Refining habitat indicators for Strategy 2 of the Wild Salmon Policy:

Practical assessment of indicators

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1. Introduction to habitat indicators and the Wild Salmon Policy

Canada's Policy for Conservation of Wild Pacific Salmon (a.k.a. the Wild Salmon Policy, WSP) was released in June 2005 (DFO 2005). The overarching goal of the Policy is to restore and maintain healthy and diverse salmon populations and their habitats. To help evaluate whether the Wild Salmon Policy is succeeding in this regard Fisheries and Oceans Canada (DFO) intends to use "habitat indicators" to assess and monitor the status of and pressures on stream, lake, and estuarine habitats in British Columbia and Yukon (see *Strategy 2 Assessment of habitat status* and *Action Step 2.2 Select indicators and develop benchmarks for habitat assessment* of the Wild Salmon Policy).

Habitat indicators can track habitat conditions over time and identify salmon habitats that are most productive, limiting, or at most risk of disturbance within Conservation Units (CU)[1]. Indicators can also improve understanding of linkages among habitat pressures, habitat status, and management responses (e.g., conservation and restoration actions).

To-date, DFO's process for developing habitat indicators has followed the following three steps:

Step 1: **Indicator Compilation and Ranking**: The first task required developing a list of habitat indicators for streams, lakes, and estuaries used by volunteer groups, DFO, and other government agencies in the U.S. and Canada. Drawing upon the work from other researchers in the Pacific Northwest, DFO's Habitat Working Group (a group of managers and scientists) developed and ranked a preliminary list of habitat indicators based on the (i) number of other groups using / citing these indicators, and (ii) scientific relevance / strength of the linkage to key habitat attributes of interest.

Step 2: **Indicator Practical Assessment**: The second task involves assessing each indicator on the basis of a number of evaluation criteria (described further in Section 2): (i) data source, (ii) data availability, (iii) relative cost, (iv) spatial extent / resolution, (v) temporal extent / frequency, and (vi) scientific relevance (from Step 1). This information was then used to develop recommendations to identify the most feasible indicators to implement, and identify a suite of indicator options that could be potentially implemented by DFO.

Step 3: **Indicator Metrics and Benchmarks**: Finally, the third step requires identifying alternative ways of measuring an indicator, termed a metric (e.g., mean annual discharge vs. peak annual flow). Associated with alternative metrics are benchmarks, maximum tolerable thresholds or ranges within which managers wish to maintain habitat conditions (e.g., optimal water temperature ranges), or below which managers wish to minimize pressures on habitats (thresholds for equivalent clearcut area).

This report provides results from the *Practical Assessment* of habitat indicators being considered by DFO for Strategy 2 of the Wild Salmon Policy. A future report will summarize findings related to identifying indicator metrics and benchmarks as related to Step 3.

[1] A Conservation Unit represents genetically similar interbreeding population(s) of salmon distributed across a defined geographic area (DFO 2005).

2. Steps to practical assessment

In completing a practical assessment of habitat indicators for DFO we pursued the following five tasks.

2.1 Clarify list of indicators

First, we worked closely with DFO to ensure the list of habitat indicators was consistent and clear. The original list of habitat indicators included language that represented both indicators (e.g., stream discharge) and metrics (e.g., % watershed area with impervious surfaces). Indicators represent habitat attributes of interest to managers which can be measured in a variety of ways, while a metric represents one of the ways an indicator can be measured. This clarification was important to focus the review of potentially relevant data sources at this stage of work, as well as accurately identifying metrics and benchmarks during later stages of work. An evaluation of the relevance / suitability of these habitat indicators was not within scope of our work. The clarified list of indicators is provided in Table 1. The first four indicators in Table 1 represent habitat quantity indicators which DFO has committed to providing under the Wild Salmon Policy. As a result, these indicators were not ranked by DFO in Step 1 of the indicator development process.

2.2 Develop conceptual diagrams

Our second task (see Section 3) was to use the list of indicators in Table 1 to develop *simple* conceptual diagrams for each species of salmon to explicitly document linkages among human actions (e.g., development activities, restoration actions, and/or conservation measures), habitat indicators (e.g., water quality, physical habitat condition), and mechanisms of life-stage specific salmon mortality (e.g., effects on egg development and survival). This exercise was important to help ensure indicators are: (a) responsive to changes in management actions; (b) representative of habitat pressures and status on a variety of salmon species / life stages; and (c) linked to known / hypothesized effects on life-stage specific survival. These diagrams can also help identify potential gaps in the list of indicators and help identify metrics that most meaningfully affect salmon life stages. Use of conceptual models has been advocated by others (e.g., Jones et al. 1996) and is consistent with the "*Pathways of Effects*" approach being applied as part of DFO's Environmental Process Modernization Plan (EPMP).

2.3 Identify potential data sources

Third, we reviewed published, grey, and web literature to identify potential data sources that could be used to inform indicators in B.C. and Yukon. We focused on identifying three types of data: (a) data collected through field measurement (e.g., physical habitat characteristics); (b) data derived from the application of existing models (e.g., empirical models to estimate water quality parameters); and (c) data derived from Geographic Information Systems or remote-sensed information (e.g., Watershed Statistics database). In identifying potentially relevant data sources, we also relied on phone interviews with a long list of contacts to elicit feedback and other perspectives on potentially relevant data sources.

2.4 Assess indicators against evaluation criteria

As a fourth task, we reviewed available information and contacted a variety of federal and provincial government agencies, non-governmental organizations, and industry representatives (see

Acknowledgements) to better understand the data sources that could feasibility be used to inform DFO's list of habitat indicators. We used six criteria and a set of related questions to evaluate the appropriateness of alternative data sources to informing the habitat indicators (see Table 2). These evaluation criteria were based on those identified by DFO, a WSP habitat indicators report (G.A. Packman & Associates and Winsby Environmental Services 2006), and our experience in developing indicators for environmental decision making.

Key outcomes from this task were the *Practical Assessment Worksheets* (see Appendix A). A summary of this information is provided in Section 5. This information guided discussions at the habitat indicators workshop (Task 5) and was used to develop final indicator recommendations (Section 6.1). Following the workshop and final review of available data sources, we assessed indicators on the basis of the level of effort required to generate indicators and metrics. We then grouped indicators into three categories based on this level of effort: (i) indicators with significant data gaps, (ii) indicators with sufficient data to inform baseline variation, and (iii) indicators with appropriate data to generate metrics. Given significant gaps and the high level of effort required to generate indicators in the first category, these were not considered when developing our recommendations. Indicators with sufficient information to inform baseline variation were considered when developing our recommendations though of a low priority. Indicators with readily available data / monitoring programs were the highest priority for consideration when developing recommendations. For this set of indicators we qualitatively evaluated tradeoffs among a number of indicator evaluation criteria to develop recommendations. A formal exploration of tradeoffs among indicator evaluation criteria (using decision analysis, for instance) was beyond the scope of this work.

2.5 Review practical assessment findings

A final task was to elicit feedback and comments on preliminarily findings of our work from DFO, First Nations, and non-governmental organizations. A workshop entitled "*Refining Habitat Indicators for Strategy 2 of the Wild Salmon Policy*", scheduled on June 26, 2007, engaged a variety of participants to elicit this feedback. The objectives of the workshop were to:

1. develop a common understanding of the suite of indicators and related data sources being considered for Strategy 2 of the Wild Salmon Policy;
2. review findings from the practical assessment of habitat indicators;
3. verify whether these findings accurately / comprehensively represent available data sources for the habitat indicators;
4. fill information gaps where the practical assessment has not accurately / comprehensively represented available data sources for the habitat indicators; and
5. evaluate the usefulness of an example set of habitat indicators for informing management decisions.

The morning included presentations by DFO summarizing the project purpose and approach to monitoring / reporting on salmon habitats under the Wild Salmon Policy and the project team summarizing preliminary results from the practical assessment (i.e., a draft version of this report). A facilitated task process was then used to engage workshop participants in: (a) verifying accuracy / comprehensiveness of practical assessment findings; (b) providing guidance to fill information gaps where necessary; and (c) evaluating usefulness of an example set of habitat indicators for developing habitat status reports. Following the workshop, an opportunity was provided to workshop participants to provide follow-up comments before finalizing this Practical Assessment Report.

Table 1. Estuary, lake, and stream habitat indicators being considered for Strategy 2 of the Wild Salmon Policy. Although not explicitly considered as an estuarine indicator, stream discharge is recognized as having an important influence on estuaries (denoted by *).

Indicator type	Indicator	Habitat type			Example metrics and parameters of interest
		Lake	Stream	Estuary	
Status	Estuarine habitat area			X	
Status	Accessible shore length, barriers	X			
Status	Accessible stream length, barriers		X		
Status	Accessible off-channel habitat area	X	X	X	
Pressure	Disturbance of estuary foreshore habitats			X	% estuary foreshore altered (e.g., carex, typha, riparian zone)
Pressure	Disturbance of in-shore habitats			X	% surface area disturbed in-shore (e.g., eel-grass zone)
Pressure	Disturbance of off-shore habitats			X	% surface area disturbed off-shore / sub-tidal (e.g. log-booms)
Pressure	Marine vessel traffic activity			X	amount of vessel traffic
Pressure	Invasives	X		X	
Status	Micro and macro algae			X	
Status	Aquatic invertebrates			X	
Status	Sediment	X	X	X	e.g., total suspended sediments also considers substrates for streams / lakes
Status	Water chemistry	X	X	X	e.g., nutrients, dissolved oxygen, pH, conductivity, or contaminants
Status	Detrital organic matter			X	flux of detrital organic matter (C,N,P) between marsh and other habitats
Status	Eelgrass habitats			X	extent of eelgrass
Status	Spatial distribution of wetlands / mudflats			X	
Status	Riparian vegetation			X	
Status	Resident fish			X	
Pressure	Riparian disturbance	X	X		% riparian zone altered % stream length riparian zone altered
Pressure	Recreational pressure	X			
Pressure	Watershed: Land cover alterations	X	X		% watershed area various land cover alterations (e.g., forestry, agriculture, urban development)
Pressure	Watershed: Hard surfaces	X	X		% water- shed area impervious surface
Pressure	Watershed: Road development	X	X		road density
Pressure	Lake foreshore development	X			% lake foreshore altered
Status	River deltas	X			Number / presence of river deltas
Status	Water temperature	X	X		
Pressure	Wetland disturbance	X	X		
Pressure	Floodplain connectivity		X		% stream length channelized, floodplain connectivity
Pressure	Water extraction		X		water withdrawal as a % of mean annual discharge (e.g., surface water, groundwater)
Status	Channel stability		X		pool:riffle, width:depth ratios, etc
Status	Stream discharge		X	*	base and peak flows
Status	Large woody debris and in-stream cover		X		
	Total number of indicators by habitat type	**14**	**15**	**16**	

Table 2. List of evaluation criteria and related questions used to guide practical assessment of habitat indicators.

Evaluation criteria	Related questions
Data source	What is name of monitoring program / database? Who is responsible contact / agency? Any appropriate citations / references?
Data availability	Are data readily available for WSP purposes? What is reliability of continued availability in future?
Relative cost	Existing program costs: What are the existing program costs to derive available information (i.e., non-DFO related)? Incremental costs: What are the incremental costs to DFO of using these data (e.g., access fees)? Can data be collected at the same time as other data? Operating costs: What is the estimated operating cost to DFO of using these data (e.g., data processing, updating)?
Spatial scale	Spatial extent: What is geographic coverage of available data? Spatial resolution: What is spatial resolution of available data (metres or kilometres)?
Temporal scale	Temporal extent: What is historical time period over which data have been collected? Temporal frequency: What is temporal frequency of collection (e.g. daily, monthly, or annually)?
Scientific relevance	What was DFO's ranking resulting from Step 1 of process for developing habitat indicators?

3. Linking habitat pressures, habitat status, salmon species, and life stages

Conceptual models for each species of salmon were developed to explicitly illustrate linkages among human actions (i.e., pressures), habitat condition (i.e., status), and mechanisms of life-stage specific salmon mortality (i.e., biological responses). The purpose of these diagrams is not to illustrate all of the possible "pathways of effects" which can lead to confusing spaghetti-diagram. Rather, these diagrams are intended to focus attention on the cause-effect linkages that are of greatest importance for management decisions. Conceptual models provide a systems perspective of the linkages among physical, chemical, and biological components / processes in an ecosystem. Such a perspective is valuable for this work because it: (i) provides a framework for summarizing the current "state of science" describing cause-effect linkages among indicators, (ii) improves clarity and transparency for discussions around indicators, (iii) ensures indicators are responsive to management actions, and (iv) helps ensure recommendations are representative of habitat pressures and status for all relevant species and life stages.

Cause-effect linkages between habitat pressures, habitat status, and biological responses are unique to habitat types. Different species of Pacific salmon use these habitats differently. Therefore, we developed habitat-specific conceptual models that relate generically to different life stages of salmon. Figure 1 provides an overview of how a sequence of habitat-specific conceptual models relates to each species across their life stages. For instance, lake-rearing sockeye salmon tend to use stream habitats for spawning (Figure 2), lake habitats for juvenile rearing (Figure 4), and estuary habitats (Figure 5) while transitioning between freshwater and marine environments.

Cause-effect linkages are represented by a series of box and arrow diagrams illustrating the sequence of interactions among system components. In these diagrams, indicators of habitat pressures are represented by dark red boxes, indicators of habitat status are represented by white or light grey boxes, and life stage responses are represented by dark grey boxes. Habitat indicators represented by grey boxes have been explicitly considered in DFO's list of indicators (Table 1), while white boxes represent intermediate linkages between this list of indicators and life stage responses. To illustrate, Figure 2 illustrates that *water extraction* (a pressure indicator) affects *stream discharge* (a status indicator). This linkage is supported by our understanding that the amount of water in a stream can affect adult spawners directly by affecting useable area of spawning habitats. Such an effect can alter spawning viability and ultimately salmon production. In addition, changes in stream discharge can also directly affect *water temperature* (another status indicator). In turn, changes in water temperature can affect adult migration, suitability of spawning habitats, as well as survival and development of eggs.

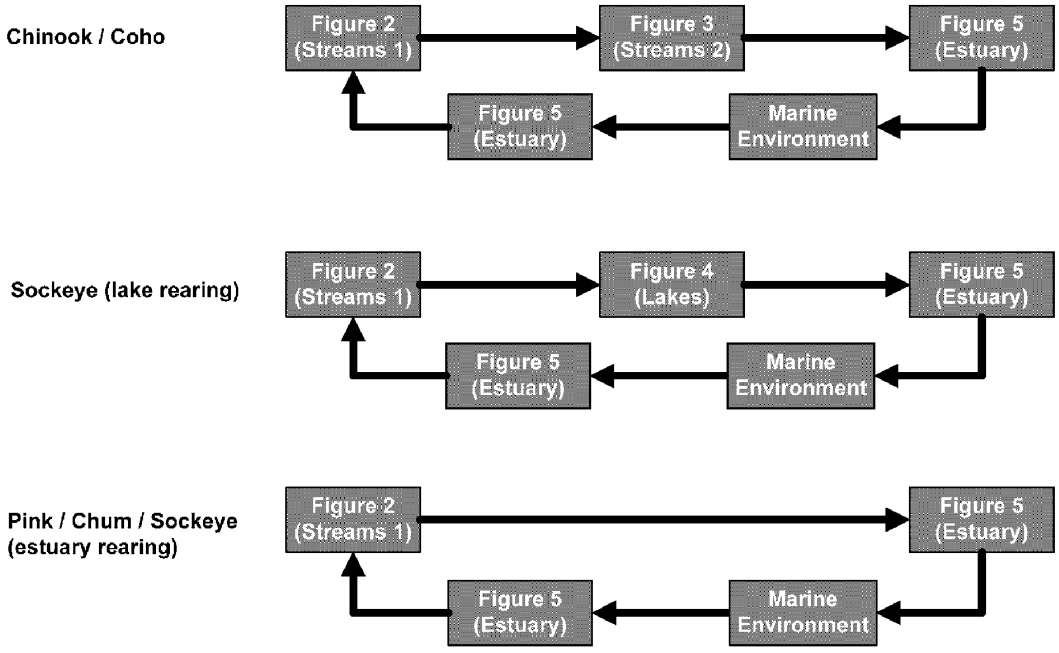


Figure 1. Overview diagram illustrating the transition among the habitat-specific conceptual models represented in Figures 2-5 for each salmon species.

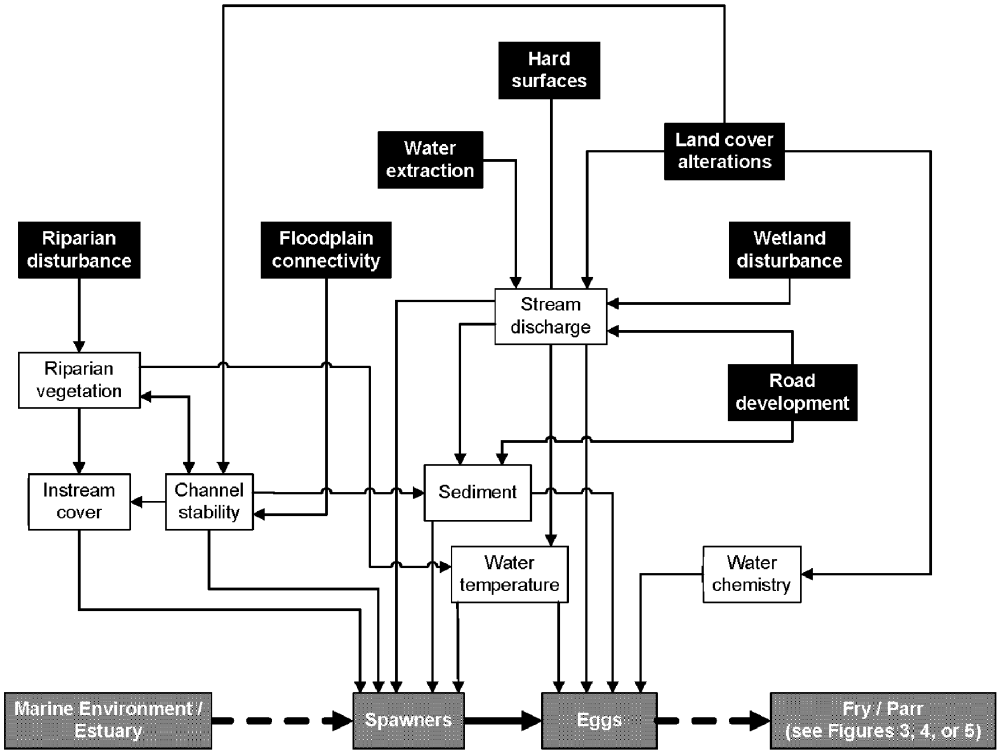


Figure 2. Summary of the linkages among habitat pressures (dark red boxes), habitat status (white or light grey boxes), and salmon life stages (dark grey boxes) in STREAM habitats. Grey boxes represent status indicators listed in Table 1, while white boxes represent implied linkages that are not represented in this table.

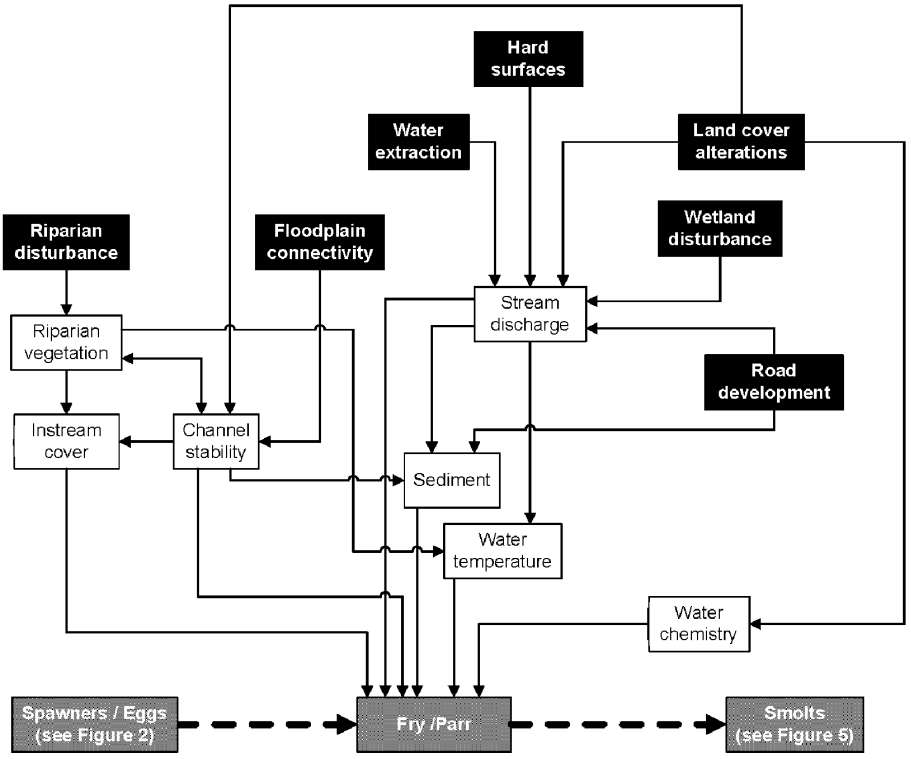


Figure 3. Summary of the linkages among habitat pressures (dark red boxes), habitat status (white or light grey boxes), and salmon life stages (dark grey boxes) in STREAM habitats. Grey boxes represent status indicators listed in Table 1, while white boxes represent implied linkages that are not represented in this table.

