Fisheries and Oceans Canada · Pêches et Océans Canada
Science · Sciences
National Capital Region
Canadian Science Advisory Secretariat
Science Advisory Report 2013/017

FRAMEWORK FOR ASSESSING THE ECOLOGICAL FLOW REQUIREMENTS TO SUPPORT FISHERIES IN CANADA

Figure 1: Map of the various DFO Regions in Canada.

Context:

Freshwater resources are under increasing threat from anthropogenic activities, and the increasing societal demands for water have led to incremental flow alterations to rivers and streams in Canada (Figure 1). Water extraction and flow alteration can impact physical attributes of rivers and cause ecological changes which can impact Canadian fisheries resources.

To better manage fisheries resources in a sustainable fashion, the Department's Ecosystem and Fisheries Management Sector requested scientific support and guidance on science-based tools for assessing impacts of flow alteration on fisheries to aid their understanding of the various methodologies, and to inform decision-makers and Canadians in their understanding of potential trade-offs of various management scenarios.

The purpose of this report is to provide technical guidance to Fisheries and Oceans Canada (DFO) managers and decision-makers to:

1) *Distinguish between and comment on the use of potentially conflicting terminology;*
2) *Summarize and evaluate the current flow assessment methodologies and approaches;*
3) *Examine methodologies used in various jurisdictions in Canada;*
4) *Propose a general framework for the assessment of ecological flow requirements for fisheries in Canada.*

Fisheries, including the ecological communities on which they depend, have adapted to the inherent natural variability of riverine ecosystems (the "natural flow regime") in which they reside. Significantly large alterations to river flow have a high probability of negatively impacting the ecosystem supporting these fisheries. In order to sustain fisheries dependant on these aquatic ecosystems, these ecological linkages with river flow must also be recognized and managed.

Particular challenges to providing this guidance in the Canadian context include (i) the broad diversity of riverine ecosystems, (ii) limited access to many riverine sites for thorough assessment, and (iii) data limitations in many situations. Given these challenges, a variety of Canadian and international experts reviewed the scientific literature, and a general framework for the technical assessment of ecological flows for fisheries was formulated. The scientific advice herein focuses on the management of discrete, definable alterations to river flow.

This Science Advisory Report is from the Fisheries and Oceans Canada, Canadian Science Advisory Secretariat (CSAS) peer review of a Standardized Framework for the Assessment of Instream Flow Needs in Canada, March 6-8, 2012. The scope of this document has been refined and certain terms amended to reflect recent amendments to the Fisheries Act (Bill C-38, June 2012). Additional publications from this process will be posted as they become available on the DFO Science Advisory Schedule.

SUMMARY

- Riverine ecosystems support many fisheries for which the Department has a regulatory mandate, including recreational, commercial or Aboriginal (CRA) fisheries. Examples of fisheries dependant on the natural flow regime include (but are not limited to) many high profile fisheries, including Atlantic Salmon, six species of Pacific Salmon, Atlantic and Lake Sturgeon, Arctic Char, American Eel, Shad and Gaspareau or Alewife, Dolly Varden, Sea Trout, etc.
- This scientific review specifically examined the “ecological flow requirements to support fisheries”. This Science Advisory Report (SAR) provides advice on the management of “the flow regimes and water levels required to maintain the ecological functions that sustain fisheries associated with that water body and its habitat”.
- The scope of this framework is for application of the *Fisheries Act* and intended to guide the assessment of ecological flows required to sustain a *fishery* (recreational, commercial, or Aboriginal), including potential future fisheries.
- *The scientific literature supports natural flow regimes as essential to sustaining the health of riverine ecosystems and the fisheries dependant on them. Riverine ecosystems and the fisheries they sustain are placed at increasing risk with increasing alteration of natural flow regimes.*
- The probability of degradation to ecosystems sustaining fisheries increases with increasing alteration to the natural flow conditions. Thus, the assessment of alterations to the flow regime should be considered in a cumulative sense, and not only on a project-by-project basis.
    - Cumulative flow alterations <10% in amplitude of the actual (instantaneous) flow in the river relative to a “natural flow regime” have a low probability of detectable impacts to ecosystems that support commercial, recreational or Aboriginal fisheries. Such projects can be assessed with “desktop” methodologies.
    - Cumulative flow alterations that result in instantaneous flows < 30% of the mean annual discharge (MAD) have a heightened risk of impacts to fisheries.
- For cumulative water use >10% of instantaneous discharge or that results in flows < 30% of the mean annual discharge (MAD), a more rigorous level of assessment is recommended to evaluate potential impacts on ecosystem functions which support fisheries. For the purposes of this science advice, and as a basis to assess the impacts of flow alteration on fisheries, a minimum of 20 years of river flow data is recommended to establish the “natural flow regime”. These data can be obtained from analysis of the:

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  - **Unaltered condition**
  - **Current condition** (use existing technical guidance from various jurisdictions where this exists)

