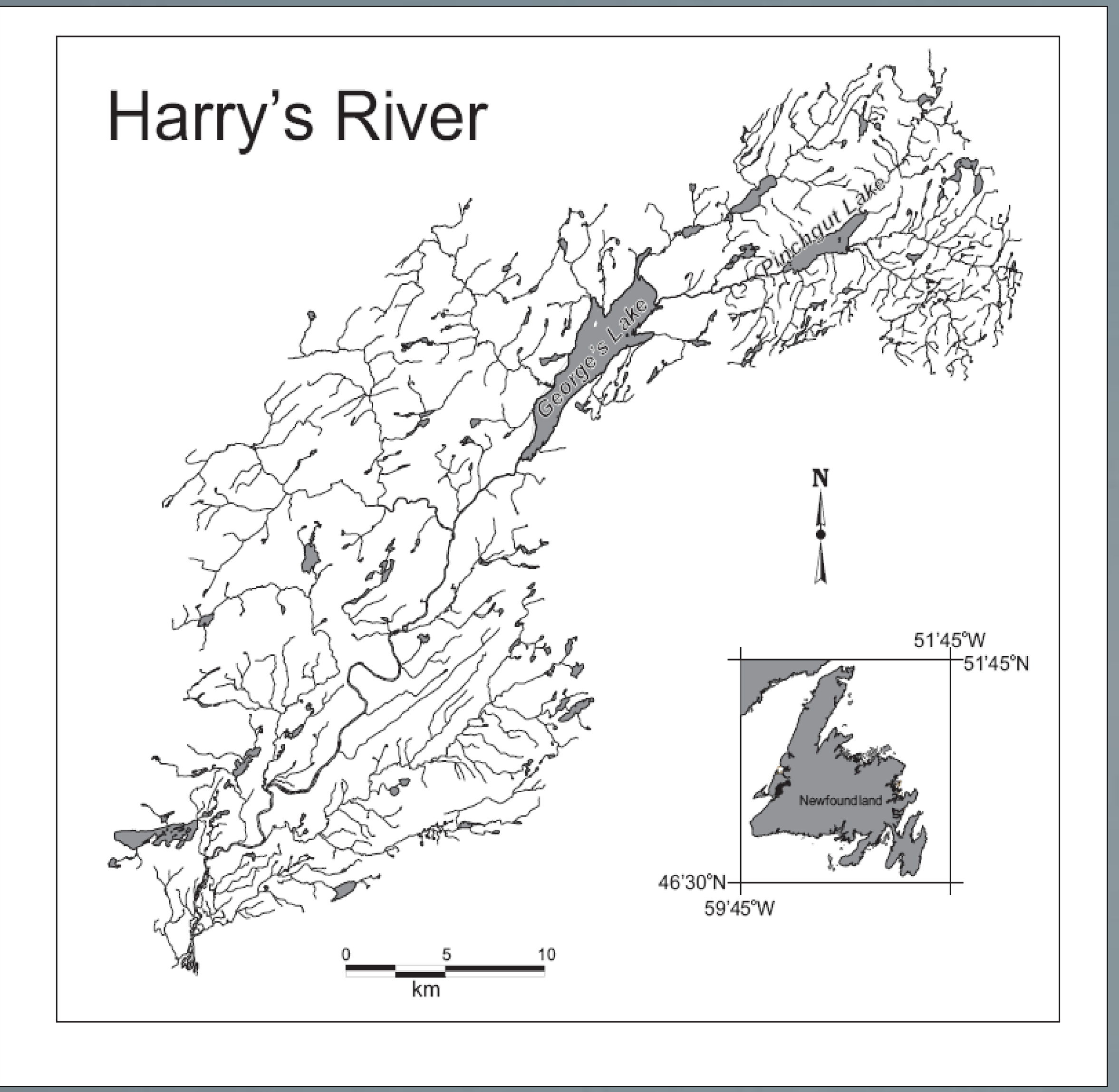

Fig. 2: Location of Harry's River in Western Newfoundland, Canada.

In the first scenario, we link the life history patterns of Atlantic salmon to the natural hydrological variability (Fig. 3), incorporating the flow requirements for migration, spawning and rearing.

In a second scenario, we present a flow regime managed for optimal hydropower production.

Finally, we propose a conceptual model for a hypothetical managed flow regime that provides the necessary hydrological flow variations to support the life history requirements of Atlantic salmon, while permitting flow regulation and modification.

Results

Freshwater flow requirements for six life of Atlantic salmon were identified (Tab.1): Phase 1 for egg and juvenile winter survival, Phase 2 for smolt and kelt downstream migration, Phase 3 for smolt and kelt ocean entry, Phase 4 for alevin emergence, Phase 5 for juvenile summer rearing and adult upstream migration, and Phase 6 adult spawning. The managed flow regime adapted to the requirements of all life stages. The flow adapted to hydropower uses 10% of the mean annual flow as per the agreement in Newfoundland. The comprise between fish conservation and power production combines aspects of both interests.