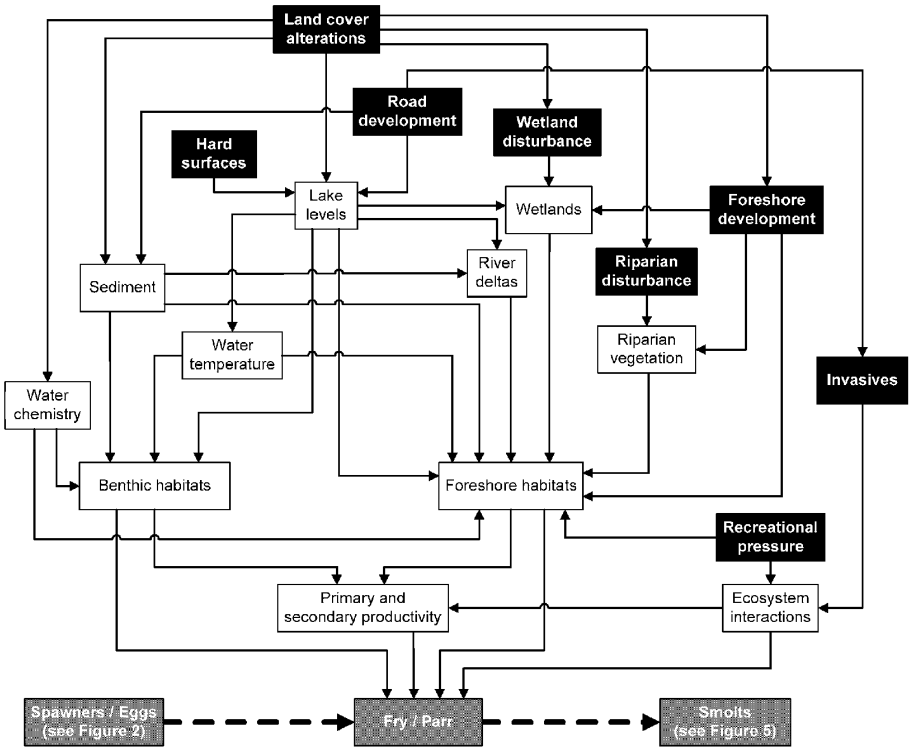


Figure 4. Summary of the linkages among habitat pressures (dark red boxes), habitat status (white or light grey boxes), and salmon life stages (dark grey boxes) in LAKE habitats. Grey boxes represent status indicators listed in Table 1, while white boxes represent implied linkages that are not represented in this table.

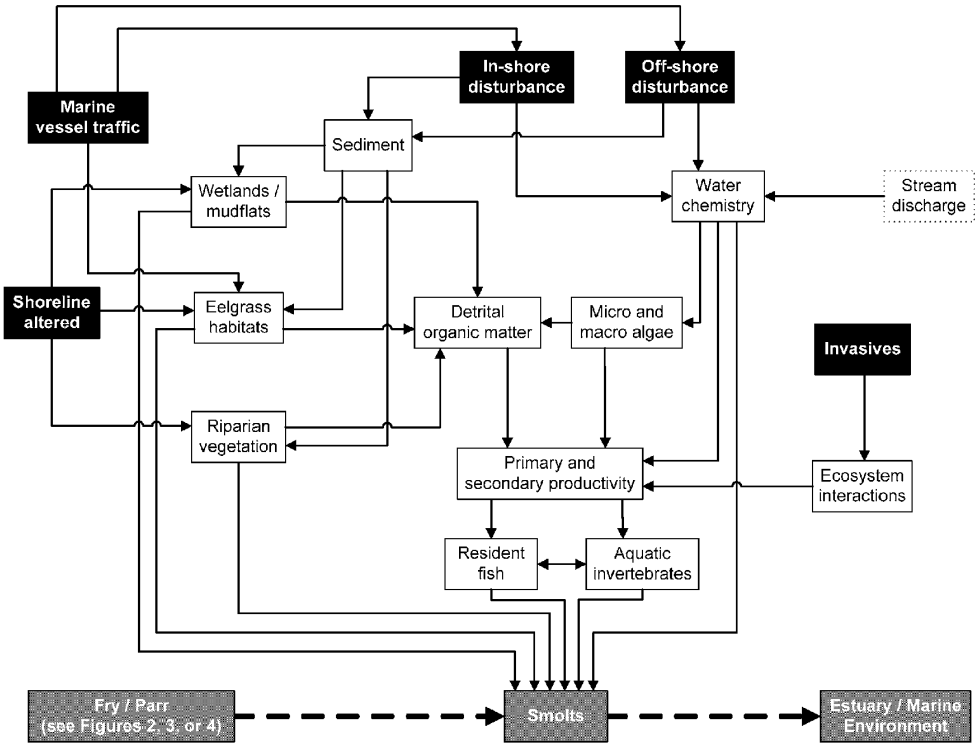


Figure 5. Summary of the linkages among habitat pressures (dark red boxes), habitat status (white or light grey boxes), and salmon life stages (dark grey boxes) in ESTUARY habitats. Grey boxes represent status indicators listed in Table 1, while white boxes represent implied linkages that are not represented in this table. Although not explicitly considered as an estuarine indicator, stream discharge is recognized as having an important influence on estuary habitats (importance denoted by light grey box with thatched outline).

4. Context for developing and using habitat indicators

4.1 Relevance to watersheds, Conservation Units, and the Pacific Region

In the context of this work, habitat indicators represent attributes of salmon habitats (i.e., pressures and status) that would be informative to track over time for decision making. Indicators are informed by data which can be used to numerically represent their value. Collection of such information for the WSP can take two forms: (i) collect new data / develop a new monitoring program, or (ii) leverage existing data sets / monitoring programs. To avoid redundancies, encourage partnerships with other organizations, and recognize that an abundance of information is already available across the Pacific Region, DFO is first looking to inform habitat indicators with existing data sets / monitoring programs (emphasis of this work). Collection of new data may be required at future stages of WSP implementation.

Given an emphasis on leveraging existing data, the appropriate use and feasibility of implementing a particular habitat indicator is driven, in large part, by the spatial coverage of available data. For instance, an available data source / monitoring program may be able to provide indicator information at the scale of a single watershed, Conservation Unit (i.e., multiple watersheds), or across the Pacific Region (i.e., multiple CUs). This understanding is drawn from the Wild Salmon Policy:

> "*Indicators may be general across CU's or specifically selected on a case-by-case basis for specific CU's and habitat types. Government agencies, First Nations, governments, watershed planning processes and stewardship groups will be asked to provide advice on the development or selection of key indicators for their watersheds, based on local knowledge and information on the kinds of data that are available.*"
>
> – page 21, DFO 2005 –

As discussed at the workshop, and consistent with the Wild Salmon Policy, three sources of data are available to inform indicators: (i) scientific / technical, (ii) local knowledge, and (iii) Aboriginal Traditional Knowledge. All are relevant for this review. Ideally, each source could provide information at the above spatial scales. In reality, however, local data or Aboriginal Traditional Knowledge is typically only collected across a single or few watersheds. Scientific studies can also be focused on sampling within a localized area (e.g., Carnation Creek). Although informative at the local scale, such data cannot be used to draw inferences at the largest spatial scale (i.e., Pacific Region) if not measured repeatedly over time and consistently across multiple watersheds, or data aren't stored in a centralized database — a necessity for developing habitat indicators that apply generally across CUs. In other words, it is more difficult to identify appropriate data sources that can generate habitat indicators to inform decision making across a broad spatial scale.

Given DFO's interest in first developing indicators that can be applied broadly across the Region, and that it isn't feasible to identify all local data sets that could be used to inform decision making as part of this work, the focus of our review was on identifying data sources that satisfy broad-scale needs for decision making. The availability / feasibility of local data to inform indicators will be extremely useful, but should be evaluated on a case-by-case basis at future stages of developing habitat indicators (e.g., when developing habitat status reports for priority watersheds / Conservation Units, as described in Section 4.2).

There are also four important distinctions between British Columbia and the Yukon Territory that have implications on developing habitat indicators across the Pacific Region. First, the amount and quality and available data differ between these jurisdictions; British Columbia has a larger number of potential data sources than the Yukon. The implication is that an indicator may not be equally represented or monitored consistently across jurisdictions, potentially resulting in data gaps. A second distinction is that occurrence of salmon species differ. Chinook and chum salmon are the primary species supported by habitats in the Yukon with coho found in some southern transboundary waters (e.g., Alsek drainage). This observation implies that only stream and estuary indicators are relevant in the Yukon (see Table 3) while all species and habitat indicators are relevant in British Columbia (see Table 1). Third, all salmon waterways in the Yukon are transboundary, while only a few are in British Columbia. The Taku, Alsek, Stikine, Unuk, and Yukon Rivers have estuaries in Alaska with headwaters in the Yukon Territory. Thus, estuary indicators in these systems need to be informed using data collected by agencies in Alaska. Finally, terrestrial and freshwater ecosystems are significantly different across the Region. To account for differences in relations between salmon and their habitats, we propose separation of DFO's Pacific Region into three areas: coastal, interior, and northern environments (Figure 6). Such a separation would allow for development of a set of habitat indicators, metrics, and benchmarks unique to each area during this and future stages of work.

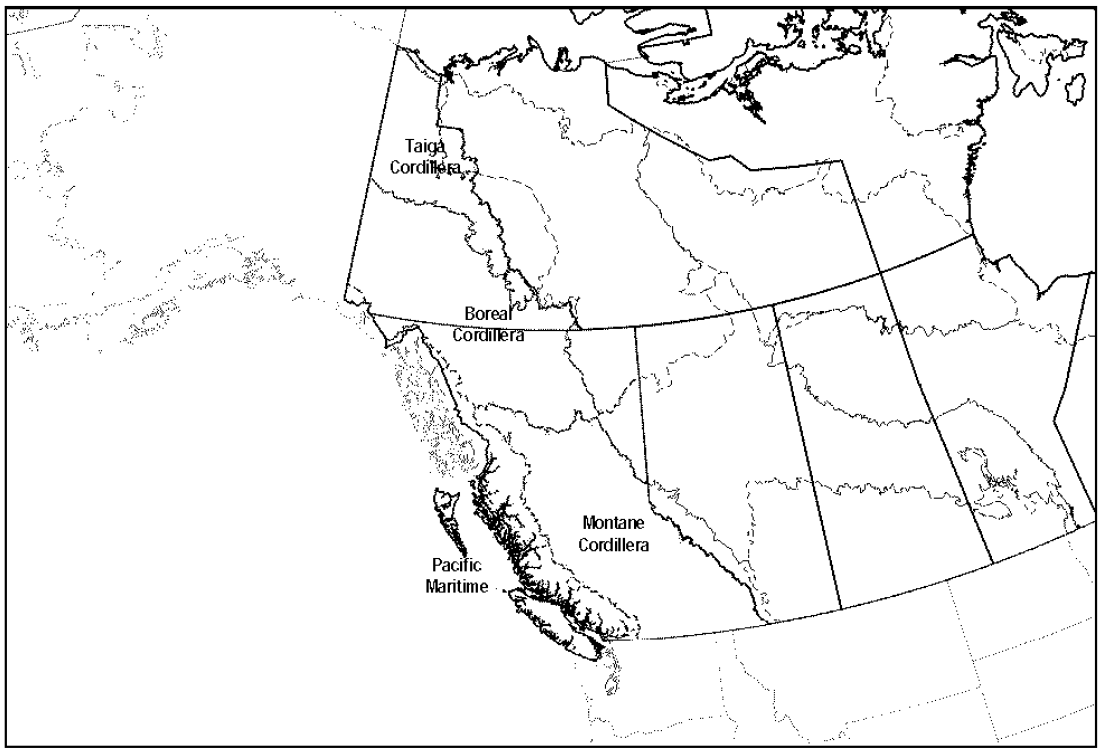


Figure 6. Map of western North America including British Columbia and Yukon (DFO's Pacific Region) and proposed boundaries for coastal (Pacific Maritime), interior (Montane Cordillera), and northern environments (Boreal and Taiga Cordillera). Boundaries are based on a map of Canada's Ecozones (in parentheses above, thatched boundaries in figure, also see http://www.ccea.org/ecozones/) using spatial data downloaded from Geogratis (http://geogratis.cgdi.gc.ca/geogratis/en/index.html).

Table 3. Estuary and stream habitat indicators being considered for Strategy 2 of the Wild Salmon Policy that are relevant to northern freshwater environments (compare to Table 1). In our discussions with experts, indicators with an asterisk (*) were identified as having limited relevance / importance in more pristine northern areas (i.e., hard surfaces and floodplain connectivity) or were considered as an indicator in other habitats (i.e., stream discharge is important for estuaries, but included as a stream indicator).

Indicator type	Indicator	Habitat type		Notes / example metrics and parameters of interest
		Stream	Estuary	
Status	Estuarine habitat area		X	
Status	Accessible stream length, barriers	X		
Status	Accessible off-channel habitat area	X	X	
Pressure	Disturbance of estuary foreshore habitats		*	% estuary foreshore altered (e.g., carex, typha, riparian zone)
Pressure	Disturbance of in-shore habitats		X	% surface area disturbed in-shore (e.g., eel-grass zone)
Pressure	Disturbance of off-shore habitats		X	% surface area disturbed off-shore / sub-tidal (e.g. log-booms)
Pressure	Marine vessel traffic activity		X	amount of vessel traffic
Pressure	Invasives		X	
Status	Micro and macro algae		X	
Status	Aquatic invertebrates		X	
Status	Sediment	X	X	e.g., total suspended sediments also considers substrates for streams / lakes
Status	Water chemistry	X	X	e.g., nutrients, dissolved oxygen, pH, conductivity, or contaminants
Status	Detrital organic matter		X	flux of detrital organic matter (C,N,P) between marsh and other habitats
Status	Eelgrass habitats		X	extent of eelgrass
Status	Spatial distribution of wetlands / mudflats		*	
Status	Riparian vegetation		*	
Status	Resident fish		X	
Pressure	Riparian disturbance	X	*	% riparian zone altered % stream length riparian zone altered
Pressure	Watershed: Land cover alterations	X		% watershed area various land cover alterations (e.g., forestry, agriculture, urban development)
Pressure	Watershed: Hard surfaces	*		limited relevance in the north, few urban centres % water- shed area impervious surface
Pressure	Watershed: Road development	X		road density
Status	Water temperature	X		
Pressure	Wetland disturbance	X		
Pressure	Floodplain connectivity	*		limited relevance in the north (only ~4km channelized near Dawson and Mayo) % stream length channelized, floodplain connectivity
Pressure	Water extraction	X		water withdrawal as a % of mean annual discharge (e.g., surface water, groundwater)
Status	Channel stability	X		pool:riffle, width:depth ratios, etc
Status	Stream discharge	X	*	base and peak flows
Status	Large woody debris and in-stream cover	X		
	Total number of indicators by habitat type	**13**	**16**	

4.2 Relevance to decision making

Building on guidance provided by the Wild Salmon Policy, Fisheries and Oceans Canada has proceeded in drafting an approach for using habitat indicators to inform decision making. To develop a set of habitat indicators that are most meaningful / useful to decision makers, it is essential to understand this decision context early on in the process (e.g., Failing and Gregory 2003).

Based on feedback received during WSP consultations and a review of indicator approaches elsewhere in the Pacific Northwest, DFO is adopting a two-tiered approach to decision making. *Tier I* decision making, representing the first line of information transfer to decision makers, will be informed by pressure indicators. Pressure indicators are recognized as being more proactive measures of impacts on the landscape and salmon habitats than status indicators. Using Geographic Information Systems and remote sensed information, pressure indicators would also be less costly to monitor over time. Therefore, the intention is to monitor / measure pressure indicators across the broadest spatial-scale (termed *extensive monitoring* under the Wild Salmon Policy).

In management areas where benchmarks have been exceeded for pressure indicators, *Tier II* decision making would be informed by status indicators – more detailed descriptions of the condition of salmon habitats. Although more directly related to biological responses than pressure indicators, status indicators will be used as *Tier II* indicators for a variety of reasons. First, a requirement for field measurement means that status indicators are more expensive to monitor. Second, high natural variability in habitat condition implies a limited ability (i.e., low statistical power) to reliably detect meaningful changes in habitat condition without sampling across many locations or long time-series. Finally, lags in response of freshwater and estuarine ecosystems to natural and human disturbances mean that measurable changes in habitat status may not be observed until after habitat degradation has occurred. Thus, the intention is that status indicators will be monitored across a much smaller area, potentially for a subset of watersheds or Conservation Units (CUs) across the Pacific Region (termed *intensive monitoring* under the Wild Salmon Policy).

Within this general framework, our understanding is that habitat indicators will then be used to develop habitat status reports, which in turn can be used to inform two scales of decision making / management action: regional and local scales. For instance, at a regional scale (i.e., B.C. and Yukon) managers may look to the pressure indicators to understand the types of regional policies that could be effective in alleviating pressures on habitats. At a local scale (i.e., watershed or Conservation Unit), Area habitat managers may use both pressure and status indicators to better understand conservation and/or restoration priorities. For instance, when developing Habitat Compensation Plans habitat indicators may help identify the most effective actions for protecting / enhancing a particular species in a watershed. A challenge with this two-tiered approach however, is that it may be difficult to identify priority conservation areas (i.e., productive pristine areas) given the emphasis on applying pressure indicators first. An understanding of habitat and population status is needed to provide this information, some of which might be available through other parts of the Wild Salmon Policy.

This summary is based on *our current* understanding of how DFO intends to use the habitat indicators and the types of decisions they will inform. We recognize that the decision context for using habitat indicators under the Wild Salmon Policy is still evolving. *Strategy 4 Integrated Strategic Planning* is specifically focused on developing decision processes that integrate information provided by habitat indicators (including other information such as ecosystem indicators) into DFO's strategic-level planning and decision making.

5. Summary of practical assessment

Based on our literature research, phone interviews, and workshop discussions, we first identified data sources that could potentially be used to inform stream, lake, and estuary indicators and then evaluated these data sources against the evaluation criteria and related questions in Table 2. The *Practical Assessment Worksheets* (Appendix A) represent the result of these efforts. In total, we identified and evaluated 68 unique data sources (Table 4). We identified an additional 25 data sources (Table 5) but did not evaluate their usefulness at informing decision making across many CUs (i.e., the Pacific Region). As discussed in Section 4.1, these additional data sources should be evaluated on a case-by-case basis for their usefulness at informing specific watersheds / Conservation Units at future stages of indicator development. These data / monitoring programs are maintained by a range of federal, provincial, and local government agencies, as well as a variety of stewardship groups. In many cases, we identified data sources that were relevant to more than one indicator. In these instances, data sources have been associated with more than one indicator in the Appendix. For instance, the Invasive Alien Plant Program can be used to inform both the lake and estuary "invasives" indicator.

In reviewing data / monitoring programs from across the Pacific Region, it became clear that almost all indicators can be informed by some data. The comprehensiveness of these monitoring programs / data sources and the level of effort needed to develop these data to the stage where they could be used to generate habitat indicators varied greatly, however. Based on our understanding of the variation in the level of effort needed to generate an indicator from available data, we *qualitatively* ranked indicators (Figures 6-8) and grouped them into three categories to our recommendations (Section 6.1), resulting in 14, 10, and 21 indicators in Type I, Type II, and Type III categories, respectively.

Type I – Indicators with significant data gaps: represent those indicators where either no data are available, or where data have been collected in a way that could not support indicator development under the Wild Salmon Policy (see Table 6). Examples include indicators where data are available in a few streams, watersheds, or regions, have been sampled on a single day or season, or have been measured by different monitoring programs using vastly different methods. Costs of generating these indicators across the Region would likely be very high (e.g., >>$100,000).

Type II – Indicators with sufficient data to inform baseline variation: represent indicators, similar to Type I, where monitoring has been opportunistic and not designed in a way to support inferences across the Pacific Region (see Table 7). However, the quantity and quality of available data are better such that they would still be useful to help decision makers understand variation in habitat conditions across streams / watersheds and across seasons / years. Such insights would be valuable for defining benchmarks. Data would need to be supplemented by new data collection, improvements to existing monitoring programs, or better coordination of existing databases to improve reliability of inference. Costs of generating many of these indicators across the Region would likely be very high (e.g., >>$100,000).

Type III – Indicators with appropriate data to generate metrics: represent indicators where appropriate monitoring programs are already in place to provide data for use in the Wild Salmon Policy (see Table 8). Available data have been collected through structured monitoring programs or rigorous methods have been applied at one point in time such that they could be repeated in the future. Additional effort would be required to manage / analyze existing data to generate appropriate metrics, or repeat sampling at times that would be most appropriate for application under the Wild Salmon Policy. These indicators are the most feasible to implement relative to the above categories.

Table 4. Summary of unique data sources evaluated during the practical assessment (see Appendix A). Organizations responsible for collecting, maintaining, and/or distributing these data are also included. These sources have been cross-referenced with the habitat types they could be used to inform.