- A "natural flow regime" can be defined as *a flow regime that is only affected by the variability in hydrological inputs and outputs (precipitation, evaporation) and natural water storage (such as groundwater) and for which the response in terms of amplitude, timing, duration and frequency of events is unaltered by human impacts.*
- If the "natural flow regime" must be calculated with hydrologic modeling, it is recommended that data with the finest available time-scale be used. For most situations, this will be daily discharge data but in special circumstances (e.g. hydroelectric projects) hourly data may be preferred.
- A floor value or 'cut-off limit' should be part of the overall prescription to conserve and protect fisheries, and should not simply be considered during low flow events. Some jurisdictions in Canada currently have established methodologies to specify this 'cut-off limit'. In general, the development of such policy guidance is encouraged (refer to Linnansaari *et al.* 2013 for further information on various Canadian jurisdictions).
- Given the inherent uncertainty in many of the ecological flow methodologies described, the use of adaptive management based on long-term and follow-up monitoring (a process based on the Before/After/Control/Impact experimental design) with multiple control locations is recommended.
- The science of assessment of ecological flows for fisheries is still evolving. It is recommended that the scientific guidance in this document be periodically revisited in order to ensure that it reflects current scientific knowledge (i.e. 5 years).
- Given the uncertainty around key relationships between flow and aquatic resources, further scientific investigation of the ecosystem-scale changes that affect fisheries subject to flow alteration is recommended. The objective of this research should be to define ecological flow assessment criteria to better inform both fisheries management decisions and policy and guidance development.

BACKGROUND

Riverine ecosystems support many fisheries for which the Department has a management and regulatory mandate, including potential future fisheries. Some examples of important CRA fisheries dependant on the natural flow regime include many high profile species such as Atlantic Salmon, six species of Pacific Salmon (Sockeye, Chinook, Coho, Chum, Pink and Steelhead), riverine char (Arctic Charr, Dolly Varden, Bull Char), American Eel, Atlantic and Lake Sturgeon, Sea Trout, Shad and Gaspareau (Alewife) and Eulachon (non-exhaustive compilation).

Many riverine ecosystems are under increasing threat from anthropogenic activities, both in terms of consumptive (e.g. irrigation) and non-consumptive (e.g. hydroelectric) uses. Increasing societal demands for water have led to substantial flow alterations of rivers in Canada. Such flow alteration can be directly linked to impacts on the physical attributes of rivers and cause subsequent ecological changes. In addition to the increasing demands for water, the ecological, social and cultural values of rivers are increasingly being recognized. With many competing needs for water, there is a need to develop guidelines for the assessment of ecological flow requirements for fisheries in Canada.

This framework for the assessment of ecological flow requirements for fisheries should be accompanied by a well-designed monitoring program, which can allow the periodic refinement of such guidance on assessment methods using an adaptive management process.

ANALYSIS

Terminology:

The science of flow management for the sustainable management of natural ecosystems is complex, as is the technical language used to describe the underlying concepts. The terminology used in environmental flow assessment literature is also variable, and includes terms such as "instream flow needs", "environmental flows", and “ecological flows”. To provide clarity towards the fisheries management obligations of DFO, some of the most commonly used terms were discussed, and a consensus definition suitable for fisheries management purposes in Canada is provided.

For a more comprehensive treatment of the various terminologies, including references and citations, the reader is referred to the accompanying Research Document (Linnansaari *et al.* 2013).

Instream Flow Needs – “The amount of water needed in a stream to adequately provide for instream uses within the stream channel" (i.e., for aquatic organisms and riverine processes).

Environmental Flow: "Environmental flow describes the quantity, quality and timing of water flows required to sustain freshwater ecosystems and the human livelihoods and well-being that depend on these ecosystems" (after the Brisbane Declaration, 2007).

Ecological Flow Needs: “The flows and water levels required in a water body to sustain the ecological function of the flora and fauna and habitat processes present within that water body and its margins”.

Base Flow is defined as "That part of the stream discharge that is sustained primarily from groundwater discharge. It is not attributable to direct runoff from precipitation or melting snow." Base flow is a hydrological term, and should not be confused or substituted for ecologically-based flow recommendations to support sustainable fisheries in Canada.

The current scientific review considered these terms within the context of the regulatory and management responsibilities of DFO. The relevant aspects of the above-noted terms were discussed, and a new definition is provided to guide the assessment of ecological flows required to sustain a fishery (recreational, commercial or Aboriginal), including potential future fisheries. Therefore, ecological flows are required to maintain the structure and function of a riverine ecosystem supporting these fisheries. The importance of ecosystem structure and function are fully recognized within this definition; however, a more fisheries-focused definition was sought by DFO managers, and is thus provided below:

Ecological flow requirements for fisheries: “*the flow regimes and water levels required to maintain the ecological functions that sustain fisheries associated with that water body and its habitat*”.