Phase	Flow condition	Life history stage	Timing
1	***Stable low flow conditions*** providing surface ice formation and limiting frazil and anchor ice formation	Incubation of ***eggs*** and overwintering of ***juveniles***.	Dec-Apr
2	***Rapid increase in flow*** (to mimic snow melt) that provides sufficient energy for sediment transport and channel maintenance	Initiation of downstream migration of ***smolts*** and ***kelts***	Apr-May
3	***Decreasing flow conditions*** after snow melt but releases of short, high flow events during night	Downstream migration of ***smolts*** and ***kelts***	May-Jun
4	***Slower decline*** in the hydrograph	Emergence of ***alevins***, arrival of ***smolts*** within 'smolt window'	Jun-Jul
5	***Stable summer flow*** with simulated spates that mimic natural events	Rearing and feeding of ***juveniles***, upstream migration of ***adults***.	Jul-Oct
6	***Flow increase*** and after spawning, followed by a ***decline in flow*** to overwintering flow levels	Spawning of ***adults.***	Oct-Dec

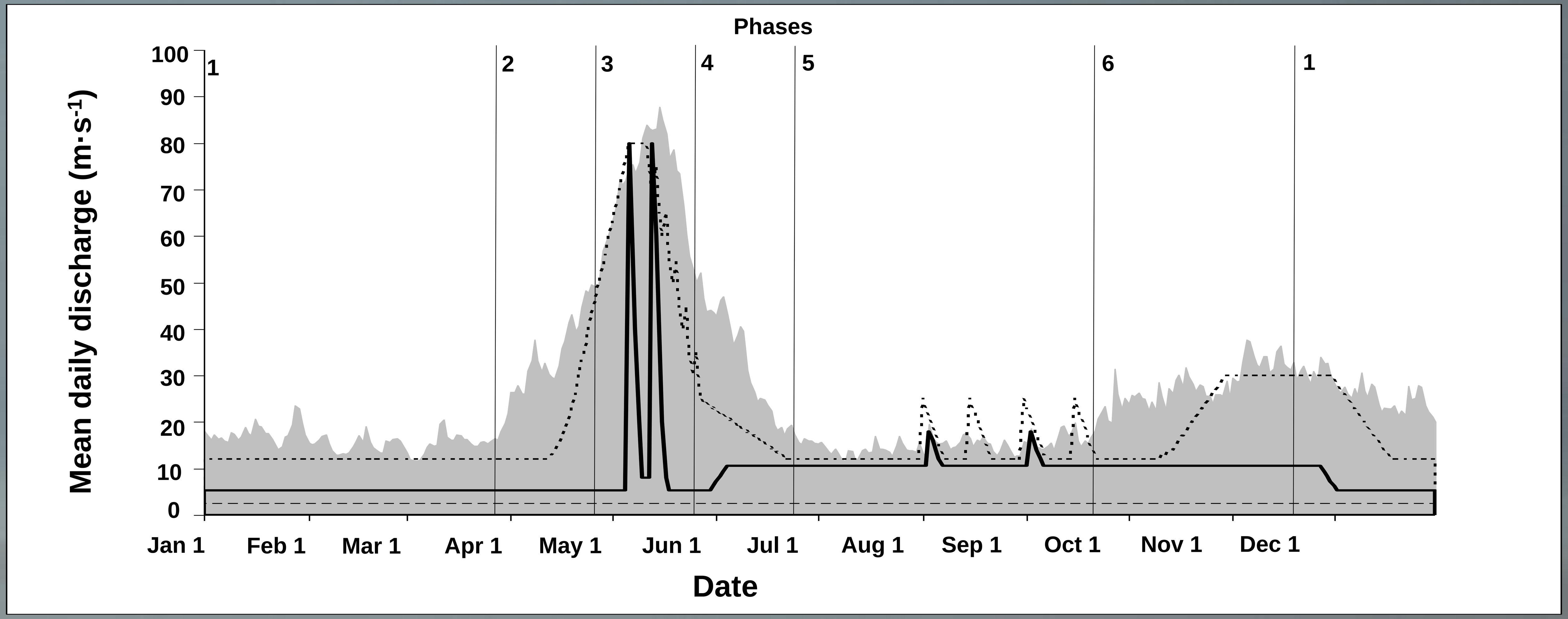

Figure 4. Mean daily flow in Harry's River, Newfoundland, Canada, in grey in the background. A theoretical managed flow regime conceptualized to fit the flow requirements of Atlantic salmon (dotted line), a managed flow from a hydropower perspective (dashed line), and a comprise between fish conservation and hydropower production (solid line).

Conclusions

This exercise identified that more information is needed on the amplitude of spring flooding necessary to initiate downstream migration while minimizing spill, which could potential be used for hydropower production.