Data Source (name)	Related organization(s)	Related habitats / indicators		
		Lake	Stream	Estuary
Baseline Thematic Mapping (BTM) (version 1)	BC Ministry of Agriculture and Lands	X	X	
BC Lake Stewardship Monitoring Program (BCLSMP)	BC Lake Stewardship Society	X		
BC Water License Database	BC Ministry of Environment		X	
BC Water Resources Atlas	BC Ministry of Environment	X		
BC Watershed Statistics	BC Ministry of Agriculture and Lands	X	X	X
Biophysical Assessment of Estuarine Habitats	Pacific Estuary Conservation Program / Canadian Wildlife Service/ Ducks Unlimited			X
British Columbia WELLs Database	BC Ministry of Environment		X	
Broad Ecosystem Inventory (BEI)	BC Ministry of Environment	X	X	
Canadian Wetland Inventory (CWI)	Canadian Wildlife Service / American Wetland Conservation Council (Canada) / Ducks Unlimited Canada	X		
Coastal Resource Information System (CRIS)	ILMB / BC Ministry of Environment			X
Community Mapping Network (CMN)	DFO / BC Ministry of Environment			X
Crown Leases and Licenses Database	Canadian Wildlife Service			X
DFO Commercial Catch Statistics	DFO			X
DFO Lake Productivity and Capacity Branch Reports	DFO	X		
DFO Sockeye Lakes Dataset	DFO	X		
Digital Road Atlas (DRA) Program	BC Ministry of Agriculture and Lands	X	X	
Ducks Unlimited Canada (DUC) Wetland Database	Ducks Unlimited Canada	X		
Environment Canada's Marine Water Quality Monitoring Program	Environment Canada			X
Environmental Monitoring system – Web Reporting (EMS-WR)	BC Ministry of Environment	X	X	X
EQ Win Database	Yukon Government		X	
Field Data Information System (FDIS)	BC Ministry of Environment		X	
Fish Passage Culvert Database – Cariboo Region, BC	BC Ministry of Environment		X	
Fisheries Information Summary System (FISS)	DFO / BC Ministry of Environment	X	X	
Floodplains Mapping Program	BC Ministry of Environment		X	X
Foreshore Inventory and Mapping (FIM)	District of Central Okanagan / BC Ministry of Environment / City of Kelowna / District of Lake Country / The Real Estate Foundation / DFO	X		
Forest and Range Evaluation Program (FREP)	BC Ministry of Forests and Range		X	
Forest Health Mapping	Natural Resources Canada / BC Ministry of Forests	X	X	
Fraser River Environmental Watch Program	DFO		X	
Fraser River Estuary Management Plan (FREMP) Atlas (hosted by the Community Mapping Network)	Fraser River Estuary Management Plan / DFO / BC Ministry of Environment			X
Fraser River Estuary Management Plan (FREMP) Sediment Budgeting	Fraser River Estuary Management Plan			X
GVRD Stormwater Management reports 1997-2002	Greater Vancouver Regional District	X	X	
Invasive Alien Plant Program (IAPP)	BC Ministry of Forests and Range	X		X
Invasive Species Atlas (Hosted by Community	DFO / BC Ministry of Environment	X		X

Data Source (name)	Related organization(s)	Related habitats / indicators		
		Lake	Stream	Estuary
Mapping Network)				
Lake Productivity and Capacity Reports	DFO	X		
Lake Surveys - Physical Characteristics, Chemical Characteristics, and Fish Collection	BC Ministry of Environment	X		
Marine Communications and Traffic Services Statistics (VTS)	Canadian Coast Guard			X
Mariculture Permitting Database (Alaska)	Alaska Department of Fish & Game			X
Marine Water Quality Monitoring Program	Environment Canada / DFO / CFIA			X
National Air Photo Library	Natural Resources Canada	X	X	X
National Road Network (NRN)	Natural Resources Canada	X	X	
Nearshore Fish Atlas of Alaska	NOAA Fisheries			X
Okanagan Basin Monitoring and Evaluation Program (OBMEP)	Okanagan Nation Alliance (ONA) / Colville Confederated Tribes (CCT)		X	
Okanagan Foreshore Program	BC Lake Stewardship Society	X		
Parkinson, E.A., J.R. Post, and S.P. Cox. 2004. Linking the dynamics of harvest effort to recruitment dynamics in a multistock, spatially structured fishery. Canadian Journal of Fisheries and Aquatic Sciences 61: 1658-1670.	Primary literature	X		
Provincial Obstacles to Fish Passage	BC Ministry of Environment		X	
Quickbird Satellite Imagery	Private companies	X	X	X
Reporting Silviculture Updates and Land Status Tracking System (RESULTS) Program	BC Ministry of Forests and Range	X	X	
Sensitive Ecosystem Inventory (SEI)	BC Ministry of Environment	X		
Shorekeepers Database	Shorekeepers			X
Shorezone mapping Alaska	NOAA Fisheries			X
State of Environment Reporting: British Columbia's Coastal Environment 2006	BC Ministry of Environment			X
Streamkeepers Data Entry Tool	DFO / Pacific Streamkeepers Federation		X	
Survey of Sport Fishing in British Columbia	BC Ministry of Environment / DFO	X		
Temperature Sensitive Streams Database	BC Ministry of Environment		X	
Vegetation Resource Inventory (VRI)	BC Ministry of Forest and Range	X		
WATEMP Database	DFO		X	
Water Survey of Canada Hydrometric Network (HYDAT Database)	Environment Canada		X	
Water Use Planning (WUP) Data	BC Hydro	X	X	
Watershed Statistics	BC Ministry of Agriculture and Lands	X	X	X
Yukon Biophysical Mapping	Yukon Government		X	
Yukon Fire History	Yukon Government		X	
Yukon Forest Cut Layer	Yukon Government		X	
Yukon Habitat Suitability Model	DFO		X	
Yukon Placer Mining Industry Water Quality Objectives Monitoring Protocol	Yukon Government		X	
Yukon Riparian Disturbance Mapping	DFO		X	
Yukon Spatial Data Clearinghouse	Yukon Government		X	
Yukon Water Board - Water Licenses Database	Yukon Government		X	
Yukon Water Resources Hydrometric Program	Yukon Government		X	
Yukon Water Temperature Data	DFO / Yukon Government		X	
Yukon Water Well Registry	Yukon Government		X	
Yukon Wetland Project	Ducks Unlimited Canada / Environment Canada		X	

Table 5. Summary of additional data sources identified, but not evaluated as part of this review. Where appropriate these data sources should be evaluated on a case-by-case basis for their ability to inform habitat indicators in specific watersheds / Conservation Units.

Data Source / Description	Related habitats / indicators		
	Lake	Stream	Estuary
BC Environmental Assessment Office (EAO) Project Information Centre (PIC) (http://www.eao.gov.bc.ca/epic/output/html/deploy/epic_project_index_report.html)	X	X	X
Canadian Environmental Assessment Registry, Yukon Territory (http://www.ceaa-acee.gc.ca/050/mapSearch_e.cfm?ProvinceID=10)		X	
Council of Forest Industry (COFI) and individual licensees	X	X	
DFO Estuary reports (available through WAVES)			X
DFO shellfish catch statistics http://www.pac.dfo-mpo.gc.ca/ops/fm/shellfish/default_e.htm			X
DFO surf smelt catch statistics http://www.pac.dfo-mpo.gc.ca/ops/fm/herring/smelt/default_e.htm			X
Haida Fisheries monitoring programs (Russ Jones 250 559 8945)	X	X	X
First Nations habitat monitoring	X	X	
Flood plain mapping models for the Fraser River			X
Forest Industry reports and estuary mapping on Vancouver Island (available from MacDonald Detwiler)			X
Fraser Basin Initiative(http://www.dfo-mpo.gc.ca/media/newsrel/2006/pr26_e.htm)		X	
Fraser River Action Program reports (http://www.rem.sfu.ca/FRAP/PDF_list)		X	
Fraser Salmon Watersheds Program (http://www.thinksalmon.com/fswp_project/)		X	
Islands Trust (e.g., Measuring Our Progress, http://www.islandstrust.bc.ca/poi/mop.cfm)		X	
Land and Resource Management Plans (LRMPs) and Regional Land Use Plans (http://ilmbwww.gov.bc.ca/lup/lrmp/index.html)	X	X	
Living Oceans Society (NGO) http://www.livingoceans.org/index.shtml			X
Municipalities / Regional Districts (e.g., stream mapping, estuary management plans)	X	X	X
Private Hydro companies	X	X	
Rafting / Kayaking operators		X	
Riparian Area Regulations (RAR) compliance and effectiveness monitoring (http://www.env.gov.bc.ca/habitat/fish_protection_act/riparian/riparian_areas.html)	X	X	
Salmonid Enhancement Program (http://www-heb.pac.dfo-mpo.gc.ca/facilities/salmonid_e.htm)	X		
Sea Change Marine Conservation Society (NGO) http://www.seachangelife.net/			X
Stott, R. and L. Smith. 2001. River Recovery: Restoring rivers and streams through dam decommissioning and modification. A Publication of the BC Outdoor Recreation Council. Available at: http://www.orcbc.ca/pdf/rivrecov.pdf		X	
University Research watersheds (e.g., UBC Malcolm Knapp Research Forest - http://www.mkrf.forestry.ubc.ca/general/index.htm, UNBC Quesnel River Research Centre - http://www.unbc.ca/qrrc/)	X	X	
Water Stewardship Community Round Tables (e.g., Cowichan Stewardship Round Table - http://www.cvrd.bc.ca/water_cowichan/index.htm, Nicola Watershed Community Round Table - http://www.nicolawump.ca/)	X	X	

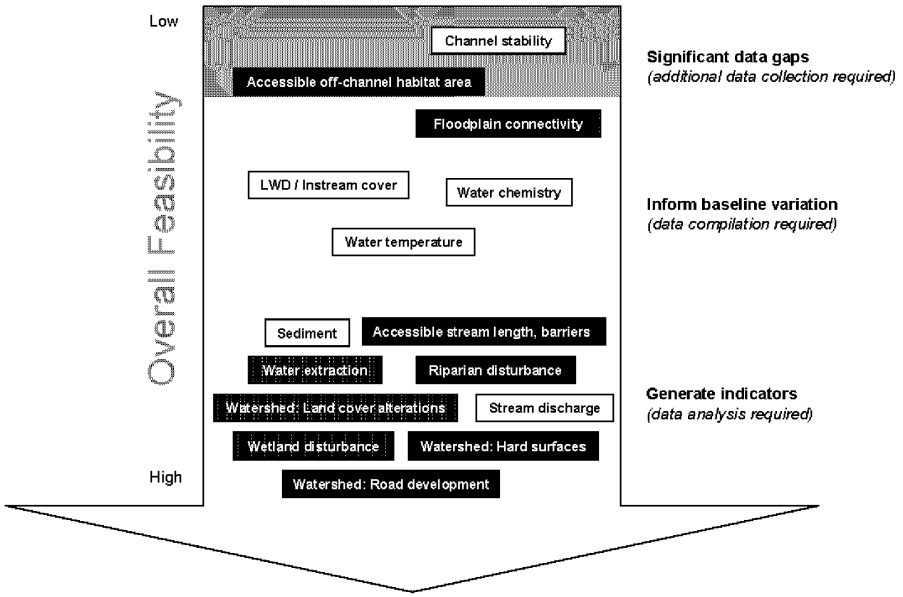


Figure 7. Qualitative representation of the level of effort required to develop available data to the point they could be used to generate STREAM habitat indicators under Strategy 2 of the Wild Salmon Policy.

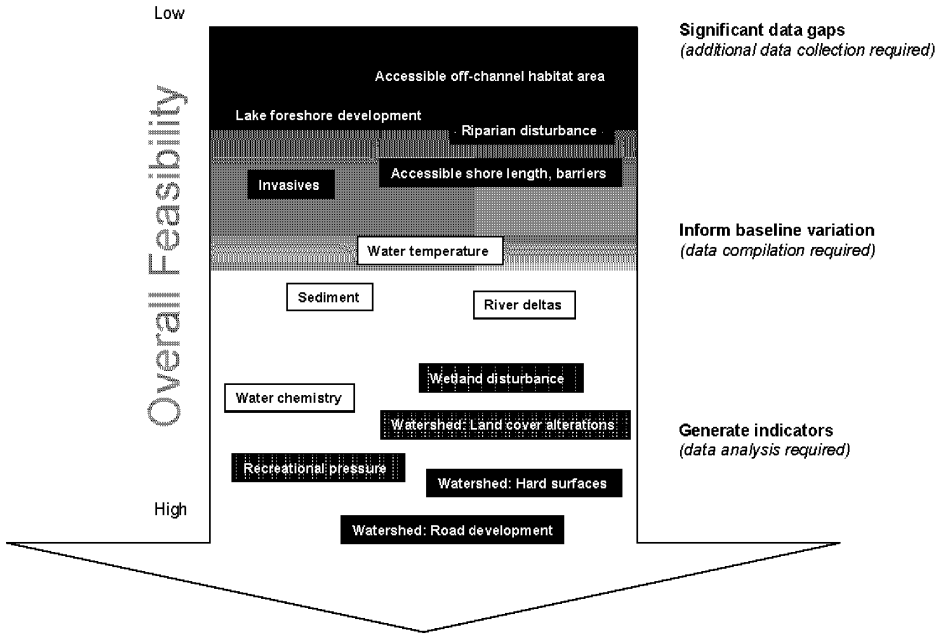


Figure 8. Qualitative representation of the level of effort required to develop available data to the point they could be used to generate LAKE habitat indicators under Strategy 2 of the Wild Salmon Policy.

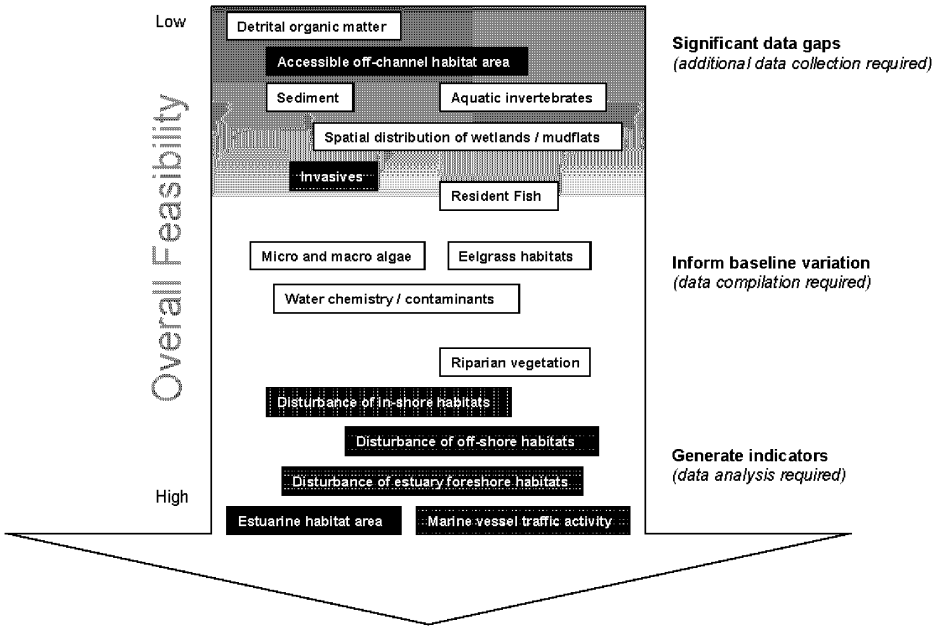


Figure 9. Qualitative representation of the level of effort required to develop available data to the point they could be used to generate ESTUARY habitat indicators under Strategy 2 of the Wild Salmon Policy.

Table 6. Summary of **habitat indicators with significant data gaps**. A significant level of additional effort would be required to use available data to inform indicators under Strategy 2 of the Wild Salmon Policy.

Habitat type	Indicator type	Indicator	Comments on data gap(s)
Stream	Quantity	Accessible off-channel habitat	Three data sources were identified to potentially inform this indictor (Quickbird Satellite Imagery, National Air Photo Library, Fisheries Information Summary System (FISS)). Two of the data sources represent remote sensed imagery which would require significant effort to interpret these data to generate the indicator across the Region. Some local information is available in BC through FISS, for instance. However, there is no centralized information source where these data could be readily summarized for the Region. Calculation of this indicator would need to consider areal extent of off-channel habitat as well as topographic data to understand areas of inundation to account for variation in water levels across seasons and years. Calculation of the indicator could use these information sources to develop a standardized / consistent approach to measuring off-channel habitats, or compile existing information through available reports / expert knowledge across watersheds and Conservation Units.
Stream	Status	Channel stability	Generation of a meaningful indicator and metric would not be trivial. Would require consideration of upslope terrain stability as well as a rate of change in channel movement over time. It would also be important to distinguish between natural channel movement and those adverse changes resulting from upslope activities. Seven data sources were identified / reviewed to potentially inform this indicator (Water Use Planning (WUP) Data, Okanagan Basin Monitoring and Evaluation Program (OBMEP), Streamkeepers Data Entry Tool, Forest and Range Evaluation Program (FREP), Field Data Information System (FDIS), National Air Photo Library, Fisheries Information Summary System (FISS)). None of these sources were deemed as providing sufficient data to provide the level of detail / information needed to inform this indicator broadly across the Region. A new targeted monitoring program would be required to generate this indicator
Stream	Pressure	Floodplain connectivity	A general data gap for stream floodplain connectivity exists in the province of BC and Yukon territory. In BC, the only data source available is through the floodplain mapping program which mapped the floodplains of major rivers affecting urbanised centers. Floodplains were mapped once sometime during the 80s to 90s, and flood limits shown are those assumed to be reached in the absence of all dykes. Dykes or other flood control mechanisms are not captured by the maps.
Lake	Pressure	Riparian disturbance	Riparian disturbance around lakes is not well catalogued for the province of BC nor is there any on going monitoring. Remote sensing methods (e.g., BTM and BEI) are for the most part unable to properly identify lake riparian zones as the resolution of these methods is too large. Ongoing monitoring at a smaller scale is required to be able to detect riparian areas are related disturbances. Suggestions coming out of the workshop included the use of QuickBird imagery (($17 per km^2), the application of Sensitive Ecosystem Inventory (SEI) methodology to more of the province, and the use of Foreshore Inventory Mapping (FIM) methodology.
Lake	Pressure	Lake foreshore development	What data is available for lake foreshore development in BC is localised to only five lakes, consequently the spatial extent is small. Some suggestions that came out the workshop including using Foreshore Inventory Mapping (FIM) methodology to fill the data gap for all sockeye lakes in the province. However, this could be quite expensive ($131 per km) and time consuming. An alternate suggestion is to use QuickBird satellite imagery ($17 per km^2) to monitor lake foreshore development. One advantage of QuickBird imagery is that it can be used to inform a slew of other indicators. A third suggestion was to use BTM mapping (an expensive endeavour), and a fourth was to look into regional district records for foreshore development. The former would be an expensive and lengthy endeavour and the latter would be very time consuming as records are not stored in a foreshore development database but would have to be filtered through individually.

Habitat type	Indicator type	Indicator	Comments on data gap(s)
Lake	Quantity	Accessible off-channel habitat	Evaluating accessible off channel habitats for lakes is difficult due to the dependence on how high the water is. A flooding event or substantial human withdrawal would be two of the few mechanisms that would cause significant changes in water level that would result in or limit access to off channel habitat. A snapshot in time of a lake is consequently insufficient. An alternative would be to use floodplain models in conjunction with existing topographic maps and local barrier information to assess prospective off-channel areas at different flood height levels. This could be relatively inexpensive to undertake (for areas where such floodplain models exist) as it would take advantage of existing analytical frameworks and mapping.
Lake	Quantity	Accessible shore length (barriers)	Similar to the indicator lake foreshore development, little data on accessible shore length exists for lakes in the province of BC. Suggestions to fill the data gap include QuickBird Satellite imagery, Foreshore Inventory Mapping, and regional district permitting applications for lakeside developments. Remote sensing done by BTM or BEI would not be able to capture the small scale of barriers along lake shores such as docks, rip rap, concrete breaks, etc.
Estuary	Status	Detrital organic matter	No agency/NGO datasets apparently exist that relate to monitoring of detrital organic matter in BC or Yukon estuaries. Research does exist that suggests how detrital turnover might be measured at localized scales in estuaries (e.g., Grout et al. 1997) but no larger efforts to determine this have been identified. Relative costs to undertake this more broadly may be small however.
Estuary	Quantity	Accessible off-channel habitat	Evaluating accessible off channel habitats for estuaries is difficult as this will be seasonally water level dependent. No single mapping effort can capture this. However, utilizing flood plain models in conjunction with existing topographic maps and local barrier information could allow assessment of prospective off-channel areas for fish at different flood height levels. This could be relatively inexpensive to undertake (in areas where such flood plain models exist) as it would take advantage of existing analytical frameworks and mapping.
Estuary	Status	Resident fish	No broad agency/NGO effort exists to monitor resident fish diversity in BC estuaries. Parks Canada is undertaking a program for evaluating fish communities in eelgrass beds in Pacific Coast National Parks (e.g., Robinson et al. 2005) and there are past research efforts in this regard for the Fraser River estuary (e.g., Grout et al. 1997) but there are no larger coordinated programs in place. NOAA Fisheries does have a broadscale design of sampling (beach seining) of resident fish species in SE Alaska eelgrass beds, however, as part of their Essential Fish Habitat (EFH) monitoring, which could provide information on resident fish populations in Yukon river estuaries. Developing a similar program for monitoring resident fish in BC estuaries would be relatively inexpensive if piggybacked on other sampling programs for commercial species.
Estuary	Status	Aquatic invertebrates	There does not appear to be any broadscale agency/NGO monitoring of aquatic invertebrates in BC or Yukon estuaries. It has been suggested that shorebird distribution and numbers (already monitored by CWS) could be used as surrogate indicators of invertebrate abundance in estuaries (if other covariates affecting bird abundance could be accounted for).
Estuary	Status	Sediment	Tracking and evaluating effects of sediment movements into BC and Yukon estuaries will be difficult. The FREMP program in the Fraser River provides a single example of the infrastructure and investment required to monitor an annual sediment budget for a large estuary. The costs of this component of FREMP could be used to calculate the costs of extending similar monitoring to other estuaries.
Estuary	Status	Spatial distribution of mudflats / wetlands	There have been no past agency/NGO programs to map and evaluate the changing composition of mudflats / wetlands in BC and Yukon estuaries. Recent work by DFO in this regard for the Campbell River estuary could provide the conceptual foundation for pursuing such analyses in other estuaries and will provide information on overall feasibility and cost of expanding such mapping.
Estuary	Status	Invasives	There appears to be a general data gap in agency/NGO monitoring of aquatic invasive species distribution and status in estuaries. Data is being assemembled for the distribution of invasive estuarine plants (e.g., Spartina) but currently this effort is limited in spatial extent (e.g., Community Mapping Network Invasive species atlas).

Table 7. Summary of **habitat indicators with sufficient data to inform baseline variation**, but insufficient data to fully inform development of a habitat indicator under Strategy 2 of the Wild Salmon Policy.