Assessment Methodologies – Recommended Application:

The techniques for the assessment of the ecological flow requirements for fisheries were classified into four general types; hydrological, hydraulic rating, habitat simulation and holistic methodologies and frameworks (Table 1). The Research Document accompanying this report comprehensively reviews the benefits, weaknesses and suggested uses for these various methods (Linnansaari *et al.* 2013).

The four general assessment (methodological) categories differ drastically both in their scope and associated implementation costs and therefore, are suited for different *levels* of assessment of ecological flows for fisheries. It is important to note that most assessment methods are not based on robust relationships between the extent of flow alteration and ecological response across the full spectrum of ecological conditions. All assessment methods can provide a technical basis for informed decision-making, but no single assessment method can be prescribed as being sufficient for all situations. The holistic methods and frameworks (wherein a combination of methods may be used) are increasingly common, especially in large scale projects, and are similar to comprehensive, large-scale environmental assessments.

Methodologies for the assessment of ecological flows for fisheries should be consistent and compatible with broader-scale ecosystem assessments to allow the potential inclusion in such 'holistic' methods (e.g. Ecological Limits of Hydrologic Alteration (ELOHA). Please refer to Linnansaari *et al.* 2013 for a complete description of this and other assessment methodologies.

Table 1: Summary of the major categories of methodologies for the assessment of ecological requirements of fisheries in Canada (after Linnansaari et al. *2013):*

Method Category	General purpose	Scale	Scope	Additional comments, including suggested uses:
Hydrological	Examination of historic flow data to find flow levels that naturally occur in a river and can be considered "safe" thresholds or within the range of natural variability patterns for flow alteration.	Whole rivers, applicable for regional-scale assessments.	Mainly based on discharge data.	Useful for situations where the potential risk of impact to aquatic resources is low. Regionalization techniques can allow the transfer of data from gauged to un-gauged systems. A “percent flow” method assumes the availability of data from a gauged reference system. Data may be available from Environment Canada (HYDAT) for use with hydrologic methods.
Hydraulic rating	Examination of change in a hydraulic variable, e.g. “wetted width”, as a function of discharge. The change in this examined variable is a proxy for the general quantity of fish habitat in a river.	Applied at a study site / river segment scale, up-scaling to whole river level based on the assumption of availability of "representative” sites. Methodology is river specific.	Based on physical (hydraulic) characteristics. Some consideration of biological characteristics.	Hydraulic methods can be effectively used to validate other statistical analyses (primarily for periods of low flow). Hydraulic relationships can work well for site-specific, individual stream sections (over a range of discharges). However, these relationships can vary (often widely) between sample sites or transects on the same river (even sites in close proximity) necessitating examination of multiple transects for each river segment studied.
Habitat simulation modelling (HSM)	Examination of change in the amount of physical habitat based on selected variables and target species, as a function of discharge.	Applied at a study site (micro) / river segment scale (meso), upscaling to whole river level based on the assumption of availability of "representative sites". River-specific.	Detailed assessment.	More indicative of assumed habitat use (by species or guilds) than necessarily reflective of actual habitat quality. Useful for identifying trade-offs in physical habitat over a range of flows. Habitat quality reported using this method is a function of sample size and spatial and temporal scales associated with data collected. Meso-habitat or generalized statistical modelling can be used to reduce costs and field work from more comprehensive habitat simulation modelling. In order for HSM methods to be biologically meaningful, habitat managers / scientists skilled in the use of these methods and with experience reviewing and conducting instream flow assessments should be involved in HSM design, data collection, and analysis. Selected study site(s) should be generally demonstrated as being representative of habitat, and hydraulics for the reach being assessed or for the particular fishery resource of interest.
’Holistic’ frameworks	Examination of flows based on multiple data inputs including expert opinion, leading to recommendations of flow regimes for all components of the riverine ecosystem. May include consideration of socio-economic objectives.	Whole rivers, applicable for regional or river specific scales	Flexible.	Useful to examine overall ecosystem function. Broad-scale, often comparable to environmental assessments in scope and content. These methods are often multi-disciplinary in nature and may require the use of experts for each riverine element/component being assessed. As such, conducting these studies may be beyond the ability of most fisheries managers to conduct by themselves.

Strengths and Weaknesses of Various Methodologies:

These four categories of methodologies differ considerably, based on both their intended use and the management objectives of the river or stream being assessed. In general, hydrological and hydraulic rating categories of assessment assume that a reduction in water availability will also reduce available physical habitat and impair ecosystem function. Habitat simulation techniques assess a range of flows at which the ecosystem structure and function can be sustained (including beyond this range). For holistic frameworks, the environmental flow regime is designed to meet management goals; often the altered flow regime emulates the variability in the natural hydrograph for the riverine ecosystem being assessed. Tables 2-5 summarize the strengths and weaknesses of these major assessment categories to better guide practitioners in their use and application for managing the ecological flow requirements for fisheries.

From an ecosystem perspective, the ‘holistic’ methods are the most comprehensive and best suited to the overall consideration of the broad range of species and ecological relationships and processes. However, from a strictly fisheries management objective, these ‘holistic’ methods are very comprehensive, often requiring large amounts of data that may not be readily available, and may require a considerable amount of time and money to collect and interpret this data. As such, ‘holistic’ methods have been likened to a detailed environmental assessment, considering a wide range of environmental factors. While comprehensive in their assessment and consideration of a broad range of environmental and socio-economic factors, ‘holistic’ methods may be more applicable to a detailed environmental review, where appropriate.

Table 2: Summary of the general strengths and weaknesses of Hydrological Methods (after Linnansaari et al. *2013).*

Strengths	Weaknesses
Can provide a simple, quick and relatively inexpensive way to display information on threshold flow levels.	Riverine ecosystems are inherently complex, thus the use of simplified hydrological statistics can lead to flow thresholds or recommendations which may be overly simplistic and not address trade-offs to aquatic resources over a range of flows.
May not require any additional fieldwork and can make use of existing (or proxy) flow data	Not recommended for studies requiring a high level of detail or precision in the prescribed limits.
Can be used for "low risk" situations (e.g. project is located upstream of fish bearing waters or where the perceived risk of negatively impacting habitat or species appears low).	Limited integration of ecological data which results in high uncertainty of hydrology-ecology relationship(s) and the potential consequence of a proposed hydrologic alteration. Cannot quantify trade-offs between flow and ecological response.
Can be used as a benchmark or lower threshold where habitat-based needs for specific ecological functions that require higher flow levels are identified by other methods	Prescribing a standard "percent of a given flow" can lead to a uniform, stable (i.e. flat-lined) environmental flow regime, not typical of natural flow variability often observed in most systems. Such environmental flow regimes may lead to biological degradation and simplification of habitats and biological communities over time. It should be noted that there has been an evolution from simple threshold definitions (i.e. magnitude), to the "natural flow paradigm" approach in which the management goal is maintenance of the many natural or historic characteristics of the hydrograph (amplitude, timing, frequency, duration, variability, etc.).

Table 3: Summary of the general strengths and weaknesses of Hydraulic Assessment Methods (after Linnansaari et al. *2013).*

Strengths	Weaknesses
Requires some field work and data collection to derive relationships between flow and specified hydraulic variables (e.g. wetted perimeter, depth, average velocity)	Not recommended as the sole method for studies requiring a high level of detail or which pose significant ecological risk.
Can be used for "low risk" situations when insufficient data exists for the river/site being assessed.	Difficult to implement with representative transects, and braided channels. Difficult to identify appropriate transects at which to collect data. The number of transects used should be commensurate with the hydraulic diversity of the river/site being assessed, but should be no less than three.
Can be used as an increased safety measure or a benchmark with other methods	Criticized for lack of direct relationship with ecological processes and inability to quantify trade-offs between flow and ecological consequence. Unsuitable for use as a single method when assessing situations which have high uncertainty for hydrology-ecology relationship
Inexpensive but river specific	Can lead to stable (i.e. uniform, "flat-lined" flow recommendations) environmental flow regime, which in turn may lead to degradation over time. Addressing intra- and inter-annual flow needs is essential for maintaining the form and function of most rivers; care should be taken when selecting appropriate hydrological indices.

Table 4: Summary of the general strengths and weaknesses of Habitat Simulation Methods (after Linnansaari et al. *2013).*

Strengths	Weaknesses
Assess one aspect of riverine ecology (i.e. quantity of habitat) to changes in flow for selected species.	Considerable amount of field work & expertise required; time consuming & relatively expensive.
Can address river-specific issues in high-risk situations	Considerable modeling assumptions are made, not always validated and uncertainty is not often expressly communicated.
Can provide a better spatial estimate of the potential impact of the project, when compared with hydrological/hydraulic methods.	Misapplication of the results is reportedly common; a change in amount of habitat is often interpreted as having a similar change in fish abundance or other target organisms. While a relationship does exist, it is often unique to each river and segment, with limited transferability.
Can provide accurate estimates of flow regimes required to maintain physical integrity of habitat in river segments (i.e., wetted area, depth, discharge and water velocity within that area).	May lead to uniform, stable (“flat-lined”) prescriptions for the ecological flows required for fisheries since the models do not address flow regime needs for other biological functions aside from habitat needs, or for other riverine components like water quality, fluvial geomorphology, and connectivity.
The resulting habitat-discharge relationship can be used as a negotiating tool (i.e. to calculate compensation requirements).	Criticized for lack of ecological specificity and uncertainty for habitat vs. species abundance relationship.

Table 5: Summary of the general strengths and weaknesses of the “holistic” methods or frameworks (after Linnansaari et al. *2013).*

Strengths	Weaknesses
All-encompassing in terms of physical, chemical, and biological variables examined.	Can be labour intensive, time-consuming (e.g. 3-5 years or more), and relatively expensive. Often require an interdisciplinary team to collect and analyze all needed information.
Flow alteration prescriptions are based on ecological considerations	Reliance on expert opinion for some components of “holistic” methods, although this is viewed as a strength by some. Properly designed, can quantify trade-offs for the evaluation of alternative management scenarios.
Can use multiple inputs, including the use of other assessment methods	Consensus building in a multi-faceted process which may be more costly and/or time-consuming; however, once agreement is attained it is a feature that adds credibility to the studies and the overall process.
Each additional element included in an analysis adds incremental information and understanding.	Each additional element included in an analysis adds additional uncertainty.