Habitat type	Indicator type	Indicator	Comment on availability / limitations of existing information
Stream	Status	Water chemistry	Five data sources were identified to report on water chemistry in British Columbia and the Yukon: Environmental Monitoring System; Water Use Planning Data; EQ Win Database; Yukon Placer Mining Industry Water Quality Objectives Monitoring Protocol; Fisheries Information Summary System. Although data are substantive across sources, these databases are disparate having been collected by different monitoring programs with different protocols, focusing on different water chemistry attributes. As with all data for Type II indicators, these data would be helpful to provide a measure of baseline variation across the Region.
Stream	Status	Water temperature	Five data sources were identified from both British Columbia and the Yukon: Temperature Sensitive Streams Database, Fraser River Environmental Watch Program, WATEMP Database, Water Use Planning (WUP) Data, and Yukon Water Temperature Data. The Fraser River Environmental Watch Program represents the only program focused on repeated monitoring of water temperatures at fixed locations as related to salmon migration. Although useful and informative, the geographic extent of this program on its own would be too limited for WSP purposes. In general, other data sources represent opportunistic monitoring across BC and Yukon. These data would provide perspective to decision makers about baseline variation in temperatures. Once available (in 1+ years), the temperature modelling work associated with Temperature Sensitive Stream designations might be informative to understanding temperatures across BC, though these models would only provide a general measures of water temperatures (e.g., annual metric, not a daily prediction of temperature).
Stream	Status	Large woody debris (in-stream cover)	Three data sources were identified in BC (DFO streamkeepers data entry tool, Forest and Range Evaluation Program (FREP), Field Data Information System(FDIS)). No data were identified for the Yukon beyond a limited set of stream files maintained in DFO Whitehorse office; these data would not be sufficient to inform any indicators. Each data source has weaknesses which preclude them from being used on their own for WSP purposes. DFO streamkeepers data entry tool hasn't been sufficiently supported to ensure consistent entry of all available data. FREP program is relatively new thus lacking historic data, plus only streams on crown forested land are included. FDIS appears to provide the best broad-scale data source, though no repeat sampling is assured at a site to monitor changes over time. Data across sources are collected / stored in different ways, creating difficulties for aggregation. Also there is no broad-scale data / monitoring in the Yukon, which constitutes a large data gap. In spite of above weaknesses, these data could be used to provide an understanding of variation across streams / years.
Lake	Status	Sediment	Data on suspended sediments (SS) is available for lakes throughout the province; however it is spatially patchy, is not available for all sockeye lakes, and is not collected in any systematic way. It would be expensive and time consuming to install monitoring sites on every sockeye lake (< 90) and therefore may not be feasible. One alternative may be to monitor land use practices via remote sensing that tend to lead to high levels of SS. A second alternative may be to develop or use a pre-existing lake productivity models that takes into account geology, topography, land cover, and precipitation to predict sediment loads. With regards to data on lake substrate there is a paucity of information available. To our knowledge there appears to be no data sources within the province of BC that record this type of information in a comprehensive and systematic manner.
Lake	Pressure	River delta	There has been no inventory or monitoring of river deltas in lakes for BC. Presence and absence information could be derived using the BC watershed atlas by mapping the water through flow each watershed polygon in order to identify where river deltas in lakes occur. This would provide baseline information for presence or absence, but it would not provide any information on the status of river deltas as they change over time and respond to environmental conditions. In order to obtain the latter kind of information direct monitoring of the delta would be required and could be achieved using QuickBird imagery or something similar.

Habitat type	Indicator type	Indicator	Comment on availability / limitations of existing information
Lake	Status	Water temperature	A general data gap exists for lake temperature in BC in so far that there is no comprehensive and continuous coverage for the province. However, a few disparate data sources that could be used to inform baseline variation are available. Water temperature data is collected by the BC Lakes Stewardship Society; however it is restricted to 43 lakes, not all of which are sockeye bearing, and monitoring is not consistent across lakes with sampling occurring at different frequencies and depths (majority just take surface temperature) across lakes. DFO lake productivity reports for sockeye lakes do not always capture water temperature and if temperature data is collected it is not housed in any central database as is water chemistry data. Workshop participants also noted that little if any water temperature data is collected in lake spawning areas where water temperature will have its greatest effect on salmon. Suggestions for the workshop on how to measure this indicator included taking an ecozone based approach with index lakes in each ecozone that could act as benchmarks for seasonal thermal profiles. The cost of using an ecozone approach to supplement what temperature data has been collected would not be very great as there are already lakes in each ecozone that are well monitored/studied (e.g., lakes in the Kootenay and Skeena region). Another suggestion was to use ice on and off time as it is felt to be more informative than water temperature with respect to what is happening in a lake.
Lake	Pressure	Invasives	Although a fair amount of data collection is ongoing for terrestrial invasive plant species in BC, there appears to be no equivalent province wide monitoring initiative for aquatic invasive species distribution and status – very little work is done on invasive aquatic invertebrates. What data are available they can be used to inform baseline variation. Data on aquatic invasives are collected either opportunistically with limited spatial coverage (e.g., Community Mapping Network Invasive species atlas and FISS) or are part of a localized effort without a standardised monitoring protocol (e.g., Cultus and Okanagan Lakes Eurasian milfoil eradication program). One possible suggestion being discussed by the interministry invasive plant working group is to expand the scope of the provincially run Invasive Alien Plant Program to include aquatic invasives. To do so would require collaboration amongst several government ministries as the Ministry of Forest and Range does not have the mandate nor the funds to do so themselves.
Estuary	Status	Eelgrass	Eelgrass mapping is being undertaken by a range of NGO groups for a fairly broad extent along BC coasts using standard mapping methods that have been developed for volunteer groups. This assembled information (and past DFO eelgrass mapping efforts) are served up on the Community Mapping Network's Eelgrass Bed Mapping Atlas. The province has also undertaken systematic one-time mapping of eelgrass in coastal shorezone units for the entire province as part of the inventory for the Coastal Resource Information System. These data sources could provide sufficient baseline information to inform future monitoring of changes in eelgrass beds in selected estuaries. Additionally, improved methods for capturing eelgrass extents through remote sensing are being developed (e.g., QuickBird satellite imagery) which should make evaluations of eelgrass distribution in estuaries more technically and economically feasible in the future.
Estuary	Status	Micro and macro algae	Micro and macro algae mapping is being undertaken by a range of NGO groups for a fairly broad extent along BC coasts. The assembled maps are served up on the Community Mapping Network's Habitat Atlases for various coastal areas. The province has also undertaken systematic one-time mapping of macro algae in coastal shorezone units for the entire province as part of the inventory for the Coastal Resource Information System. These data sources could provide sufficient baseline information to inform future monitoring of changes in algal beds in selected estuaries.
Estuary	Status	Water Chemistry / Contaminants	Minimal water chemistry information is collected directly in BC and Yukon estuaries but some inferences can be made from water quality monitoring by Environment Canada in shellfish areas and from upstream water quality monitoring undertaken for the province's EMS system. The province's State of the Environment Report for the coast also summarized sediment contaminant levels in selected provincial estuaries which could be used as a comparative baseline. Although there are currently no scheduled plans for a repeat assessment of contaminants, this might possibly be undertaken by the province at a future time.

Table 8. Summary of practical assessment findings for **habitat indicators with appropriate data to generate metrics**. See Table 2 for clarification of these headings. Note use of the following abbreviations: Data availability: Y – yes, N – no, UNK – unknown; Relative cost: NA – not available, L – low $0-$50K, M – moderate = $50K-$100K, H – high > $100K; Spatial extent: No. of areas, local, regional, provincial; Spatial resolution: NA – not applicable, metres, kilometres; Temporal extent: year(s) of sampling; Temporal frequency: <monthly, monthly, seasonal, annual, multi-year; Scientific relevance: rank (score). Program costs refer to those resources associated with the initial program delivery by non-DFO entity, incremental cost refers to the cost to DFO to use these data for WSP purposes, and operating costs refer to the effort required by DFO to apply the data to generate the relevant habitat indicator.

Habitat type	Indicator type	Indicator	Data source(s)	No of reviewed sources	Data availability	Relative cost			Spatial extent	Spatial resolution	Temporal extent	Temporal frequency	Scientific relevance (rank / score)	Overall feasibility / comments on calculation of indicator
						Program costs	Incremental costs	Operating costs						
Stream	Quantity	Accessible stream length, barriers	▪ Provincial Obstacles to Fish Passage ▪ Yukon Habitat Suitability Model	4	YES	HIGH	LOW	LOW	Pacific Region (BC & YK)	Point locations	1970 - present	unknown	Not ranked	**High:** Barrier information is available for BC. This information would need to be combined with a provincial watershed atlas (1:50,000 or 1:20,000) to calculate an appropriate indicator. Barrier information is lacking for the Yukon, though probably not as extensive a concern as in BC. Yukon also lacks a watershed atlas for the Territory, though the habitat suitability model does provide a framework for building an atlas and calculating this indicator for the Yukon watershed only. Given regional efforts in BC to better understand barriers (e.g., Okanagan and Cariboo), the provincial obstacle database should be supplemented / updated with regional information to improve its accuracy.
Stream	Pressure	Watershed Land cover alterations	▪ Baseline Thematic Mapping / Watershed statistics ▪ Yukon Biophysical mapping ▪ Yukon Fire History ▪ Yukon Forest Cut Layer	4	YES	HIGH	LOW	HIGH	Pacific Region (BC & YK)	1:250,000	1990s – present	multi-year	7 out of 13 (7.5)	**Medium:** Classifying land cover alteration is complex in so far that one needs to use multiple data sources (e.g., satellite imagery and GIS shapefiles). Land alterations could include: agriculture, forestry, urban development, wildfire, mining activities, and road networks. Neither BTM nor BEI are updated with new landsat imagery on a regular basis. Updating of landsat imagery is the limiting step in using either of these methods in so far that it will be the most costly both from a monetary and time perspective. The Yukon has not applied a similar approach to measuring land cover alterations, though such a project would be consistent with the Yukon Biophysical Mapping project which is currently under development.
Stream	Pressure	Watershed Hard surfaces	▪ Baseline Thematic Mapping / Watershed statistics	4	YES	HIGH	LOW	HIGH	BC	1:250,000	1990s - present	multi-year	6 out of 13 (7.5)	**Moderate.** To fully catalogue impervious surface for a given watershed roads and parking lots (from NRN) should be coupled with urban centers (from BTM or BEI). BTM offers the best provincial coverage for impervious surfaces; however, it has not been updated with new landsat imagery for the entire province. Updating the landsat imagery is the limiting step in so far that it will be the most costly both from a monetary and time perspective. Extent of hard surfaces are limited in the Yukon.
Stream	Pressure	Watershed Road development	▪ National Road Network (NRN) / Watershed statistics	3	YES	NA	LOW	MOD	Pacific Region (BC & YK)	metres	1979 – present	Annual	5 out of 13 (9)	**High.** The NRN is already in GIS format, is updated regularly, includes the best available data from BC and the Yukon, and is not costly to obtain / use. In addition, the effort required to calculate desired metrics from the GIS files should be low. Statistics on road density, stream crossing, and road length are summarized in the watershed statistics. A limitation is that the Yukon does not have a complete watershed atlas against which to calculate road densities or road-stream crossings. The Yukon Habitat Suitability Model is developing an intelligent stream linework that could be used for such purposes.
Stream	Pressure	Wetland disturbance	▪ Broad Ecosystem Inventory (BEI) / Watershed atlas ▪ Yukon Biophysical mapping	6	YES	HIGH	LOW	HIGH	Pacific Region (BC & YK)	1:250,000	1990s to present	Annual	8 out of 13 (7.5)	**Moderate.** BEI provides the best provincial scale coverage as it distinguishes between different kinds of wetlands, a distinction that is important when thinking about fish habitat. Although, the landsat imagery has only been updated once withing BEI, the methodology and more recent imagery are readily available to upgrade the BEI. Two drawbacks of BEI are: first, the cost of updating the landsat imagery used by the BEI; and second, as a consequence of the scale/resolution of mapping BEI tends to overlook and/or misclassify smaller wetlands. Ideally, the broad scale mapping would be coupled with on the ground monitoring that systematically verifies and catalogues wetlands in the

Habitat type	Indicator type	Indicator	Data source(s)	No of reviewed sources	Data availability	Relative cost			Spatial extent	Spatial resolution	Temporal extent	Temporal frequency	Scientific relevance (rank / score)	Overall feasibility / comments on calculation of indicator
						Program costs	Incremental costs	Operating costs						
														province. The Canadian Wetland Inventory (CWI) aims to do just this, however it is still in an inchoate stage. An inventory of wetlands in BC and Yukon does not presently exist nor is there any on going monitoring of wetlands occurring. Several disparate data sources conducting monitoring do exist (e.g., Ducks Unlimited Canada, Community Mapping Network, SEI projects, and Wetland Keepers projects) and could be used to inform baseline variation; however there is no systematic coherency between the sources and the spatial extent of these sources is too limited to actively inform the indicator. Remote-sensed imagery of wetlands for the Yukon should be coordinated with the Yukon Biophysical mapping.
Stream	Pressure	Water extraction	Surface water: ▪ BC Water License Database ▪ Yukon Water Board - Water Licenses Database ▪ Water Resources Atlas Groundwater: ▪ British Columbia WELLs Database ▪ Yukon Water Well Registry	7	YES	NA	LOW	LOW	Pacific Region (BC & YK)	Surface water by waterbody; groundwater by point locations	Depends on data source	Updated regularly	12 out of 13 (5.5) though recognized by DFO this rank should be higher	**High:** Seven data sources were identified / reviewed. Both surface water and groundwater extraction need to be captured by this indicator. Databases with such information are available for both British Columbia and the Yukon: surface water (BC Water License Database and Yukon Water Board - Water Licenses Database) and groundwater (British Columbia WELLs Database and Yukon Water Well Registry). Monitoring of actual amounts of water taking associated with water licenses is relatively non-existent, however. This poses a challenge to determining actual water extraction in watersheds of interest. Regardless, a summary of these data would be informative to understanding where water supplies are oversubscribed. This indicator should also be accompanied with some measure of stream discharge for nearby, or index watersheds. Maps of areas with restrictions on allocations of water licenses are also available and would be informative (e.g., Water Resources Atlas).
Stream	Pressure	Riparian disturbance	▪ Baseline Thematic Mapping / Watershed statistics ▪ Yukon Biophysical Mapping	10	YES	HIGH	LOW	HIGH	Pacific Region (BC & YK)	1:250,000	1990s – present	multi-year	2 out of 13 (10.5)	**Moderate:** A large number of potential data sources were identified to inform this indicator. Given the need for broad-scale representation of disturbance, the best option is to apply remote sensing imagery across BC and Yukon. Riparian disturbance in the Yukon would likely be the result of Placer mining and wildfire disturbance. To-date the Territory has not comprehensively mapped riparian disturbance. One gap is a complete watershed atlas (i.e., stream linework and watershed polygons) does not exist for the territory, though the Yukon Habitat Suitability model could provide a starting framework to develop the atlas.
Stream	Pressure	Sediment	▪ Water Survey of Canada Hydrometric Network ▪ Yukon Placer Mining Industry Water Quality Objectives Monitoring Protocol	5	YES	HIGH	LOW	LOW	Pacific Region (BC & YK)	Emphasis on larger rivers	High variable, depends on stations of interest	daily	10 out of 13 (7)	**Moderate:** Five data sources were reviewed / identified from across the Pacific Region: Water Survey of Canada Hydrometric Network, Yukon Placer Mining Industry Water Quality Objectives Monitoring Protocol, Streamkeepers Data Entry Tool, EQ Win Database, Water Use Planning (WUP) Data, and Field Data Information System (FDIS). The Water Survey of Canada Hydrometric Network and Yukon Placer Mining Industry Water Quality Objectives Monitoring Protocol are the clear front runners as these represent structured and continuous monitoring of suspended sediments. The limitation with these specific data sets is that they may not be broad-scale enough for DFO purposes. Hydrometric network measures sediments at fewer streams than are being monitored for stream discharge. The Yukon monitoring protocol is associated with placer mining activities only. These data would be informative to helping decision makers understand background variation in suspended sediments. Field Data Information System (FDIS) was the only source capturing stream substrate information using broadly applied and standardized methods.
Stream	Status	Stream	▪ Water Survey of Canada	6	YES	HIGH	LOW	LOW	Pacific	Emphasis on	High	Daily	4 out of 13	**High:** Two good sediment monitoring programs exist across the region.

Habitat type	Indicator type	Indicator	Data source(s)	No of reviewed sources	Data availability	Relative cost			Spatial extent	Spatial resolution	Temporal extent	Temporal frequency	Scientific relevance (rank / score)	Overall feasibility / comments on calculation of indicator
						Program costs	Incremental costs	Operating costs						
		discharge	Hydrometric Network (HYDAT Database) ▪ Yukon Water Resources Hydrometric Program						Region (BC & YK)	larger rivers	variable, depends on stations of interest		(10)	Although in its infancy, the sediment monitoring associated with placer mining in the Yukon follows a rigorous and repeated sampling design. In addition a subset of the Water Survey of Canada hydrometric stations across the region also monitor sediment. A constraint however, is that these monitoring programs tend to focus on large rivers, meaning smaller streams would not be captured through these efforts.
Lake	Status	Water Chemistry	▪ DFO Sockeye Lakes Dataset	6	YES	MOD	LOW	LOW	BC	NA	1980s – present	Monthly to multi-year	5 out of 12 (9)	**High.** The sockeye lakes dataset contains water chemistry data for all sockeye nursery lakes in the province. The only drawback of the dataset is that lake specific data varies in quantity and temporal extent across lakes – surveys are not systematic across the province.
Lake	Pressure	Watershed Road Development	▪ National Road Network (NRN) / Watershed statistics	3	YES	NA	LOW	LOW	BC and Yukon	m	1979 – present	annual	8 out of 12 (7.5)	**High.** The NRN is already in GIS format, is updated regularly, covers the desired spatial areas, and is not costly to obtain and use. In addition, the effort required to calculate desired metrics from the GIS files should be low. Statistics on road density, stream crossing, and road length are summarized in the watershed statistics.
Lake	Pressure	Watershed Land cover alteration	▪ Baseline Thematic Mapping / Watershed statistics ▪ Forest Health Mapping	4	YES	HIGH	LOW	HIGH	BC	1:250,000	1990s – present	multi-year	1 out of 12 (11)	**Moderate.** Classifying land cover alteration is complex in so far that one would need to use multiple data sources. Land alteration would include developments in/of: agriculture, forestry, urban, fire, mining, and road networks. BTM offers the best provincial coverage of land use; however, BTM has not regularly been updated with new landsat imagery. Updating the landsat imagery is the limiting step in using this method in so far that it will be the most costly both from a monetary and time perspective. The watershed statistics provides land summaries of each watershed.
Lake	Pressure	Watershed Hard surface	▪ Baseline Thematic Mapping / Watershed statistics	4	YES	HIGH	LOW	HIGH	BC	1:250,000	1990s - present	multi-year	3 out of 12 (9.5)	**Moderate.** In order to fully catalogue impervious surface for a given watershed roads and parking lots (from NRN) should be coupled with urban centers (from BTM or BEI). BTM offers the best provincial coverage for impervious surfaces; however, it has not been updated with new landsat imagery for the entire province. Updating the landsat imagery is the limiting step in so far that it will be the most costly both from a monetary and time perspective.
Lake	Pressure	Recreational Pressure	▪ National Road Network ▪ BC Water Resource Atlas ▪ Survey of Sport Fishing in British Columbia	5	YES	HIGH	LOW	LOW	BC	1) m 2) 1: 50,000 3) NA	1) 1979 – present 2) 2004 - present 3) 1976 - present	1) annual 2) ongoing 3) every 5 years	11 out of 12 (5.5)	**High.** A combination of these three data sources would provide comprehensive detail of recreational pressure for the province. The BC water resource atlas recreational sensitivity layer coupled with the distance of lakes from roads would give high level recreational pressure information for the province. At the watershed / CU level, the Survey of Sport Fishing provides lake specific information that could be used to give an indication of lake usership (i.e., relative number of visitors).
Lake	Pressure	Wetland Disturbance	▪ Broad Ecosystem Inventory (BEI) / Watershed statistics	6	YES	HIGH	LOW	HIGH	BC	1:250,000	1990s to present	Annual	10 out of 12 (6.5)	**Medium.** BEI provides the best provincial scale coverage as it distinguishes between different kinds of wetlands: a distinction that is important when thinking about fish habitat. Although, the landsat imagery has only been updated once withing BEI, the methodology and more recent imagery are readily available to upgrade the BEI. Two drawbacks of BEI are: first, the cost of updating the landsat imagery used by the BEI; and second, as a consequence of the scale/resolution of mapping BEI tends to overlook and/or misclassify smaller wetlands. Ideally, the broad scale mapping would be coupled with on the ground monitoring that systematically verifies and catalogues wetlands in the province. The Canadian Wetland Inventory (CWI) aims to do just this, however it is still in an inchoate stage. An inventory of provincial wetlands does not presently exist nor is there any on going monitoring of wetlands occurring at a provincial scale. Several disparate data sources conducting monitoring do exist (e.g., Ducks Unlimited Canada,

Habitat type	Indicator type	Indicator	Data source(s)	No of reviewed sources	Data availability	Relative cost			Spatial extent	Spatial resolution	Temporal extent	Temporal frequency	Scientific relevance (rank / score)	Overall feasibility / comments on calculation of indicator
						Program costs	Incremental costs	Operating costs						
														Community Mapping Network, SEI projects, and Wetland Keepers projects) and could be used to inform baseline variation; however there is no systematic coherency between the sources and the spatial extent of these sources is too limited to actively inform the indicator.
Estuary	Pressure	Marine vessel traffic	▪ Marine Communications and Traffic Services Statistics (VTS) ▪ DFO Catch Statistics	2	YES	HIGH	LOW	LOW	BC	kilometers	2002-present	<monthly to annual	12 out of 14 (8.5)	**High.** The VTS database provides direct vessel traffic information on larger ships. DFO Catch statistics on catch and vessel days can be used to infer traffic densities of smaller fishing boats. A combination of these 2 datasets should provide comprehensive and regularly updated information on marine vessel activity in and around estuaries along the BC coast.
Estuary	Quantity	Estuarine habitat area	▪ Biophysical Assessment of Estuarine Habitats	1	YES	HIGH	LOW	LOW	BC (442 major estuaries)	meters	2007	One time only	Not ranked	**Moderate.** The Biophysical Assessment provides a solid baseline inventory of estuarine habitat area for larger delineated estuaries across BC, and a standardized methodology for repeat surveys. Use of this information for monitoring of future changes in estuarine habitat area will depend on a commitment to repeat mapping, at least in selected representative areas.
Estuary	Pressure	Disturbance of foreshore habitats	▪ Biophysical Shoreline Mapping (CRIS) – Shoreline Hardening ▪ Fraser River Estuary Management Program	4	YES	HIGH	LOW	LOW	BC Regional	meters	2002	Annual to Multi-year	1 out of 14 (11)	**Moderate.** The shoreline hardening inventory undertaken by the province for the CRIS program has provided baseline mapping of estuarine foreshore disturbance in costal southern BC. Further shoreline hardening mapping will be undertaken by MOE in additional areas of the province in coming years. This broader scale mapping can be supplemented in the Fraser River estuary (where CRIS has not been undertaken) by the more intensive and regularly updated mapping of foreshore development for FREMP.
Estuary	Pressure	Disturbance of in-shore habitats	▪ Crown Land Leases and Licenses	4	YES	HIGH	LOW	LOW	BC	meters		Multi-year	7 out of 14 (9.5)	**High.** The province's Crown Leases and Licenses database provides a quantification of the extent of land devoted to industrial or conservation activities within defined estuaries across the province. This information is continually updated with changes in lease status and the CWS has committed to regular summary updates of this information for use in evaluating extent of disturbance (intertidal and subtidal) within estuaries.
Estuary	Pressure	Disturbance of off-shore habitats	▪ Crown Land Leases and Licenses	3	YES	HIGH	LOW	LOW	BC	meters		Multi-year	8 out of 14 (9)	**High.** The province's Crown Leases and Licenses database provides a quantification of the extent of land devoted to industrial or conservation activities within defined estuaries across the province. This information is continually updated with changes in lease status and the CWS has committed to regular summary updates of this information for use in evaluating extent of disturbance (intertidal and subtidal) within estuaries.
Estuary	Status	Riparian vegetation	▪ Biophysical Shoreline Mapping (CRIS) – Shoreline Hardening ▪ Fraser River Estuary Management Program	2	YES	HIGH	LOW	LOW	BC Regional	meters	2002	Multi-year	4 out of 14 (10.5)	**Moderate.** The shoreline hardening inventory undertaken by the province for the CRIS program has provided baseline mapping of existing estuarine riparian vegetation in some urbanized areas of southern BC. Further riparian mapping using this approach will be undertaken by MOE in additional areas of the province in coming years. This broader scale mapping can be supplemented in the Fraser River estuary (where CRIS has not been undertaken) by the more intensive and regularly updated mapping of riparian vegetation for FREMP.