Framework for Assessing the Ecological Flow Requirements for Fisheries in Canada:

Science supports the view that natural flow regimes are essential for sustaining fisheries and the ecosystem structure and function which supports them.

The probability of effects to riverine ecosystems, and subsequently the fisheries that depend on these ecosystems, increases with increasing alteration to the natural flow regime. For

Canadian rivers and streams, the expert consensus is that cumulative flow alterations of less than +/- 10% of the magnitude of actual (instantaneous) flow in the river relative to a "natural flow regime" have a low probability of detectable negative impacts to ecosystems including those that support CRA fisheries (see Figure 2). This assessment of alterations to the flow regime should be considered in a cumulative sense, and not only on a project-by-project basis. For fisheries in ecosystems subjected to levels of cumulative water extraction or augmentation of greater than 10% of instantaneous flows, a rigorous level of assessment is required to evaluate potential impacts on ecosystem structure and function that support fisheries.

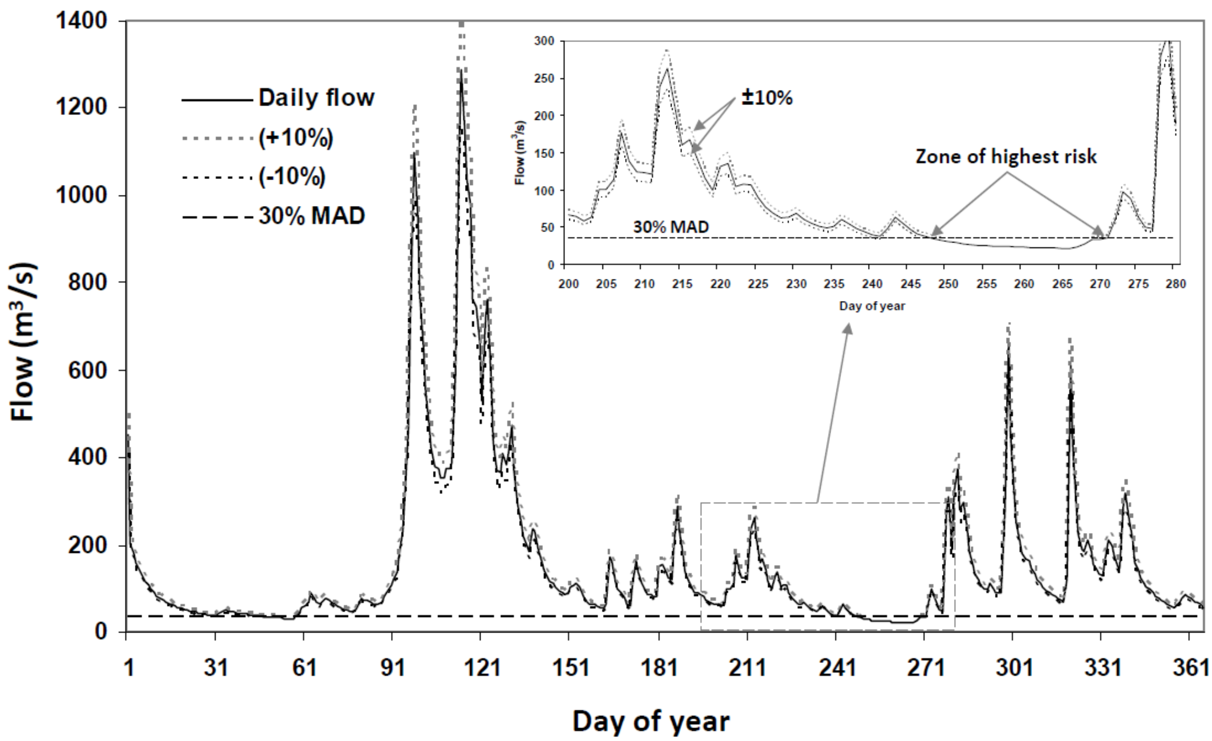

Figure 2: Graphic depiction of +/- 10% instantaneous flow and of 30% Mean Annual Discharge (MAD). Refer to Figure 3 for detailed examination of zone of highest risk. - (Courtesy of D. Caissie, 2012)

In addition, there was consensus amongst workshop participants that cumulative flow alterations that result in instantaneous flows less than 30% of the Mean Annual Discharge (MAD) have a heightened risk of impacts to ecosystems that support fisheries (see 'zone of highest risk' in Figure 3). The MAD is a relatively robust hydrological indicator, which has a strong correlation to the size of the drainage basin on a regional basis. It is thus a good indicator/metric for use in watersheds with insufficient data from the hydrologic record. Thus, for instances where the cumulative water use reduces the river flow below the level of 30% of the MAD, a rigorous level of assessment should be required to evaluate potential impacts on ecosystem functions that sustain fisheries, including identification of mitigation measures. During low flow events (i.e. drought, historic low flows, etc.), a 'cut-off limit' is recognized as an important part of the overall prescription to be applied during these critical low flow events, and can serve to conserve and protect fisheries. It is widely recognized that having such a limit can preserve ecosystem structure and function in riverine ecosystems that support fisheries. Some jurisdictions in Canada and elsewhere currently have established methodologies to specify this ‘cut-off limit’, for example the “Alberta Desktop Method” (Government of Alberta)

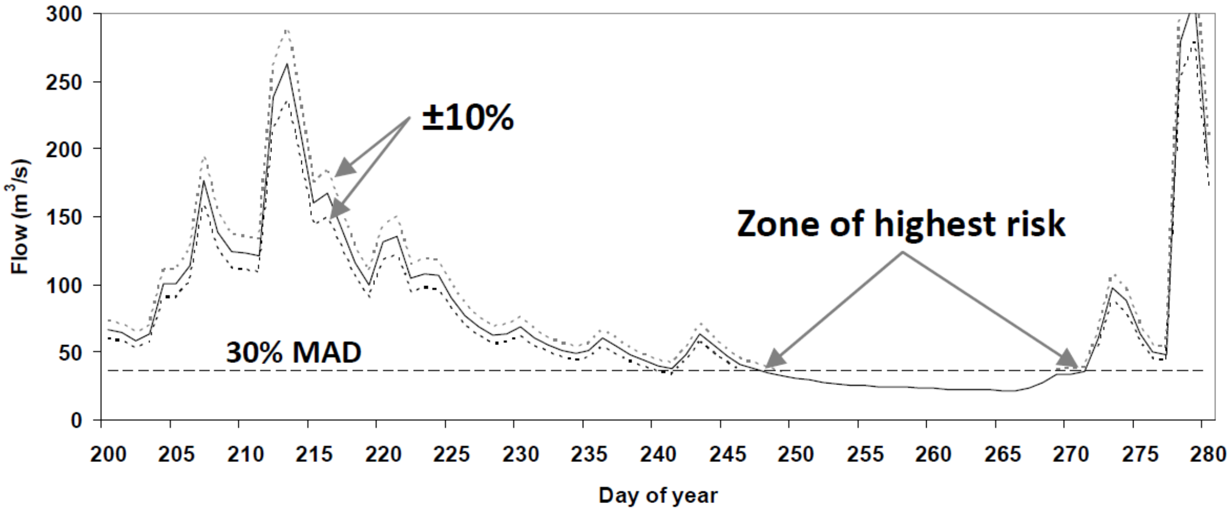

Figure 3: Detailed depiction of zone of highest risk; expressed as instantaneous discharges which are less than 30% Mean Annual Discharge (MAD) for the river/stream being assessed. (Courtesy of D. Caissie, 2012)

These flow management guidelines/criteria are highly dependent on the existence of long-term gauging data or defensible hydrologic simulations. Given the inherent uncertainty in all of the assessment methodologies described and the important role of other co-varying parameters (e.g. water temperature), the use of a scientifically based adaptive management process including pre- and post-project monitoring is recommended. Adaptive management programs will also improve policy development related to ecological flows for fishery protection in the long term.

To provide a statically robust basis of assessment, the use of a minimum of 20 years of river flow data is recommended to establish the “natural flow regime”. The data to establish the “natural flow regime” can be obtained via two scenarios. For ecosystems where there are very low levels of cumulative water use prior to the proposed project (**unaltered condition,** i.e. pre-project) and flow data are available, actual recorded data can be used directly for the analysis. By contrast, where there is already a significant amount of cumulative water use or flow alteration, then the river flows should be ‘naturalized’ to establish the “natural flow regime” for assessment purposes. For scenarios where these data do not exist, it is possible to use synthesized (i.e. modeled) stream flow data for this purpose. However, in doing so, it is important to both calibrate and validate the modeled results.

CONCLUSIONS AND ADVICE

1. Given that the science of ecological flow requirements for fisheries is an emerging science, additional research on flow alteration-ecosystem response relationships is required. Some research is being done nationally and internationally, and should be incorporated when appropriate. More research is still needed in this regard.
2. A pressing research need exists regarding the integration of the various components of assessment (both physical and biological-ecological), and will represent a significant positive development when such a model or models are developed. DFO

(and other Federal departments with related research programs) should support such efforts where appropriate.