6. Recommendations

6.1 Implementing the framework in the short-term

Below we recommend two options for developing habitat indictors in the short-term. Table 9 summarizes a "*basic*" option; Table 10 summarizes an "*ideal*" option. Given common analytical methods and data sources we recognize there are sensible groupings about how multiple indicators can be calculated for more than one habitat type. Thus, we've grouped indicators based on the common data sets we envision as being needed for a single analytical project. For each project we have also assigned a qualitative measure of the relative costs based on previous cost categories – Low is $0-$50K, Moderate is $50K-$100K, and High is > $100K (drawn from values for operating cost in Table 8). Scientific relevance is based on DFO's rankings from earlier stages of work: high relevance ranks within the top third, moderate relevance ranks within the middle third, while low relevance ranks within the lowest third of indicators.

These recommendations are based on indicators that could most practically be implemented given considerations of data availability, relative cost, spatial scales, temporal scales, and scientific relevance. They are not based on what would be most appropriate if an entirely new habitat monitoring program was being developed to support the Wild Salmon Policy. As well, these options do not include the six quantity habitat indicators because DFO has committed to providing these indicators for streams (accessible stream length & accessible off-channel habitat), lakes (accessible shoreline length & accessible off-channel habitat), and estuaries (estuary habitat area & accessible off-channel habitat area) regardless of these recommendations.

These options represent a subset of habitat indicators to recognize that DFO will not be able to implement all those listed in Table 1. To reach a narrower list, we developed these recommendations by focusing on Type III indicators – those indicators with sufficient data / monitoring programs to generate metrics (see Table 8). The "*basic*" option reflects a minimum list of Type III indicators that have high relevance and could feasibly be implemented given constraints in cost. This option recommends 14 indicators (6 stream, 5 lake, and 3 estuary indicators), drawing upon 7 separate analytical projects. Most of these indicators have a high or moderate scientific relevance and low cost. Project #3 is of high cost, but also provides the greatest number of indicators. The "*ideal*" option includes all indicators included in the basic option, with an additional four Type III and two Type II indicators that are scientifically relevant and could feasibly be implemented at lowest cost relative to other indicators. This option recommends 20 indicators (8 stream, 6 lake, and 6 estuary indicators), requiring 12 analytical / monitoring projects.

An observation in that there is an emphasis on pressure indicators in this list: 12 of 14 and 16 of 20 are pressure indicators in the basic and ideal options, respectively. We have two comments given this outcome. First, this emphasis is primarily the result of there being more data sources available for pressure indicators at a broad-scale. In other words, it appears that infrastructure for broad-scale monitoring of habitat status is lacking across the Pacific Region. This is a critical gap given that accurate measures of habitat status will be important to evaluating population status and priority Conservation Units under the Wild Salmon Policy. Thus, priorities for new monitoring in the future should be focused on measuring habitat status given the abundance of pressure information that is available. Second, given the significant use of remote-sensed imagery for informing habitat indicators, we recommend DFO consider a rigorous validation exercise to quantify error rates with these data and to ensure they represent landscape pressures within reasonable ranges of error.

Table 9. List of habitat indicators recommended as a "basic" option.

Habitat Type	Indicator Type	Indicator	Data sources / analytical project	Relative cost	Scientific relevance
Stream	Pressure	Water extraction	Project #1: ▪ BC Water License Database ▪ Yukon Water Board - Water Licenses Database ▪ Water Resources Atlas ▪ BC WELLs Database ▪ Yukon Water Well Registry	Low	Low*
Stream	Status	Stream discharge	Project #2: ▪ Water Survey of Canada Hydrometric Network ▪ Yukon Water Resources Hydrometric Program	Low	High
Stream / Lake	Pressure	Watershed: Road development	Project #3: ▪ National Road Network / BC watershed statistics ▪ Baseline Thematic Mapping / BC watershed statistics ▪ Forest Health Mapping ▪ Yukon Biophysical Mapping ▪ Yukon Fire History ▪ Yukon Forest Cut Layer	High	High
Stream	Pressure	Riparian disturbance			High
Stream / Lake	Pressure	Watershed: Land cover alterations			Moderate / High
Stream / Lake	Pressure	Watershed: Hard surfaces			Moderate / High
Lake	Status	Water chemistry	Project #4: ▪ DFO Sockeye Lakes Dataset	Low	Moderate
Lake	Pressure	Recreational pressure	Project #5: ▪ National Road Network ▪ BC Water Resource Atlas ▪ Survey of Sport Fishing in BC	Low	Low
Estuary	Pressure	Disturbance of in-shore habitats	Project #6: ▪ Crown Land Leases and Licenses	Low	Moderate
Estuary	Pressure	Disturbance of off-shore habitats			Moderate
Estuary	Pressure	Marine vessel traffic	Project # 7: ▪ Marine Communications and Traffic Services Statistics ▪ DFO Catch Statistics	Low	Low

* Water extraction has been recognized by DFO that it should be ranked higher than in their initial assessment of scientific relevance.

Table 10. List of habitat indicators recommended as an "ideal" option.

Habitat Type	Indicator Type	Indicator	Data sources / analytical project	Relative Cost	Scientific relevance
Stream	Pressure	Water extraction	Project #1: ▪ BC Water License Database ▪ Yukon Water Board - Water Licenses Database ▪ Water Resources Atlas ▪ BC WELLs Database ▪ Yukon Water Well Registry	Low	Low*
Stream	Status	Stream discharge	Project #2: ▪ Water Survey of Canada Hydrometric Network ▪ Yukon Water Resources Hydrometric Program	Low	High
Stream / Lake	Pressure	Watershed: Road development	Project #3: ▪ National Road Network / BC watershed statistics ▪ Baseline Thematic Mapping / BC watershed statistics ▪ Forest Health Mapping ▪ Yukon Biophysical Mapping ▪ Yukon Fire History ▪ Yukon Forest Cut Layer	High	High
Stream	Pressure	Riparian disturbance			High
Stream / Lake	Pressure	Watershed: Land cover alterations			Moderate / High
Stream / Lake	Pressure	Watershed: Hard surfaces			Moderate / High
Lake	Status	Water chemistry	Project #4: ▪ DFO Sockeye Lakes Dataset	Low	Moderate
Lake	Pressure	Recreational pressure	Project #5: ▪ National Road Network ▪ BC Water Resource Atlas ▪ Survey of Sport Fishing in BC	Low	Low
Estuary	Pressure	Disturbance of in-shore habitats	Project #6: ▪ Crown Land Leases and Licenses	Low	Moderate
Estuary	Pressure	Disturbance of off-shore habitats			Moderate
Estuary	Pressure	Marine vessel traffic	Project # 7: ▪ Marine Communications and Traffic Services Statistics ▪ DFO Catch Statistics	Low	Low
Stream	Status	Water temperature	Project # 8: ▪ New monitoring program building on available data	Moderate	Moderate
Stream / Lake	Pressure	Wetland disturbance	Project # 9: ▪ Broad Ecosystem Inventory (BEI) / Watershed atlas	High	Moderate / Low
Estuary	Pressure	Disturbance of foreshore habitats	Project # 10: ▪ Biophysical Shoreline Mapping (CRIS) – Shoreline Hardening ▪ Fraser River Estuary Management Program	Low	High
Estuary	Pressure	Riparian vegetation			High
Estuary	Status	Eelgrass	Project # 11: ▪ New monitoring program building on available data	High	Moderate

* Water extraction has been recognized by DFO that it should be ranked higher than in their initial assessment of scientific relevance.

6.2 Improving the framework in the long-term

A framework for future selection and use of indicators can be assembled by referring to existing indicator systems that are effective in detecting disturbed and undisturbed habitats. While the use of indicators is a recent trend in the management of fish populations, habitat indicators have a relatively long history in the management of water quality in streams and lakes. Lessons learned from this other work are worth examining for development of a fish based indicator system.

Over large regional scales, bioassessment procedures based on multimetric indices of biotic composition and abundance have been used to monitor water quality (Karr 1981, Karr and Chu 1999, Barbour et al. 1999, Whittier et al. 2007). A multimetric index is the combination of a number of individual metrics (e.g. number of mayflies, stoneflies, caddisflies (EPT), percent chironomids) to form a single score. It is developed from the biota found at a set of sites thought to be on a gradient from no disturbance to highly disturbed, and then applied to sites with an unknown degree of disturbance (e.g. Kearns and Karr 1994). A multimetric score for a site of unknown condition is compared to scores from sites of known condition (defined in categories of poor to excellent mainly based on expert opinion and local knowledge) to determine site condition. The Index of Biotic Integrity (IBI) that was developed for fish by Karr (1981) is perhaps the best known of multimetric bioassessment methods although in recent years, various IBIs have been developed for wide ranging ecozones and for different animal and plant communities (Whittier et al. 2007). Locally, a multimetric IBI was successfully developed for the Skeena region of British Columbia (Rysavy 2000, Bennett and Rysavy 2003, Croft 2004). This work provided an initial step in the process of developing a forest ecosystem sustainability indicator system that is now part of a performance based toolbox to assess impacts on aquatic ecosystems from forest harvesting activities in the Skeena region.

Another biological assessment approach known as the Reference Condition Approach (RCA) is based on characterization of undisturbed reference sites in a wide variety of environments, relating the natural environment of these sites to their biota, and then predicting the biota that would be found at a new "test" site if it was in reference condition. Reference condition describes a suite of attributes found at sites having little or no exposure to stressors caused by land use and other human activities. A predictive model is built using multivariate statistical tools that allows comparison of a test site with an appropriate reference condition. A test site is determined to be in reference condition if the biological community found at that site is similar to that found at reference sites. If biological attributes at the test site fall outside the range of natural variability found at those reference sites, the null hypothesis that the test site is the same as the reference group is rejected (Bailey et al 2004). The degree of biological dissimilarity between a test site and the reference condition is a measure of the extent of disturbance (Bailey et al. 2004). RCA is used as a standard procedure for testing site quality in many countries, particularly in the UK (Wright et al. 2000), Australia (Parsons and Norris 1996), and more recently in Canada (Bailey et al. 2004, Sylvestre et al. 2005, Reynoldson et al. 1997, Reynoldson et al. 2001, Perrin et al. 2007).

Both the IBI and the RCA are screening tools for water quality and habitat assessment within a large region (Figure 10). Both approaches are based on the concept of comparison to a biological reference condition and can be considered complimentary (Reynoldson et al. 1997). They can be applied to plant and animal communities, including fish. The IBI is based on the sum of a selected number of biological metrics that are found to be sensitive to a known gradient of water quality or ecosystem health within a region. The RCA combines the ideas of multivariate modeling of entire biological communities (Wright et al. 2000) with the concept of comparison to a reference condition. RCA is more comprehensive because it includes complete communities rather than parts of communities in a final predictive model. While the RCA is more computationally complex than IBI, modern computing power makes site testing a

rapid and simple process. CABIN[2] is a web portal where testing of sites in Canada using the RCA can be run. CABIN is a database management system capable of archiving biological, GIS derived basin characterization information and habitat data for all reference and test sites. It houses and enables use of both RCA models and IBI scores to determine habitat condition. It includes standard sets of protocols and methods for all phases of data collection and processing, including standard field sheets and laboratory forms, and will soon contain on-line training tools. In Canada, where the RCA is receiving greater research and management interest than IBI, lakes and streams (Bailey et al. 2004) and estuaries (Perrin and Sylvestre 2006) are suitable for the development of RCA models and data pertaining to all of these environments can be hosted on the CABIN website.

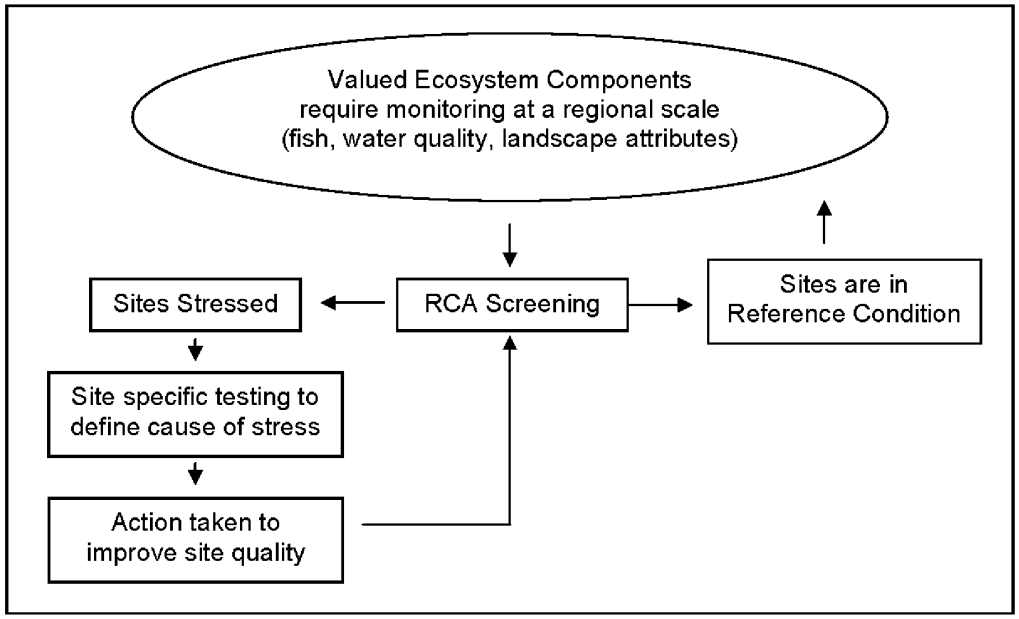


Figure 10. Schematic illustration representing how RCA fits into environmental decision-making (from Perrin et al. 2007).

Among the bioassessment methods, a structured approach is used in the selection of habitat variables that are used to describe site attributes. In recent work on RCA modeling, a protocol was developed for the selection of those habitat variables (Perrin et al. 2007). They can be considered the same as metrics in Table 1 that are used to define the DFO habitat indicators. While DFO has completed a preliminary selection of habitat indicators and associated metrics, the RCA protocol for variable selection is a useful tool to update the list and adapt to changing availability of habitat data in future years. It mainly sets rules for the selection of variables, thus avoiding circular debate about what variable or indicator should or should not be considered in a site testing process.

The protocol requires two groups of variables describing habitat attributes to be measured and compiled. The variables that do not vary with anthropogenic disturbance (Reynoldson et al. 2001, Sloane and Norris 2003) can be called **natural gradient variables** and are similar to the "status" indicators identified by DFO (Table 1). In the RCA they are used for building the reference condition model. Among streams, lakes, and estuaries they are typically based on geomorphological and other physical attributes including:

[2] Canadian Aquatic Biomonitoring Network, cabin.cciw.ca/cabin/asp/english/welcome.asp

- descriptions of stream morphology, gradient, and the drainage basin at the sampling site including bankfull width, wetted width, channel depth, percent of different flow habitats (pools, glide, riffle, cascade), area of drainage basin upstream of the sampling site, elevation, relief, percent of the watershed area that is in the alpine, percent of avalanche chute area in the watershed, water temperature);
- lake morphometrics (mean depth, maximum depth, water residence time, area of littoral zone, area of pelagic zone, etc.);
- substrate characteristics including relative abundance of particle categories (e.g. silt, sand, gravel, cobble);
- water attributes including drainage density of streams, stream length, and percent of the drainage area comprised of wetlands, lakes, and ice;
- characteristics of riparian vegetation development (e.g. grasses present or absent, over-stream cover, riparian species composition);
- composition of riparian vegetation (e.g. barren, grass/herb, shrub, tree type);
- parent material geology (e.g. presence/absence or proportion of intrusives, volcanics, sedimentary, metamorphic, and ultramafic rock);
- geographic location (e.g. latitude and longitude);
- landscape metrics (elevation, slope, relief);
- area of unmodified mudflats in an estuary;
- upstream extent of a salt wedge intrusion; and
- organic matter content in sediment.

Some groups of well known variables are not included in this list. Nutrients are not included because anomalous nutrient discharges can modify growth of periphyton (Stockner and Shortreed 1978, Perrin et al. 1987, Bothwell 1989) and cause change in whole system production (Johnston et al. 1990, Deegan and Peterson 1992). Concentration of metals are not included because they can cause toxicity in biota (Campbell and Stokes 1985, Hickey and Clements 1998) while treatment of mine water discharge with lime (e.g. major cations) can reduce this toxicity (Perrin et al. 1992). Even basic electrochemical analytes including total dissolved solids/conductivity, alkalinity, pH, and dissolved oxygen are not included because they can be modified by anthropogenic disturbance or water treatment.

Stressor gradient variables are those that can be affected by human activity and are similar to the "pressure" variables listed in Table 1. They are diagnostic in nature and are used to examine potential cause of site disturbance using a variety of statistical procedures after initial site testing. Among streams, lakes, and estuaries they can include but are not limited to:

- chemical concentrations including macronutrients (e.g. TP, SRP, TDP, NO3-N, NH4-N, TN), electrochemical analytes (pH, DO, TDS, conductivity), metals, alkalinity, oils;
- suspended sediment concentration and turbidity;
- water temperature metrics (mean, maximum and minimum temperature for a given time period, degree days);
- road metrics (road density, number of gravel road stream crossings, paved road density, etc.);
- forest harvesting metrics (area of historic logging, area of active logging, area of openings, area of forest stands or percent of total forested area by age class);

- land use metrics (area of urban land use upstream of sampling site, area of agriculture land use upstream of sampling site, area of park, percent of forest burned before given years);
- mining metrics (area of open pits, number of ore truck crossings, number of abandoned pits, area of tailings piles);
- impoundment metrics (distance from dam, presence/absence of a dam, size of reservoir (area, mean depth, maximum depth), extent of drawdown, length of river flooded); and
- shipping and port metrics (length of river where channel dredging occurs, number of vessels per unit time by vessel size, number and size of marinas, area of mudflat occupied by marinas, volume of wastewater discharged from vessels per unit time, rate of discharge of contaminants from industry, etc.).

It is noteworthy that in the RCA, habitat attributes are used to classify sites to particular groups that are defined using composition and abundance of biota. The actual site testing is done by comparing the biota at a test site to the biota in a particular reference sample group. Hence, the site testing is based on comparison of biological communities.

In compiling the list of natural and stressor gradient variables, logistics of being able to complete the measurements in reasonable time in the field and the benefits of mining information from GIS databases that is more cost effective than operation of field crews is considered.

Using a list of candidate habitat variables, a consensus-based exercise is used to identify redundancies and compile a final list for developing indicator models. Decisions must, however, be based on a clear focus on how the data will be used for site testing. In the RCA, for example, only natural gradient variables can be used for model development and those variables must be easily measured or derived not only for model development but also for routine site testing after the model is built. Other assessment methods can have different data needs that must be defined before final lists of habitat indicators or metrics are selected.