3. A more detailed technical examination is required on the effectiveness of the recommended thresholds across the diversity of river and stream systems in Canada. To provide greater certainty in the management application, the thresholds recommended in this report (i.e. +/- 10% of instantaneous flow; 30% of mean annual discharge) should be tested and monitored on a variety of representative Canadian rivers.
4. To further develop expertise within the Department, additional training on these assessment methods and networking with researchers and practitioners is recommended.
5. To increase the understanding of project proponents and reduce the likelihood of potential problems, the early and on-going engagement of both managers and scientists in the assessment of ecological flows to sustain fisheries is encouraged.
6. It is recommended that a comprehensive synthesis document be produced for the Canadian context regarding the information needs for the assessment of ecological flows to sustain fisheries. To this end, and in the interim, there are several comprehensive source documents, all acceptable from a scientific perspective.
    a. *Instream Flows for Riverine Resource Stewardship* (revised edition, Instream Flow Council, 2004)
    b. Environmental Flow Assessments for Rivers: Manual for the Building Block Methodology (Updated Edition, Water Research Commission, 2008).
    c. *Table of Concordance for Clean Energy Projects*. British Columbia Ministry of Forests, Lands and Natural Resources; Ecosystems; Regional Operations, South Coast. Working draft. December 2010 (pers. Comm. S. Babakaiff)
    d. *A Desk-top Method for Establishing Environmental Flows in Alberta Rivers and Streams*. Allan Locke and Andrew Paul. Alberta Environment and Alberta Sustainable Resource Development (April 2011).
7. Develop a checklist for assessors to use when reviewing reports proposing flow alterations (i.e. to ensure the data has been validated, collected and analyzed correctly).

OTHER CONSIDERATIONS

Riverine flow is considered the ‘master variable’ that connects many important ecological functions and overall ecosystem function. These include (but are not limited to); hydrology, biology, geomorphology, connectivity (including the influence of groundwater), and water quality. These elements of riverine structure and function are equally important and inter-related (dependant), and none should be considered in isolation.

The scientific advice and recommendations in this report are specific to the assessment of flow for sustaining CRA fisheries in Canada. However, ecological flow requirements for fisheries should not be considered in isolation from other flow-related variables (e.g. temperature, dissolved gases, nutrients, pH, etc). Thus, a more comprehensive framework for river assessment is required. Further scientific work should consider water temperature (at all times of year) in the same fashion as ecological flow requirements for fisheries, including an examination of temperature-ecological response relationships across a gradient of flow alteration.

It is recommended that any model(s) used in the assessment of ecological flows for fisheries be calibrated and validated for the specific river or stream being examined. However, it is important to note that the data used to create and calibrate these models cannot be the same data used to 'validate' the model. Thus, to properly validate the model, new or additional field data should be collected for the specific river being assessed. Similarly, the development of regional approaches that are validated for each region is also strongly encouraged.

It is recommended that a technical document be produced to provide guidance on establishing "natural flow" conditions from which to assess the impacts of flow alteration. This technical guidance should include consideration of transferability of data from hydrometric stations to ungauged stations, via statistical techniques, rainfall-runoff models, or by other approaches using local meteorological data as inputs, and be based on a minimum of 20 years of continuous hydrological data. *Note*: Managers and practitioners should note that technical guidance is available for some jurisdictions in Canada. Additional guidance can be found in Appendix 1 of this report.

Research and Management Across Jurisdictions and Disciplines:

As described in the body of this report, ecosystem responses to changes in ecological flow requirements for fisheries are complex and not always readily discernable. These complex ecosystems present a challenge to manage as our ability to predict outcomes is limited, which can present a risk to sustaining CRA fisheries. In addition, riverine ecosystems that support CRA fisheries are managed by multiple authorities (federal, provincial, territorial, municipal), often with limited coordination across jurisdictions.

The various management authorities across jurisdictions may use a variety of methods to collect and analyze monitoring data. The net result is a number of different programs attempting to measure the same thing – the response of fisheries to cumulative impacts including changes in ecological flows – yet often arriving at different conclusions.

To better ensure sustainability of CRA fisheries dependant on these riverine ecosystems, there is a need to improve the study of bio-physical relationships, including robust monitoring and evaluation. A multi- and inter-jurisdictional partnership[1] could improve the understanding of linkages between fisheries response and changes in ecological flows and other environmental stressors. Designed in isolation, research and monitoring programs can run the risk of being too costly to implement over large scales and will likely be unable to disentangle cumulative environmental impacts. On the other hand, easily implemented standard approaches may provide insufficient consideration of technical details. However, a multi-disciplinary, multi-jurisdictional oversight committee and research chair could design research and monitoring programs to answer management questions that are sufficiently sophisticated, scientifically defensible and address cumulative effects, while still being practical and cost-effective to implement. Such a partnership would maximize the ability to detect ecosystem-level responses and isolate the cause to flow alteration, along with the resultant effects on CRA fisheries. Such a standardized program should include data collection and centralized storage, analysis, and interpretation of results for management.

To address these cross-jurisdictional issues, such a partnership is recommended. A multi-disciplinary oversight committee composed of these groups could ensure that the products of

[1] Such a partnership could include interested participants from governments (Federal, Provincial, Aboriginal, Métis and First Nations, municipal), research scientists, academia, industry, watershed management organizations, environmental organizations, etc. This list is non-exhaustive and only intended to be illustrative of collaboration between statutory decision-makers and other involved parties.

research scientists are best aligned to inform decision making for both fisheries and the waters upon which these fisheries depend. Such a partnership would ensure the highest level of scientific integrity, including peer review and publication, while being guided by input from all partners in program design.

Caveats to this report:

Certain riverine ecosystems were not directly considered in this report: Intermittent, seasonal or ephemeral streams and rivers are those that, under natural conditions, do not have continuous flows during all times of the year. Although such systems may provide ecosystem structure and functions to support fisheries, prescribing ecological flows could be very different for these ecosystems as compared to larger perennial streams or rivers (those with continuous flow). The ecological contributions of intermittent, seasonal and ephemeral streams in relation to their fisheries would be necessarily very site-specific to those particular ecosystems. Given that ecological/environmental flow frameworks are typically designed with the assumption that some flow remains in the river at any given time, the advice within this report is not necessarily recommended for direct application to intermittent, seasonal or ephemeral streams or rivers. Additional research is required to better describe the bio-physical relationships in such ecosystems to their respective fisheries, relative to those specific rivers or streams.

Finally, the issue of "hydro peaking" or "flow ramping" at hydroelectric facilities was not specifically discussed within this Science advisory process, and thus not considered within the context of this report. Hydroelectric peaking (or 'hydro peaking') is characterized by rapid changes in discharge to meet peak electricity demand, resulting in the alteration of hydrological characteristics of flow downstream (including magnitude, duration, timing, rate of change, and frequency of change in flow). Additionally, the rate(s) of change to discharge and river stage were not considered. We note that the basic ecological principles (i.e. the 'natural flow paradigm') and methodologies discussed here still have application to these projects. However, these situations are highly complicated both ecologically and economically, and the associated issues are typically unique to each situation. As such, study needs and management opportunities are unique and are thus beyond the scope of this document to adequately address.

SOURCES OF INFORMATION

This Science Advisory Report is from the March 6-8, 2012 National Peer Review on "Standardized Framework for the Assessment of Instream Flow Needs in Canada". Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

Linnansaari, T., Monk, W.A., Baird, D.J. and Curry, R.A. 2013. Review of approaches and methods to assess Environmental Flows across Canada and internationally. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/039. viii + 74 p.

APPENDIX 1:

Determination of Impact on Flow Alteration on Fisheries: National Technical Guidance

a) Cumulative flow alterations <10% in amplitude of the actual (instantaneous) flow in the river relative to a “natural flow regime” have a low probability of detectable impacts to ecosystems that support commercial, recreational or Aboriginal fisheries.

b) Cumulative flow alterations that result in instantaneous flows < 30% of the mean annual discharge (MAD) have a heightened risk of impacts to fisheries.

c) For cumulative water use >10% of instantaneous discharge or that results in flows < 30% of the mean annual discharge (MAD), a more rigorous level of assessment is recommended to evaluate potential impacts on ecosystem functions which support fisheries.

* for further information, refer to the body of this advisory report.

Definition of Instantaneous Discharge:

“Instantaneous flow” or “Instantaneous discharge” is defined as the actual discharge in a river or stream as measured at any given point in time. For some projects, instantaneous flow may be required for the analysis rather that daily or weekly flows.

Discharge/flow data:

a) For situation/sites where discharge/flow data is available, +20 year average daily or weekly discharges should be used for the instream flow analysis.

b) For situation/sites where flow data is not available, then the use of synthesized (i.e. modeled) stream flow data is recommended. These data can be prorated (generally a transfer of information from a proximal hydrometric station(s)), or simulated using a hydrological model. For the purposes of this analysis, +20 years of synthetic data should be used (prorated or simulated). In order of preference, and based on available information, these data should be synthesized from:

   i) Another hydrometric station within the same river or stream reach (either prorated data or simulated data could be calculated).

   ii) Another hydrometric station within the same watershed that serves as a proxy for the site of proposed flow alteration (either prorated data or simulated data could be calculated).

   iii) Another hydrometric station within close proximity from the study site; prorated or simulated data could be used to serve as a proxy to the site of proposed flow alteration. However, there need to be a demonstration that the transferred data represents flow conditions (high, mean, and particularly low flows) at the study site.

   iv) When the transfer of hydrometric data is no longer an option (e.g., site too distant or different in size); then instream flow studies will most likely need to rely on regional hydrological studies (i.e. regression of many sites that represents flow characteristics (e.g., regional low flow study, etc).

THIS REPORT IS AVAILABLE FROM THE:

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ISSN 1919-5087

Correct citation for this publication

DFO. 2013. Framework for Assessing the Ecological Flow Requirements to Support Fisheries in Canada. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2013/017.

Aussi disponible en français :

MPO. 2013. Cadre d'évaluation des exigences relatives au débit écologique nécessaire pour soutenir les pêches au Canada. Secr. can. de consult. sci. du MPO, Avis. sci. 2013/017.