Among assessment options, IBI and RCA approaches can first be considered since they have been repeatedly mentioned as potentially useful tools and they have sustained scientific peer review as accepted and scientifically defensible methods. They are based on multivariate computations to derive biological metrics (IBI) or sample groups (RCA). They rely on many taxa to be effective because it is the biota within a community that is used as the basis for site assessment. A difficulty in applying IBI or RCA to Pacific salmonids in any habitat is the limitation to only 5 species (7 if steelhead and searun cutthroat are included) and usually only one (e.g. juvenile sockeye in lakes or pink salmon in spawning habitat in streams) or two (e.g. juvenile coho and Chinook in streams) occur together at a given time in a given habitat of interest. The number of taxa could be increased if an IBI or RCA model included all fish species encountered within habitats of interest (streams, lakes, or estuaries), which was the approach used by Karr (1981) in the first IBI that was proposed and adopted for assessing fish habitat in the US. It is not clear, however, if DFO would consider habitat assessments based on multiple fish species as opposed to restricting habitat assessment to Pacific salmon. There is also a lack of availability of matching biological and habitat data for an RCA type of model. While DFO has been collecting data describing salmon biology and habitat needs for decades, data sets are not linked from which observations of distribution and abundance by life stage and associated habitat attributes are compiled over large regional scales and large time scales. This linking of data is something that may be a long term objective but it is not available for present needs of habitat assessment. For these reasons (a possible focus on one or few species not multivariate data, and general unavailability of biological observations linked to habitat observations), habitat assessment using biologically based approaches such as IBI or RCA may not be appropriate. Given that bioassessment using IBI and RCA is in widespread use, it is recommended that

DFO consider the inclusion of all fish species in streams, lakes, and estuaries for possible development of these methods as a means to monitor fish habitat attributes. Such an approach might also be appealing to other agencies (e.g., B.C. Ministry of Environment) if DFO were to develop multi-agency partnerships in habitat monitoring.

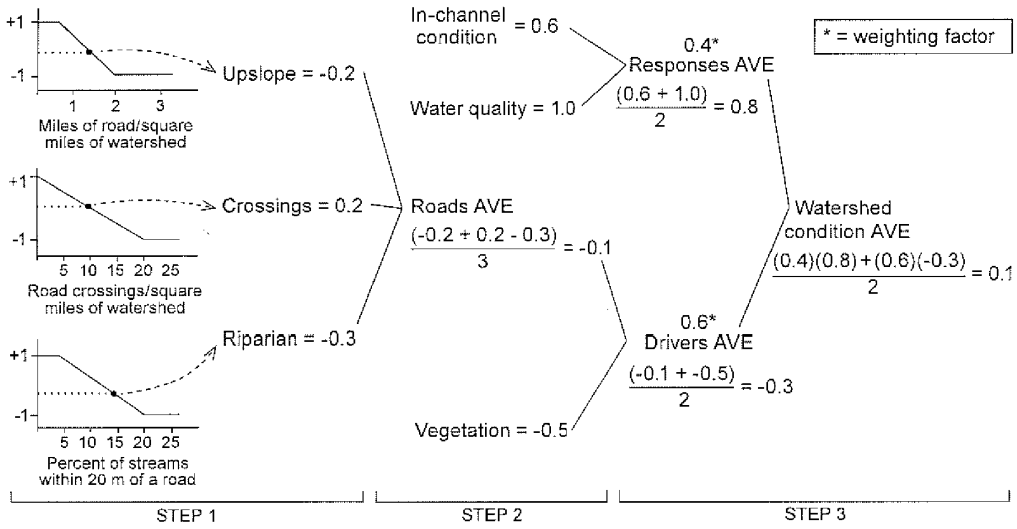
Another approach can be considered if the focus is only on Pacific salmon and related habitats. Habitat needs based on life history and behaviour are well known (e.g. Groot and Margolis 1991, Scott and Crossman 1973). Evidence that degradation of habitat either by physical modification or chemical change can alter survival, distribution, and abundance of salmon populations is also well known (e.g. Levings et al. 1989, Hartman and Scrivener 1990, Gregory and Bisson 1997, Levy 1996). This evidence has largely come from univariate experimentation and monitoring in a myriad of studies conducted over the many decades. From this work, relationships between physical and chemical attributes of habitat and salmon abundance and survival can be used to conceptually model habitat condition on large regional scales.

Gallo et al (2005) used this concept in development of a decision-support model to assess watershed condition in the northwestern United States. As is the case in British Columbia, coordinated biological and habitat data were lacking but there was good understanding of relationships between habitat attributes and suitability of habitat to support fish throughout the region. An array of habitat attributes was used as the basis of assessment, using knowledge of relationships between those attributes and fish abundance and distribution. In this respect, the method was a bioassessment procedure but it used habitat attributes as surrogates for biological health. Gallo et al (2005) proposed a structured habitat assessment procedure as shown in Figure 11 as a measure to document habitat condition before monitoring of large areas could be completed and before significant funding could be applied to complete a monitoring plan. A similar situation exists with DFO today with the need to develop an assessment process but activities are presently constrained by limited funding for a large scale monitoring initiative. The method included three steps (Figure 11):

Step 1: Evaluation criteria are determined for each habitat attribute. The criteria can be curves to score each attribute between +1 ("good" condition) and -1 ("poor" condition). The curves are based on published literature, field data, and professional judgement and local knowledge.

Step 2: Evaluation scores for each of the attributes are aggregated for each general model component (e.g. a road component, forest harvesting component, etc.) using user-defined rules. The rules are factors that are applied to the component scores to weight them according to relative importance based on expert knowledge.

Step 3: Evaluation scores are further aggregated to form a watershed condition score.



Example of a simplified decision-support model. In step 1, individual attributes are evaluated by using evaluation criteria. In steps 2 and 3, the evaluation scores of the attributes are aggregated to determine the overall watershed condition score.

Figure 11. Example of a simplified decision-support model (from Gallo et al. 2005). In step 1, individual attributes are evaluated by using evaluation criteria based on local knowledge and expert opinion and values from the literature. In steps 2 and 3, the evaluation scores of the attributes are aggregated to determine the overall watershed condition score.

The attributes can be structured into "stressor gradient" and "natural gradient" attributes as well as response variables (attributes of a stream or lake or estuary that responds to landscape based attributes). Each can be weighted according to relative importance based on expert opinion to form a final score. For any given site, response variable data can be derived from any field measurements that may be available and the stressor and natural gradient variables can be derived mainly using GIS data layers. Many of these data layers can be accessed through the Province of BC spatial data directory known as the Land and Resource Data Warehouse (LRDW), which is the corporate repository for integrated land, resource and geographic data that supports a variety of business requirements for the natural resource sector, government agencies, industry, and the public (www.lrdw.ca). These data layers are extensive and have proven very useful in the derivation of predictor variables for RCA model building in BC (Perrin et al. 2007).

While this approach of using decision-support models can be considered an interim step before a more quantitative approach is applied, it does have advantages. The system is easy to explain to non-technical audiences and it is easy to understand. Models can be developed to assess condition of fish habitat on any spatial scale ranging from a single drainage to whole ecozones. Most importantly for DFO, the models can be refined and rerun on data from earlier periods to correct deficiencies as new data become available to improve understanding of habitat-fish interactions. The models can also be run using standard criteria to assess change in condition of habitat at points in time to examine temporal trends in habitat condition.

While a refined list of habitat indicators and metrics will be derived in the present project for each of streams, lakes, and estuaries, it is recommended that a focus on variables that have the best chance of being sensitive to change in habitat condition be prioritized for a given ecoregion. For example,

concentration of total phosphorus might be expected to have greater influence along the coast where waters are utraoligotrophic compared to drainages in the central interior of British Columbia that are naturally nutrient rich and change in TP concentration will do little to productivity. These will be the variables having greatest importance and greatest predictive power in modeling of habitat condition whether an IBI or RCA model or decision-support model is developed for actual use in assessing fish habitat. This process might best be accomplished by stratifying the table of indicators (Table 1) by ecoregion. Indicators could then be ranked according to expected predictive power based on published literature and professional judgment / local knowledge. In this way, the indicators will be set up for use in any of the modeling approaches that might be developed for routine testing of salmon habitat condition.

A common theme among the well established habitat assessment methods, whether the method is an IBI, an RCA model, or a decision support model, is the development of a pass/fail decision or score using a structured numerical method. In this way, similar decisions can be made by anyone who follows the protocol for a given site or other spatial unit. In the present approach that DFO is proposing to assess habitat, it is not clear how decisions can actually be made regarding the state of habitat at some location. Tier 1 decision making will apparently be informed by pressure indicators but how that happens in some logical process has yet to be defined. A second level of decision making, called Tier II, that may occur where some benchmark or threshold has been exceeded, will apparently be informed by status indicators. Again, how that happens in some logical process has yet to be defined. It is strongly recommended that these decision processes be clearly defined because they will be the basis supporting habitat status reports that DFO expects to use to describe the status of habitats at regional and local scales. A structured quantitative or logical process that is easy to follow such as the decision support model outlined above is recommended such that uncertainty and ambiguity are avoided in using habitat condition to support decisions on fish population management.

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Appendix A – Practical Assessment Worksheets

Data Source: Biophysical Assessment of Estuarine Habitats

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Estuarine Habitat Area	Quantity	Estuary	

Data Source

The Biophysical Assessment of Estuarine Habitats project identified and mapped 442 of B.C.'s estuaries on behalf of the Pacific Estuary Conservation Program (PECP) using standardized criteria and Geographic Information System (GIS) tools. The project provided a quantifiable regional overview of estuary habitats that links existing biophysical data and attributes to assist conservation planning. Individual estuaries were ranked for their biological importance to waterbirds (ducks, geese, swans, loons, and grebes) using data and metrics of estuary size, habitat type and rarity, herring spawn occurrence, waterbird use, and intertidal biodiversity.

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Data Availability

The database and GIS mapping of estuarine area and other estuarine attributes developed for the project is available from Kathleen Moore (CWS) or on request from Ducks Unlimited Canada.

Relative Cost

Data purchase / collection: Uncertain but total cost for the project was shared between Canadian Wildlife Service, Ducks Unlimited Canada, Georgia Basin Action Plan, and the BC Ministry of Environment

Data / indicator maintenance: No additional costs. The database is maintained by Canadian Wildlife Service and Ducks Unlimited.

Total cost: Low (1 week): Cost of time for DFO analyst to extract and compile existing human use datasets/layers into summary statistics for selected areas.

Spatial extent/ resolution

442 major estuaries defined for the entire BC coast (with the exception of the Fraser River Basin). Estuaries were identified as the intersection of large rivers with the coastline. Large rivers were defined by double-lined rivers (≥20m width) from existing datasets such as the Terrain Resource Inventory Mapping (TRIM I&II) basemaps (1:20,000 scale) (BCMSRM 2002) and fourth order rivers from the British Columbia Watershed Atlas basemaps (based on National Topographic Series maps at a 1:50,000 scale). Estuaries located with this criteria were mapped as discrete areas from a variety of input sources. Estuary boundaries were defined to include the intertidal (below coastline to lowest normal tide) and supratidal (above coastline) zones as well as habitat features connected to each river or stream above the coastline to an upstream distance of 500m. Estuary extent was determined by capturing polygons for physiographic features such as marsh, swamp, islands, river/streams, ditches, sand/gravel bars, and lakes from TRIM. Intertidal areas and some supratidal or intertidal marsh features not shown in TRIM were digitized and added as polygons. These physiographic features were obtained, captured, and verified from a wide variety of datasets including the provincial TRIM I&II basemaps, digital orthophotos (1:20,000 scale), airphotos (1:15,000 to 1:40,000 scale), Canadian Hydrographic Service (CHS) digital marine charts of varying scales, and 1:50,000 scale NTDB Watershed Atlas. Digital chart products were obtained from Nautical Data International (2002). Estimates of the aerial extent of each estuary and associated features (measured in hectares) were derived from these procedures.

Temporal extent/ frequency

This mapping of estuarine areas was undertaken as a once only effort by the Canadian Wildlife Service. Uncertain of plans for future updates of these estuary surveys.

Data Source: Coastal Resource Information System (CRIS) Biophysical Shoreline Database

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Disturbance of Estuary Foreshore Habitats	Pressure	Estuary	Shoreline 'hardening' modifications that are recorded in the surveys include boat ramps, concrete bulkheads, land fill, rip rap, sheet pile, wooden bulkhead, boat ramps, piers and docks, recreational slips, and deep sea vessel slips. The percentage of each shoreunit that has been modified by these features is estimated to the nearest 10%, and multiplied by the shoreunit length to calculate the Shore Modification Length (m).
Micro and Macro Algae	Status	Estuary	Biobands represent assemblages of biota along the shoreline. Algae (seaweed) biobands (rockweed, green algae, bleached red algae, red algae) were categorized as absent (not observed in the shoreunit), patchy (occurs with <50% cover in the band) or continuous (occurs with >50% cover of the band in the shoreunit).
Eelgrass Habitats	Status	Estuary	Eelgrass (*Zostera marina*) biobands were categorized as absent (not observed in the shoreunit), patchy (occurs with <50% cover in the band) or continuous (occurs with >50% cover of the band in the shoreunit).
Riparian Vegetation	Status	Estuary	A complementary issue with shoreline hardening is the associated loss of coastal riparian habitat (i.e., trees and shrubs are often removed to facilitate construction or simply to improve view-scapes. Included with shoreline 'hardening' modifications that are recorded within CRIS are measures of % riparian occurrence (% estimate of the shoreunit length shaded by overhanging riparian vegetation) and the length of the riparian vegetation along the shoreline (% riparian occurrence times the length of the shoreunit).

Data Source

The Coastal Resource Information System (CRIS) contains the Biophysical Shoreline Database. To gather the information within the Biophysical Shoreline Database, a comprehensive survey using oblique videography of British Columbia's shoreline was conducted. The shoreline was subdivided into smaller pieces, and the characteristics of each piece described, recorded and classified. For this undertaking British Columbia's shoreline was subdivided into pieces where the morphology, sediment texture and dynamic physical processes do not vary in the along-shore direction (morpho-dynamic homogeneity). These alongshore units are dubbed 'shoreunits'. Shoreunits are further subdivided into across-shore components, which are categorized into zones. The database holds many attributes describing the along-shore and across-shore components of each shoreunit including: Physical Coastal Class, Repetitive Shore Type, Shoreline Habitat Class, Exposure Class, Biological Banding (biobands), Form and Material. Video of the shoreline to support these designations is available. In some urban areas this base shoreline inventory has been supplemented by an assessment of 'shoreline hardening' within a shoreunit. Shoreline hardening refers to instances where existing natural shorelines of soft sediment have been hardened to increase shoreline slope or to increase shoreline stability.

Contacts

Carol Ogborne, Integrated Land Management Bureau, Tel: (250) 356-6998, Email: Carol.Ogborne@gov.bc.ca
Barron Carswell, Ministry of Environment, Tel: 250-387-4519, Email: Barron.Carswell@gov.bc.ca

References

Harper, J.R. 2007. Shoreline hardening indices for British Columbia. Coastal and Ocean Resources Inc. Saanich Rd., Sydney, BC. CORI Project: 07-08.

Data Availability

Information from the Biophysical Shoreline Database is available within the British Columbia Coastal Resource Information System (CRIS), an internet based interactive map for viewing coastal and marine data, accessible at

ilmbwww.gov.bc.ca/cis/coastal/others/crimsindex.htm. A wide variety of coastal and marine resources are also included on CRIS, such as aquaculture, selected fisheries information, and offshore oil and gas information. The development of the Coastal Resource Information System is ongoing. The application provides access to data currently held on MSRMs Land and Resource Data Warehouse (LRDW).

Actual GIS files of all shoreline habitat themes from the Biophysical Shoreline Database are also available for download from the Bureau ftp site: ftp://ftp.gis.luco.gov.bc.ca/pub/coastal/shorezone data/. The information within the Biophysical Shoreline database is considered high quality, but the provincial foreshore habitat has only been surveyed once to date.

Relative Cost[3]

Data purchase / collection:

This data is free to users except for the Strait of Georgia Area. The shorezone data for this area is viewable on the CRIS website but can only be directly obtained through the signing of a data agreement, as the information was paid for by a third party. Total cost for CRIS project data collection over its 15 years has been about $5.25 million. However, this cost is not passed on to individuals wanting to use the data but rather is a service provided by the Integrated Land Management Bureau of the Ministry of Agriculture and Lands.

Data / indicator maintenance:

Assembling all of the data into seamless layers over 2 years by the Bureau has required an additional $500,000 (for data cleanup, assembly, modeling and loading the data into SDE).

Total cost: Low (1 person month). Cost of time for DFO analyst to extract and compile existing human use datasets/layers into summary statistics for selected areas. Cost of creating new provincial-wide shoreline datasets/maps would be a multi-million dollar endeavour.

Spatial extent/ resolution

CRIS surveys have been undertaken for the entire British Columbia coastline from U.S./Canada border to Canada/Alaska border. Supplemental shoreline hardening analyses were only undertaken for the southern Straight of Georgia (approximately 1500 km of shoreline) to date.

In terms of spatial resolution CRIS subdivided British Columbia's shoreline pieces where the morphology, sediment texture and dynamic physical processes do not vary in the along-shore direction (morpho-dynamic homogeneity). These alongshore units are dubbed 'shoreunits'. Shoreunits are further subdivided into across-shore components, which are categorized into zones (smallest unit of spatial resolution).

Temporal extent/ frequency

Data collection period to acquire information for entire coastline was from 1987-2002. There are no provincial-scale repeat surveys but there is an ongoing process to creating a seamless provincial layer of all of the shoreline themes for all of the project areas. It is intended that supplemental shoreline hardening surveys will be undertaken by the province's Ocean and Marine Fisheries Branch around urban areas at irregular intervals in the future (approx. every 5 years) (B. Carwell, pers. comm.). It is intended that supplemental shoreline hardening and riparian vegetation surveys will be undertaken by the province's Ocean and Marine Fisheries Branch around urban areas at irregular intervals in the future (approx. every 5 years) (B. Carwell, pers. comm.). In addition, there are plans for repeat mapping by the BC MOE's Ocean and Marine Fisheries Branch of major algae/kelp beds at fairly regular intervals (B. Carswell, pers. comm.).

[3] Relative costs listed refer to data collection/data maintenance of all CRIS data layers, not just the data relevant to this particular indicator

Data Source: State of Environment Reporting: British Columbia's Coastal Environment 2006

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Disturbance of Estuary Foreshore Habitats	Pressure	Estuary	In the State of the Environment reporting there is an overview of indicators that relate to the condition of the province's estuaries (e.g., estuary tenures, protected areas, protected area stressors, intact land and sea areas) and a summary of status at the time of assessment.
Marine Vessel Traffic Activity	Pressure	Estuary	Included with this State of the Environment reporting is an overview of marine traffic volume and movements along the B.C. coast and a summary of status at the time of assessment.
Water Chemistry (contaminants)	Status	Estuary	The State of the Environment reporting includes an overview (from a variety of datasets) of sediment contaminants: PCBs, polycyclic aromatic hydrocarbons (PAHs), and mercury from selected estuaries across BC and a summary of status at the time of assessment.

Data Source
The British Columbia Coastal Environment project (2006), provided a comprehensive look at the environment of the terrestrial and marine regions of the BC coast. The project focused on six elements: Population and Economic Activity; Climate Change; Industrial Contaminants; Ecosystem Protection; Biodiversity; and Fisheries.

Contacts
Linda Gilkeson, SOE Reporting, BC MOE, Tel: 250 387-9410, Email: Linda.Gilkeson@gov.bc.ca
Barron Carswell, Ministry of Environment, Tel: 250-387-4519, Email: Barron.Carswell@gov.bc.ca

Data Availability
The final 2006 summary report are available from BC MOE's Strategic Policy Division website: www.env.gov.bc.ca/soe/bcce/

The British Columbia Coastal Environment project was planned, funded and executed in collaboration with the BC Ministry of Environment (MoE), Fisheries and Oceans Canada (DFO), Environment Canada, the University of British Columbia Fisheries Centre and the University of Victoria Geography Department. This was the first collaborative state of environment (SOE) report in BC since the State of Environment Report for British Columbia in 1993. At this point there are no plans for a repeat collaborative effort by the SOE Reporting team, but later updates may be undertaken by the Ocean and Marine Fisheries Branch of BC MOE.

Relative Cost
Data purchase / collection: Electronic copies (free) or hardcopies ($112.00) of the final 2006 summary report from the SOE website.
Data / indicator maintenance:
Total cost: Low (< 1 week). Cost of time for DFO analyst to extract and compile existing estuarine condition summaries for selected areas.

Spatial extent/ resolution
Entire British Columbia coastline from the top of the coast mountains, west to Canada's 200-mile limit in the Pacific Ocean. Spatial resolution is broadscale, either at the scale of the entire BC Coast or at the scale of selected indicator regions or areas.

Temporal extent/ frequency
Data was collected for the report was summarized for 2004.

Data Source: Fraser River Estuary Management Program (FREMP) Atlas (hosted by the Community Mapping Network)

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Estuarine Habitat Area	Quantity	Estuary	
Disturbance of Estuary Foreshore Habitats	Pressure	Estuary	
Riparian Vegetation	Status	Estuary	
Disturbance of Off-shore Habitats	Pressure	Estuary	
Disturbance of In-shore Habitats	Pressure	Estuary	

Data Source
The Fraser River Estuary Management Program (FREMP) classifies intertidal and nearshore areas and colour-codes these on the basis of the relative values of their habitat features. The shoreline of the Fraser River is thus divided into contiguous colour code line segments based on their inherent natural features and extent of shoreline development. In this context, the term, "segment", refers to a continuous section of line of a single colour. FREMP segment colour coding is: Red coded shoreline - shoreline areas having highly productive habitat features and/or areas where habitat compensation has been previously constructed to offset habitat impacts; Yellow coded shoreline - shoreline areas having moderately productive habitat features; Green coded shoreline - shoreline areas with low productivity or lacking habitat features.

Contacts
Anna Mathewson, BIEAP/FREMP, Telephone: (604) 775-5756, E-mail: mail@bieapfremp.org
Rob Knight, Ministry of Environment, Tel: (604) 582-5317, E-mail: rknight@telus.net
Brad Mason, Fisheries and Oceans Canada, Tel: (604) 666-7015, E-mail: masonb@dfo-mpo.gc.ca

Data Availability
The Fraser River Estuary Management Plan Atlas displays habitat in the Fraser River estuary mapped to inform FREMP planning processes. The mapped riparian polygons are available within an interactive GIS hosted by the Community Mapping Network (CMN) website at http://www.shim.bc.ca/atlases/FREMP/main.cfm. The GIS layers/databases for these delineated habitats can be obtained on request from FREMP and the CMN project contacts.

Relative Cost
Data purchase / collection: All databases maintained by the CMN are free to interested users. Some of the linked databases maintained on the CMS website may require agency and/or CMN contact permissions to access.

Data / indicator maintenance: Database/GIS applications on the CMN website cost from zero dollars (free volunteer work) to up to $5,000-$10,000 to build. Agency programs are currently not paying any money ($0) for maintenance but have contributed support money to CMN in the past. Generally, if the varied agencies represented on the CMN website paid $1000-2000 per year this would be sufficient for site maintenance. That would help sustain the CMN software, hardware and maintenance personnel. In the absence of solid agency funding the CMN is kept functioning on a project by project basis and through some outside funding sources.

Total cost: Low (1 week). Cost of time for DFO analyst to merge and summarize FREMP data layers as required.

Spatial extent/ resolution
Fraser River, British Columbia, Canada (from Kanaka Creek and the outlet of Pitt Lake downstream to Georgia Strait including the outer banks from Point Grey to the U.S. border and Boundary Bay). Mapped at resolution of m^2.

Temporal extent/ frequency
Original mapping of coast: 1984 - 1989, updated 1996; with digital data updated periodically. Habitat inventory of riparian areas was initially based on 2002 air photo interpretations. Since then, this information has been ground-truthed, with updates in 2006 and more scheduled this summer (2007).

Data Source: Coastal Resource Information System (CRIS) Human Use data layers

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Disturbance of In-Shore Habitats	Pressure	Estuary	
Disturbance of Off-Shore Habitats	Pressure	Estuary	

Data Source
The CRIS contains database/GIS layers on Human Use. The information available in CRIS for this Human Use category that relates to condition of estuarine habitats includes locations of: Airports, Anchorages, Boat launches, Cruising routes, Disposal facilities, Dive sites, Ferry routes and terminals, Kayak routes (salt and fresh Water), Marinas, Marine hazards, Marine industries, Moorage, Navigational aids and Tenures.

Contacts
Carol Ogborne, Integrated Land Management Bureau, Tel: (250) 356-6998, Email: Carol.Ogborne@gov.bc.ca

Data Availability
Information on Human Use is planned but not yet available for viewing within the British Columbia Coastal Resource Information System (CRIS), an internet based interactive map for viewing coastal and marine data, accessible at ilmbwww.gov.bc.ca/cis/coastal/others/crimsindex.htm. A wide variety of coastal and marine resources are also included on CRIS, such as aquaculture, selected fisheries information, and offshore oil and gas information. The development of the Coastal Resource Information System is ongoing. The application provides access to data currently held on MSRMs Land and Resource Data Warehouse (LRDW). GIS files of Human Use are currently available for download from the Bureau ftp site: ftp.gis.luco.gov.bc.ca/pub/coastal/shorezone_data/. The information within the Human Use data layers is considered high, but this compilation of mapping has only been completed once. There are no current plans for repeat surveys.

Relative Cost[4]
Data purchase / collection: This data is free to users except for the Strait of Georgia Area. The shorezone data for this area is viewable on the CRIS website but can only be directly obtained through the signing of a data agreement, as the information was paid for by a third party. Total cost for CRIS project data collection over its 15 years has been about $5.25 million. However, this cost is not passed on to individuals wanting to use the data but rather is a service provided by the Integrated Land Management Bureau of the Ministry of Agriculture and Lands.

Data / indicator maintenance: Assembling all of the data into seamless layers over 2 years by the Bureau has required an additional $500,000 (for data cleanup, assembly, modeling and loading the data into SDE).

Total cost: Low (1 person month). Cost of time for DFO analyst to extract and compile existing human use datasets/layers into summary statistics for selected areas. Cost of creating new provincial-wide shoreline datasets/maps would be a multi-million dollar endeavour.

Spatial extent/ resolution
Entire British Columbia coastline from US/Can border to Canada/Alaska border.

Temporal extent/ frequency
Data collection period to acquire information for entire coastline was from 1987-2002. There are no repeat surveys but there is an ongoing process to creating a seamless provincial layer of all of the shoreline themes for all of the project areas.

[4] Relative costs listed refer to data collection/data maintenance of all CRIS data layers, not just the data relevant to this particular indicator.

Data Source: Crown Leases and Licenses Database

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Disturbance of In-Shore Habitats	Pressure	Estuary	
Disturbance of Off-Shore Habitats	Pressure	Estuary	
Disturbance of Foreshore Habitats	Pressure	Estuary	

Data Source
Information on estuary tenures from the province's Crown Leases and Licenses database has been assembled and synthesized by the Canadian Wildlife Service for broad use. The extent of the area within each estuary allocated to different estuary tenure types (i.e., extent of conservation tenures, economic tenures, no tenures) provides an indication of the degree of disturbance to habitats within the estuary. Tracking of changing estuary tenures can provide an indirect indicator of changes in disturbance extent.

Contacts
Kathleen Moore, Canadian Wildlife Service, Tel: (604) 940-4660, Email: Kathleen.Moore@ec.gc.ca

Data Availability
The synthesis of information on estuarine tenure status is available on request from Kathleen Moore.

Relative Cost[5]
Data purchase / collection: The cost of undertaking an assessment of tenure status for provincial estuaries costs approximately $5,000 - $10,000.

Data / indicator maintenance: There is no additional cost associated with maintenance of this data. The Crown Leases and Licenses database is already a supported database for provincial planning purposes.

Total cost: Low (1 week). Cost of time for DFO analyst to extract and compile existing human use datasets/layers into summary statistics for selected areas.

Spatial extent/ resolution
Summaries for 442 defined and mapped estuaries along the extent of the entire BC coast.

Temporal extent/ frequency
Full provincial summary of BC estuaries has only been undertaken once by CWS, but they are committed to regular updates of this information (K. Moore, pers. comm.)

[5] Relative costs listed refer to data collection/data maintenance of all CRIS data layers, not just the data relevant to this particular indicator.

Data Source: Marine Communications and Traffic Services Statistics (VTS)

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Marine Vessel Traffic Activity	Pressure	Estuary	

Data Source
Marine Communications and Traffic Services (MCTS) provides annual Pacific Region statistics on marine vessel traffic (vessel numbers, vessel types, vessel sizes, and vessel movement patterns) from 5 monitoring zones centered around Vancouver, Victoria, Prince Rupert, Comox and Tofino.

Contacts
Ian Wade, Canadian Coast Guard, Marine Communications Traffic Services, E-mail: WadeI@pac.dfo-mpo.gc.ca

Data Availability
Summary VTS statistics are freely available on request from the Coast Guard's MCTS services www.pacific.ccg-gcc.gc.ca/mcts-sctm/index_e.htm. The Coast Guard sees this as important information that will continue to be collected regularly in the future, with plans for improved abilities to track and display vessel movements more precisely.

Relative Cost
Data purchase / collection: Raw data on marine vessel traffic collected as part of regular Coast Guard MCTS monitoring program. This cost is not passed on to individuals wanting to use the data but rather is a service provided by the Coast Guard. Data can be obtained for free in Excel spreadsheet summaries from MCTS. Total costs of collecting VTS data by the Coast Guard is considered confidential and requires a direct request to the Regional Director IBMS, Maritime Services to obtain this information.

Data / indicator maintenance: Direct annual costs of collecting VTS data by the Coast Guard is considered confidential and requires a direct request to the Regional Director IBMS, Maritime Services to obtain this information.

Total cost:. Low (1 week). Indicator information (vessel summary statistics of choice) could be calculated very easily from raw annual data from each MCTS Center that is provided by MCTS in a single Excel spreadsheet.

Spatial extent/ resolution
Five BC coast monitoring zones centered around Vancouver, Victoria, Prince Rupert, Comox and Tofino, encompassing Strait of Georgia, east and west coasts of Vancouver Island, Queen Charlottes, and mainland coast to north of Prince Rupert. Although it is likely possible to track individual boats at metre accuracy (GPS data), the spatial resolution of available data for this dataset is at the scale of a full monitoring zone.

Temporal extent/ frequency
VTS data has been collected by the Coast Guard on an annual basis from 2002 to the present and will continue to be collected on an annual basis in the future.

Data Source: Community Mapping Network (CMN)

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Micro and Macro Algae	Status	Estuary	Algal mapping data in the CMN has been assembled from past agency remote sensed algal mapping efforts as well as ground based mapping by regional districts and volunteer groups.
Eelgrass Habitats	Status	Estuary	Eelgrass mapping data in the CMN has been assembled from past agency remote sensed algal mapping efforts as well as ground based mapping by regional districts and volunteer groups.

Data Source
The Community Mapping Network maintains a suite of web-based interactive maps/databases that capture current estuarine habitat mapping efforts for BC derived from agency research projects, regional habitat atlases or volunteer projects mapping algal bed extents with GPS.

Contacts
Rob Knight, Ministry of Environment, Tel: (604) 582-5317, E-mail: rknight@telus.net
Brad Mason, Fisheries and Oceans Canada, Tel: (604) 666-7015, E-mail: masonb@dfo-mpo.gc.ca

Data Availability
Habitat atlases are available on the Community Mapping Network (CMN) website at www.shim.bc.ca/atlases/atlas.html. GIS layers/databases on for each of these habitat atlases can be obtained on request from the CMN project contacts. Long term access to these datasets in their present compilations will be dependent on maintenance of the CMN website, which is not currently a provincial/federal agency directly funded undertaking.

Relative Cost
Data purchase / collection: All databases maintained by the CMN are free to interested users. Some of the linked databases maintained on the CMS website may require agency and/or CMN contact permissions to access.

Data / indicator maintenance: Database/GIS applications on the CMN website cost from zero dollars (free volunteer work) to up to $5,000-$10,000 to build. Agency programs are currently not paying any money ($0) for maintenance but have contributed support money to CMN in the past. Generally, if the varied agencies represented on the CMN website paid $1000-2000 per year this would be sufficient for site maintenance. That would help sustain the CMN software, hardware and maintenance personnel. In the absence of solid agency funding the CMN is kept functioning on a project by project basis and through some outside funding sources.

Total cost: Low (1 -3 person months). Cost of time for DFO analyst to extract and merge all algal bed data layers from across the suite of individual habitat atlas shapefiles into seamless micro and macro algae coverages.

Spatial extent/ resolution
Various areas along the coast of British Columbia. Habitat atlases maintained by CMN that show the extent of estuarine habitat types for specific areas include the Pacific Coast Resource Atlas, Prince Rupert Atlas and the Southern Gulf Islands Atlas, as well as the Offshore Oil and Gas Map provided by the Ministry of Energy, Mines and Resources. Spatial resolution is variable across the different datasets displayed, depending on the mapping agency/group represented.

Temporal extent/ frequency
One time only for information assembled in most Habitat Atlases but potentially repeated mapping of local areas at irregular intervals, dependent on the activities of participating volunteer mapping groups.

Data Source: Shorekeepers Database

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Aquatic Invertebrates	Status	Estuary	
Micro and macro algae	Status	Estuary	

Data Source
The Shorekeepers database contains longterm data on intertidal habitat and marine invertebrates collected by volunteers following the rigorous Shorekeepers methodology developed by DFO.

Contacts
Sean MacConnachie, Fisheries and Oceans Canada, Tel: (250) 756-7265, Email: MacConnachieS@pac.dfo-mpo.gc.ca
Glen Jamieson, Fisheries and Oceans Canada, Tel: (250) 756-7223; Email: jamiesong@pac.dfo-mpo.gc.ca

Data Availability
The Shorekeepers database can be obtained directly from the Shorekeepers contacts. This central database is maintained by DFO. Shorekeepers data can also be accessed via the Shorekeepers Atlas on the Community Mapping Network (CMN) public website.

Relative Cost
Data purchase / collection: This data is free to users. Total cost for Shorekeepers data is minimal as data is collected by volunteers.

Data / indicator maintenance: Minimal cost associated with maintaining centralized Shorekeepers database by DFO researchers and community stewards.

Total cost: Low (1 week). Cost of time for DFO analyst to extract and compile existing Shorekeepers data on aquatic invertebrates into summary statistics for selected areas.

Spatial extent/ resolution
Numerous intertidal monitoring sites on Vancouver Island.

Temporal extent/ frequency
Annual collection of consistent data at monitoring sites for 3 or more years.

Data Source: Fraser River Estuary Management Program (FREMP) Sediment Budgeting

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Sediment	Status	Estuary	As part of Fraser River management FREMP tracks and regulates the overall sediment budget for the estuary so as to preserve hydrological processes necessary to maintain the estuary's rich diversity of fish and wildlife.

Data Source
The Fraser River Estuary Management Program (FREMP) is a collaborative partnership of Environment Canada, Fisheries and Oceans Canada, Transport Canada, BC Ministry of Environment, Fraser River Port Authority, North Fraser Port Authority and the Greater Vancouver Regional District to coordinate environmental management within the Fraser River Estuary.

Contacts
Anna Mathewson, BIEAP / FREMP Policy Coordinator, Tel: (604) 775-5755 Email: mail@bieapfremp.org

Data Availability
Sediment budgets for the estuary are summarized in Dredging annual reports available on the FREMP public website at www.bieapfremp.org/fremp/managementplan/actionareas_navigation.html

Relative Cost
Data purchase / collection: FREMP's annual Dredging reports are free from the FREMP website.

Data / indicator maintenance: Continuing collection and annual summarization of sediment budget information for the estuary will continue to be a primary undertaking of FREMP as it is seen as critical to ensuring that sediment removed from the Fraser Rive estuary remains within the limits of the river to replenish itself.

Total cost: Low (less than 1 week). Cost for analyst to collate FRMEP dredging report summaries of annual sediment budgets.

Spatial extent/ resolution
FREMP's assessment of the sediment budget for the estuary is determined by measuring the total inflow of sediment at Mission against the outflow of sediment into the Strait of Georgia. The goal is to maintain sediment equilibrium for the Fraser River estuary by keeping estuary dredging volumes over the long term at about 70% of the incoming sediment load. The sediment budget is used as a tool to achieve a goal of balanced sediment removal.

Temporal extent/ frequency
The sediment budget has been calculated for the estuary each year since 1997 and will be continued annually into the future.

Data Source: Environment Canada's Marine Water Quality Monitoring Program

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Water Chemistry (contaminants)	Status	Estuary	Molluscan bivalve shellfish and the waters in which they grow are routinely monitored for the presence of sewage contamination by Environment Canada (EC) in partnership with DFO and CFIA (food inspection).

Data Source
EC's mandate is to classify the shellfish growing waters based on sanitary water quality surveys and shoreline pollution source assessments. Coliform bacteria are used as the indicator organisms to determine the sanitary quality of shellfish bearing waters, in comparison to national standards for fecal coliform levels in marine waters.

Contacts
Stewart Yee, Environment Canada, Tel: 604-666-2947, Email: Stewart.Yee@ec.gc.ca

Data Availability
Information from the Marine Water Quality Program for BC estuaries is available from Stewart Yee.

Relative Cost
Data purchase / collection:

Data / indicator maintenance:

Total cost:

Spatial extent/ resolution
Almost all of the British Columbia coast has been classified to some extent for shellfish growing potential by Enviroment Canada for this program. For monitoring purposes Environment Canada has subdivided the BC coast into 34 shellfish growing areas, which are further subdivided into 159 sectors. Shellfish water quality is assessed using approximately 3500 marine and 1900 freshwater sampling stations form which 5000 samples are collected annually for fecal coliform analyses. Salinity measurements are also taken on the marine samples.

Temporal extent/ frequency
Environment Canada has been assessing the sanitary quality of shellfish growing waters on the west coast of Canada on a regular basis since the early 1970's and will continue regularly in the future.

Data Source: Invasive Alien Plant Program (IAPP)

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Invasives	Pressure	Lake	
Invasives	Pressure	Estuary	Invasive plants tracked by the program are limited to terrestrial, riparian and tidal (e.g. *Spartina*) ecosystems as MOFR does not currently monitor aquatic invasives (e.g., algae).

Data Source
The Invasive Alien Plant Program (IAPP) Application is the database for invasive plant data in BC. Invasive plants tracked by the program are limited to terrestrial and riparian ecosystems as MOFR does not currently monitor aquatic invasives (e.g., algae). The IAPP is intended to co-ordinate/share information generated by various agencies and non-government organizations involved in invasive plant management. The application has been developed to allow the entry, edit and query of invasive plant information including: site details; invasive plant inventory information; planning; treatment methods and data; and, monitoring data. The IAPP program is coordinated by the BC Ministry of Forests and Range. The IAPP atlas provides the foundation for the E-Flora BC atlas pages for invasives species (E-Flora is hosted by UBC); hence the reason E-Flora was not reviewed as a data source.

Contacts
Val Miller, BC Ministry of Forests and Range, Tel: 250 825 1166, Email: Val.Miller@gov.bc.ca
Susan Turner, BC Ministry of Forests and Range, Tel: 250 828 4596, Email: Susan.Turner@gov.bc.ca

Data Availability
The database from the IAPP is available through the Land and Resource Data Warehouse (www.lrdw.ca/) in an oracle database. Access to the IAPP application requires either an IDIR for provincial government staff or BCEIDs for MOF clients. Government staff can apply for access by contacting forhisp.bceid@gov.bc.ca. The IAPP interactive mapping tool that is available to the public can be accessed at www.for.gov.bc.ca/hfp/invasive/IAP_01.htm. Invasive plant data is collected by a variety of government and non-government agencies and will continue to be done so in the future.

Relative Cost
Data purchase / collection: There is no cost associated with using the IAPP database and the cost of collecting the data is not transferred to individuals using the data.

Indicator maintenance / development: The cost of maintenance and development of the indicator is dependent on the metric used.

Total cost: Low – Moderate (1-2 person months required annually).

Spatial extent/ resolution
The geographic coverage of the IAPP is for all of BC, but only includes terrestrial ecosystems.

Temporal extent/ frequency
The collection period for data collected by the IAPP program is 2005 to the present. Data is updated on an ongoing basis by MOFR staff and is dependent on data submissions from other agencies.

Data Source: Invasive Species Atlas (hosted by Community Mapping Network)

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Invasives	Pressure	Lake	CMN's Invasive Species Atlas contains mapped information on invasive freshwater fish, wildlife and plants.
Invasives	Pressure	Estuary	CMN's Invasive Species Atlas contains mapped information on invasive freshwater fish, wildlife and plants, including detailed mapping of invasive *Spartina* species (Cordgrass) in some tidal marsh areas.

Data Source
The Community Mapping Network maintains a suite of web-based interactive maps/databases that capture invasive plant and fish species for BC derived from agency research projects, regional habitat atlases or volunteer projects.

Contacts
Rob Knight, Ministry of Environment, Tel: (604) 582-5317, E-mail: rknight@telus.net
Brad Mason, Fisheries and Oceans Canada, Tel: (604) 666-7015, E-mail: masonb@dfo-mpo.gc.ca

Data Availability
The Invasive Species Atlas is available on the Community Mapping Network (CMN) website at www.shim.bc.ca/atlases/atlas.html. GIS layers/databases from the Invasive Species Atlas can be obtained on request from the CMN project contacts. Long term access to this dataset in its present compilations will be dependent on maintenance of the CMN website, which is not currently a provincial/federal agency directly funded undertaking.

Relative Cost
Data purchase / collection:
All databases maintained by the CMN are free to interested users. Some of the linked databases maintained on the CMS website may require agency and/or CMN contact permissions to access. Invasive species mapping data in the CMN has been assembled from past agency mapping efforts as well as ground based mapping by regional districts and volunteer groups.

Data / indicator maintenance:
Database/GIS applications on the CMN website cost from zero dollars (free volunteer work) to up to $5,000-$10,000 to build. Agency programs are currently not paying any money ($0) for maintenance but have contributed support money to CMN in the past. Generally, if the varied agencies represented on the CMN website paid $1000-2000 per year this would be sufficient for site maintenance. That would help sustain the CMN software, hardware and maintenance personnel. In the absence of solid agency funding the CMN is kept functioning on a project by project basis and through some outside funding sources.

Total cost: Low (1 week). Cost of time for DFO analyst to amalgamate all CMN invasive species data layers shapefiles into one comprehensive file of invasive species coverage for the province.

Spatial extent/ resolution
Various areas along the southern BC lower mainland and Vancouver Island. Spatial resolution is variable across the different datasets displayed, depending on the mapping agency/group represented.

Temporal extent/ frequency
One time only for information assembled in the Invasive Species Atlas but potentially repeated mapping of local areas at irregular intervals, dependent on the activities of participating volunteer mapping groups.

Data Source: Environmental Monitoring System – Web Reporting (EMS-WR)

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Sediment	Pressure	Lake	
Water chemistry	Status	Lake	
Water chemistry (contaminants)	Status	Estuary	
Water chemistry	Status	Streams	

Data Source
The EMS-WR is supported and coordinated by the BC Ministry of Environment and can be accessed at www.env.gov.bc.ca/air/wamr/ems_internet/. The program was designed to capture data covering physical/chemical and biological analyses performed on water, air, solid waste discharges and ambient monitoring sites throughout the province. Contains B.C. data on outdoor air quality, drinking water quality (minimal), other water quality, soil contaminants, hazardous products (industrial), pesticides (industrial, farm). *Data types*: biomonitoring, biological, microbiological, chemical, and geographic. *Geolocators*: longitudinal / latitudinal coordinates.

Contacts
EMS Helpdesk to request a username and password, Tel: (250) 356-1924, Email: emshelp@gems5.gov.bc.ca

Data Availability
The EMS-WR database is available; however, individuals must first create an account in order to access the database. For an account individuals must contact the EMS help desk. This program, in various forms, has been operational for the past fifty odd years and long-term accessibility and operation of the EMS program is highly reliable.

Relative Cost
Data purchase / collection: There is no cost associated with using the data once an individual has been approved. Collection of EMS data is undertaken by the province. The field work, equipment, and lab analysis required to run the program is estimated as multi-million dollar project.

Indicator maintenance / development: The cost of maintaining/developing the indicator will primarily consist of the cost of labour to compile the relevant data from the EMS-WR database.

Total cost: Low to moderate (1 to 3 person months). Other than the effort and associated cost of extracting the data from the EMS-WR data base there is no cost to using this data source.

Spatial extent/ resolution
EMS monitoring stations are located at sites across the entire province of BC. A map of actual EMS site locations can be viewed in the BC Water Resource Atlas (srmapps.gov.bc.ca/apps/wrbc/). Each EMS station provides a point sample of the site, meaning the ability to infer from a site specific data to a broader scale would have to be determined on an individual basis.

Temporal extent/ frequency
The frequency with which data are collected from an EMS station is station dependent; however data is update in the database on a daily basis. Some stations have data collected on a regular basis (daily, monthly, annually) while others have only been monitored once. The temporal extent of data (time span) likewise varies among EMS station. The earliest records for some EMS stations date back to 1965 and extend to the present.

Data Source: BC Lake Stewardship Monitoring Program (BCLSMP)

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Sediment	Pressure	Lake	
Water Chemistry	Status	Lake	
Water Temperature	Status	Lake	

Data Source

The BC Lake Stewardship Society (BCLSS) in partnership with the BC Ministry of Environment operates the *BC Lake Stewardship and Volunteer Monitoring Program* (BCLSMP). The program collects water quality data as well as general habitat observation for 43 lakes across the province. Water quality data includes: water temperature, total suspended sediment, phosphorous concentrations, and dissolved oxygen concentrations.

Contacts

Kristi Carter, BC Lake Stewardship Society, Tel: 250 717 1212, Email: kristic-bclss@shaw.ca
Carolyn Johns, BC Lake Stewardship Society, Tel: 250-717-1212, Email: carolynj-bclss@shaw.ca

Data Availability

The data collected by the BCLSMP is available on-line in report format (http://www.bclss.org/index.html). Raw data can be obtained in excel format by contacting BCLSS directly. With respect to reliability of the program, this is dependent on continued funding from various agencies. Past and current sponsors have included the BC Ministry of Environment and Vancouver foundation. Thus far the program has surpassed all its set targets and funding has been renewed until 2009.

Relative Cost[6]

Data purchase / collection: There is no cost associated with obtaining and using the data. With respect to the cost of collecting the data: volunteers collect the data (no labour costs); lab analysis of water samples ($2,000 per site); travel time and accommodation (dependent on site location); shipment of samples to lab ($40 per sample set); field equipment ($2,000). Data collection for level 2 monitoring on a single lake (only requires cooler shipping during spring overturn as opposed to bi-weekly for a level 3) will break down to approximately:

Indicator maintenance / development: Development of this indicator would require a method by which to infer a site sample on a lake to the whole lake, as well as to the watershed. Reoccurring costs after baseline data established are estimated at $2,500 - $3,000 per site.

Total cost: Low (1 person month)

Spatial extent/ resolution

The BCLSMP monitors lakes across the province. Data is colleted on a site by site basis for individual lakes; consequently spatial scale would be dependent on the spatial level to which the site samples were inferred.

Temporal extent/ frequency

The BCLSMP has been collecting baseline data for some lakes since 2003. If a lake is in a fairly stable state, sampling is conducted every 10 years once the baseline data (minimum 3 years) is collected. For lakes that may have indicators of instability, testing will occur every 5 years following the baseline data collection. If volunteers are willing, Secchi and surface temperature data is collected on an ongoing basis

[6] Relative costs listed are for collection of all data by the BCLSS, not just the data relevant to this particular indicator.

Data Source: DFO Lake Productivity and Capacity Branch Reports

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Water Chemistry	Status	Lake	
Water Temperature	Status	Lake	

Data Source
The Fraser Lakes Studies and North and Central Coast Productivity Programs conduct ecosystem-level lake studies which provide information necessary for stewardship of sockeye rearing lakes in the province and for conservation, management, and restoration/enhancement of sockeye. Objectives of the program are to determine trophic status, limiting factors, productive capacities, and juvenile sockeye numbers, distribution, behaviour and diet in Fraser system sockeye nursery lakes. A series of technical reports and articles have been published on sockeye lake productivity (see references below). Website: http://www.pac.dfo-mpo.gc.ca/sci/mehsd/projects/lake_prod_e.htm

Contacts
Ken Shortreed, Fisheries and Oceans Canada, Tel: (604) 824 4707, Email: shortreedk@pac.dfo-mpo.gc.ca
Jeremy Hume, Fisheries and Oceans Canada, Tel: (604) 824 4705, Email: humej@pac.dfo-mpo.gc.ca

References
Shortreed, K.S., Hume, J.M.B., and Malange, K. 2007. Preliminary categorization of the productivity of 37 coastal and Skeena River system lakes in British Columbia. Can. Tech. Rep. Fish. Aquat. Sci. 2718: 91 p.

Shortreed, K.S., K.F. Morton, K. Malange, and J.M.B. Hume. 2001. Factors limiting sockeye production and enhancement potential for selected B.C. nursery lakes. Can. Sci. Adv. Secretariat Res. Doc. 2001/098: 69 p

Hume, J.M.B., K.F. Morton, D. Lofthouse, D. MacKinlay, K. S. Shortreed, J. Grout, and E. Volk. 2003. Evaluation Of Restoration Efforts On The 1996 Upper Adams River sockeye salmon run. Can. Tech. Rep. Fish. Aquat. Sci. 2466: 57 pp.

Schubert, N., A. Cass, T. Cone, B. Fanos, M. Foy, J. Gable, J. Grout, J. Hume, M. Johnson, K. Morton, K. Shortreed and M. Staley. 2002. Status of Cultus Lake sockeye salmon *(Oncorhynchus nerka)*. Pacific Scientific Advice Review Committee, PSARC Working Paper S2002-11.69 p.

Hume, J.M.B., K.S. Shortreed, and K.F. Morton. 1996. Juvenile sockeye rearing capacity of three lakes in the Fraser River system. Can. J. Fish. Aquat. Sci. 53: 719 733.

Henderson, M.A., Levy, D.A., and Stockner, J.S. 1992. Probable consequences of climate change on freshwater production of Adams River sockeye salmon (*Oncorhynchus nerka*). GeoJournal 28(1): 51-59.

Data Availability
Yes the data is available for wild salmon policy purposes.

Relative Cost
Data purchase / collection: There is no cost associated with using the data

Indicator maintenance / development: Compiling the data from all the various data sources is very time intensive. In addition, lake monitoring on a province wide scale is an expensive process. (>$50,000 per lake)

Total cost: Low to moderate (1-4 person month). Dependent on level of effort required to keep the central database up to date from the various data sources.

Spatial extent/ resolution
Comprehensive data is available for at least 90 sockeye nursery lakes across the province. For a list of lakes refer to Shortreed et al. (2001) and Shortreed et al. (2007).

Temporal extent/ frequency
Data collected from 1977 to the present. Quantity of data for each lake varies ranging from intensive multi-year ecosystem studies on some lakes to one-time limnological surveys on others. There is no systematic method by which all BC sockeye lakes are sampled.

Data Source: DFO Sockeye Lakes Dataset

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Water Chemistry	Status	Lake	

Data Source
This dataset provides research-grade analytical chemistry support for a variety of freshwater research projects including the productive capacity of sockeye nursery lakes, lake enrichment for sockeye salmon enhancement, oligotrophication effects of reduced salmon-derived nutrients and other habitat impacts. The data collected by the DFO Lake Productivity and Capacity Branch is included in this dataset.

Contacts
Erland MacIssac, Fisheries and Oceans Canada, Tel: (604) 666-7917 , Email: eamac@sfu.ca

Data Availability
Yes the data is available for wild salmon policy purposes. It is currently archived in excel format.

Relative Cost
Data purchase / collection: There is no cost associated with using the data

Indicator maintenance / development:
The cost of developing and maintaining the indicator from this data source is believed to be low. Two to three weeks would be required to convert the excel database into a more useful access database. In addition, many of the database entries have not yet been georeferenced and would need to be as part of the indicator development.

Total cost: Low (>$50,000)

Spatial extent/ resolution
The database contains water chemistry data for all sockeye nursery lakes in BC.

Temporal extent/ frequency
Data collected from 1980s to the present. Quantity of data for each lake varies ranging from intensive multi-year ecosystem studies on some lakes to one-time limnological surveys on others. There is no systematic method by which all BC sockeye lakes are sampled

Data Source: Lake Surveys - Physical Characteristics, Chemical Characteristics, and Fish Collection

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Water Chemistry	Status	Lake	

Data Source
Lake Surveys querying tool draws from the consolidate waterbodies survey (CWS) and provides information on chemical data such as pH, TDS, hydrogen sulfide, secchi disc, physical data such as area, volume, depth and information on fish caught in surveyed lakes. The lake surveys query tool is supported by the BC Ministry of the Environment and can be accessed at srmapps.gov.bc.ca/apps/fidq/.

Contacts
David Tesch, BC Ministry of Environment, Tel: 250 387-1908, Email: David.Tesch@gov.bc.ca

Data Availability
The database behind the lake survey querying tool is available. Collection of data is currently done on an add hoc basis and is often incomplete for several fields. A decade or more has passed since any systematic survey of BC lakes has been carried out by the province. Consequently, the reliability of this data source is thought to be low.

Relative Cost
Data purchase / collection: There is no charge for using the lake surveys data source. At present, the majority of data collected on lakes is done so by the private sector at no cost to users of the data.

Indicator maintenance / development:

Total cost: Low (1 person month). Data is stored in an oracle database and it would not require significant amounts of effort to extract the relevant data and organize it for required purposes. MOE has stated that they would perform the data extraction in house at no charge.

Spatial extent/ resolution
The database behind the lake survey query tool covers individual lakes across BC. Spatial resolution: 1:20,000.

Temporal extent/ frequency
The frequency and time coverage period varies for each individual lakes. Some of the earliest records date back to the 1950s.

Data Source: Water Use Planning (WUP) Data

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Water Chemistry	Status	Lake	
Sediment	Status	Streams	BC Hydro has sediment data available for some rivers. Data have been collected as related to channel morphology and sediment movement and completed as part of spawning habitat assessments or substrate composition studies. Generally, this information has been collected as part of one-time studies, but some areas have repeated measurements over time.
Water chemistry	Status	Streams	No program has been implemented that monitors water chemistry regularly. Water chemistry has been monitored sporadically across select rivers and reservoirs. Nutrient concentrations are monitored in some watersheds. Conductivity is the most common parameter which is measured during fish sampling. Very limited data are available for dissolved oxygen, pH, and contaminants.
Riparian disturbance	Pressure	Streams	More information on riparian vegetation is available recently, than historically. However, only a few rivers monitor riparian vegetation. Monitoring is usually associated with understanding cottonwood establishment in floodplain areas.
Water temperature	Status	Streams	Approximately half of BC Hydro facilities have monitored historic in-river water temperature data. These data are not always monitored under Water Use Planning. Intention is to likely continue monitoring this water quality parameter in the future. Punteledge River is the area with the greatest water temperature concerns across BC Hydro's operations.
Water extraction	Pressure	Streams	BC Hydro has perfect information related to water extraction / diversions associated with their operations only. Only a few watershed divert water out of the system (e.g., Ash, Bridge, Coquitlam, Cheakamus, Jordan, Walheach). Most other operations only store water.
Channel stability	Status	Streams	During the development of Water Use Plans, an extensive amount of information was collected to understand channel stability across BC Hydro's facilities. However, this information was collected as part of one-time studies, and can not be planned on for repeated measurement into the future.
Stream discharge	Status	Streams	Very good information is available across all hydro systems. Discharge is either measured directly or estimated in a few locations.

Data Source

Water Use Plans have been developed for most of BC Hydro's hydroelectric facilities through a consultative planning process involving participants such as government agencies, First Nations, local citizens and other interest groups. Monitoring is focused on understanding effectiveness of flow operations in achieving multiple environmental, social, and economic objectives. Thus, BC Hydro's monitoring program is focused on understanding impact hypotheses to inform management decisions or understand outstanding questions about the system. The program is not targeted towards baseline monitoring as would be required for the Wild Salmon Policy.

Contacts

Brent Mossop, BC Hydro, Tel: (604) 528-1424, Email: brent.mossop@bchydro.com

References

BC Hydro. 2007. Water Use Planning. See http://www.bchydro.com/environment/wateruse/wateruse1775.html.

Data Availability

Given the focus of BC Hydro on understanding impact hypotheses, there are no assurances that monitoring will be sustained into the future.

Relative Cost
BC Hydro's effectiveness monitoring program through Water Use Planning costs approximately $20 million per year across all operations.

Spatial extent/ resolution
BC Hydro only monitors the large rivers and reservoirs on which they operate. These include facilities in the following regions and facilities: Vancouver Island (Ash River, Campbell River, Jordan River, and Puntledge River), Lower Mainland (Alouette, Bridge River, Cheakamus, Coquitlam-Buntzen, Clowhom, Stave River, and Wahleach), Southern Interior (Clayton Falls, Falls River, and Peace River), and Northern (Aberfeldie, Columbia River, Duncan Dam, Elko, Seven Mile, Shuswap Falls and Sugar Lake, Spillimacheen, Walter Hardman, and Whatshan). Many of these rivers sustain salmon populations, though only two reservoirs sustain / pass salmon (e.g., Comox Lake in Puntledge River System pass a few salmon, and Seton Lake in the Bridge River system).

Temporal extent/ frequency
Temporal frequency of monitoring is highly variable across indicators of interest. Monitoring programs are starting to ramp up across facilities, in many cases with annual monitoring planned in the near-term to mid-term (i.e., 5-10 years). Historic one-time studies, which include data on a variety of indicators, are available for some systems.

Data Source: Reporting Silviculture Updates and Land Status Tracking System (RESULTS) Program

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Riparian Disturbance	Pressure	Lake	
Riparian Disturbance	Pressure	Streams	

Data Source
The RESULTS (Reporting Silviculture Updates and Land status Tracking System) application tracks silviculture information by managing the submission of Openings, Disturbances, Silviculture activities and Obligation declarations as required by the Forest and Range Practices legislation. The RESULTS program is coordinated by the Ministry of Forests and Range.

Contacts
Ralph Winter, BC Ministry of Forests and Range, Tel: 250 387 8906, Email: Ralph.Winter@gov.bc.ca

Data Availability
The oracle database for the RESULTS program is available to government employees and can be accessed at www.for.gov.bc.ca/his/results/ once a login profile has been created. With respect to data source reliability it is perceived to be high seeing that provincial legislation requires tree harvesters to submit detailed accounts of what has been logged on an annual basis to the province.

Relative Cost
Data purchase / collection: There is no charge for using the RESULTS database. In addition, there is no cost for data collection to users; the private sector must collect the data as mandated under provincial legislation.

Indicator maintenance / development:
Personnel internal to the MOE/MOFR will be able to extract and compile the desired data form the RESULTS database and give it to DFO. DFO will therefore only need to calculate the metric from the data.

Total cost: Low (1 person month)

Spatial extent/ resolution
The geographic coverage of RESULTS only includes crown lands and does not necessarily contain baseline forest inventory for some TFL (i.e. RESULTS documents what is being done, therefore if there is no logging/silviculture activity there may not be a record of what the tree cover is).

Temporal extent/ frequency
The RESULTS program began collecting data in 2004 and is currently collecting data on an ongoing basis.

Data Source: Foreshore Inventory and Mapping (FIM)

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Riparian Disturbance	Pressure	Lake	In the past FIM has not explicitly collect data on riparian disturbance, however it could be inferred from the data collected on lake foreshore development. In the future, FIM could be designed to inventory the riparian area separately from the foreshore area.
River Delta	Status	Lake	FIM methoddology does not explicitly inventory river deltas; however to do so would require minimal additional effort beyond that required to inventory the foreshore.
Accessible Shore Length, barriers	Quantity	Lake	FIM results did not report on accessible shore length, but could easily from the video imagery collected.
Lake Foreshore Development	Pressure	Lake	

Data Source
In the summer of 2004, the Regional District of Central Okanagan, in partnership with Ministry of Environment, City of Kelowna, District of Lake Country, The Real Estate Foundation and Fisheries and Oceans Canada, conducted a detailed inventory of the foreshore of Central Okanagan Lake[7]. The aim of the project was to categorize the foreshore according to near shore and upslope characteristics such as foreshore morphology, land use, existing riparian condition, and anthropogenic alterations. The project used Global Positioning System (GPS) technology and detailed digital shoreline video to capture foreshore characteristics.

Contacts
Brent Magnan, Regional District of Central Okanagan, Tel: 250 469 6213
Brad Mason, Fisheries and Oceans Canada, Tel: 604 666 7015, E-mail: masonb@dfo-mpo.gc.ca

Data Availability
The results from the study and database hard copy are available on line at: www.regionaldistrict.com/departments/planning/env/env_planning_foreshore.aspx. Electronic version of raw data can be obtained from the Regional District of Central Okanagan Environmental Planning Staff.

Relative Cost
Data purchase / collection: There is no cost to obtaining the data. Data collection, including in kind contributions, was estimated to be around $17,000 ($131 per kilometre of foreshore). This included contracting out video management services to a camera man, 3 field days of data collection, and wages for 4 people (3 techs and 1 boat operator).

Indicator maintenance / development: Digitisation of field videos (18 hrs of video in total) was contracted out at a total cost of $6,500 ($50 per kilometre of foreshore).

Total cost: Low (1-2 person weeks would be required to calculate desired statistics from ARCview maps of foreshore).

Spatial extent/ resolution
Foreshore inventory mapping and analysis was only conducted for central Okanagan lake. Habitat segments of less than 100m long were lumped into the preceding, adjacent habitat segment. GPS was used to map out foreshore segments and is accurate to 1m.

Temporal extent/ frequency
The data collected by the foreshore inventory mapping project was collected in 2004. At present no repeat studies have been scheduled.

[7] Foreshore studies have also been done on Windermere Lake, Osoyoos Lake, Cowichan Lake, and Kootenay Lake using the same methodology (Brad Mason 2007, pers. comm.). Methodology was developed by the SHIM network.

Data Source: Baseline Thematic Mapping (BTM) (version 1)

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Riparian Disturbance	Pressure	Lake	With BTM there is a potential for misidentification or oversight of smaller riparian areas due to the scale of mapping.
Watershed: Land Cover Alterations	Pressure	Lake	
Watershed: Hard Surfaces	Pressure	Lake	
Lake Foreshore Development	Pressure	Lake	
Wetland Disturbance	Pressure	Lake	There is a potential for misidentification and oversight of small wetland areas due to scale of mapping.
Riparian Disturbance	Pressure	Stream	
Wetland Disturbance	Pressure	Stream	
Watershed: Hard Surfaces	Pressure	Stream	
Watershed: Land Cover Alterations	Pressure	Stream	

Data Source
The Baseline Thematic Mapping (BTM) layer represents land use polygons as determined by a combination of analytic techniques, mostly using Landsat 5 image mosaics. BTM 1 was done on a federal satellite image base that was only accurate to about 250m. The images were geo-corrected, not ortho-corrected, so there is distortion in areas of high relief.

Contacts
Malcolm Grey, Ministry of Agriculture and Lands, Tel: (250) 387-9365, Email: Malcolm.Grey@gems3.gov.bc.ca

Data Availability
The BTM layer is available for use from the Land Resource Data Warehouse (LRDW) (http://www.lrdw.ca/).

Relative Cost
Data purchase / collection:
The BTM layer is freely available from the LRDW. Collection of imagery required to create the BTM layer for the province would not cost very much (satellite imagery is inexpensive). Furthermore, the provincial government purchases landsat imagery of the province annually.

Indicator maintenance / development:
To produce the BTM map of land use for the province would be multimillion dollar investment. To produce statistics from BTM land use map for the province would cost hundreds of thousands of dollars.

Total cost: High (several person years to create the BTM map of land use from satellite imagery; 2-3 weeks to produce statistics from the map). For example, to recreate a BTM land use map for the lower Thompson area took approximately a year.

Spatial extent/ resolution
The BTM layer covers the entire province of BC. Resolution: 1:250,000.

Temporal extent/ frequency
The digitisation of imagery required to create the BTM layer has only been undertaken once. Images used were from the period 1992-1997. It is unknown when the province will update the BTM for the entire province as it is an expensive endeavour. Currently, the lower Thompson region and the Sunshine Coast have been the only two regions to have been updated with new BTMs.

Data Source: Vegetation Resource Inventory (VRI)

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Riparian Disturbance	Pressure	Lake	
Watershed: Land Cover Alterations	Pressure	Lake	

Data Source
The Ministry of Forests and Range and forest licensees, is implementing the components of the Vegetation Resources Inventory (VRI). The VRI is a photo-based, two-phased vegetation inventory program consisting of: Phase I: Photo Interpretation and Phase II: Ground Sampling. VRI is designed to answer two questions: 1) Where is the resource located?; and 2) How much of a given vegetation resource (for example, timber or coarse woody debris) is within an inventory unit? The private forest industry and forestry consultants will be conducting (on private and crown land) the VRI. Forest Analysis and Inventory Branch will provide standards, procedures and audit functions. Website: http://www.for.gov.bc.ca/hts/vri/index.html.

Contacts
Laurence Bowdige, Ministry of Forests and Range, Tel: 250 356 5509, Email: Laurence.Bowdige@gov.bc.ca
Tim Salkeld, Ministry of Forests and Range, Tel: 250 356 7185, Email: Tim.Salkeld@gov.bc.ca

Data Availability
Yes, the data from VRI are available; Anyone with a valid BCEID has access to the VRI data that is stored on the Land and Resource Data Warehouse (LRDW). The VRI does not track riparian information specifically; however, it would be possible to approximate riparian disturbance using attributes in the data file. To track changes over time one needs to make a special request for some of the archived data (if one is wanting to do a retrospective look at past information) or one needs to store progressive versions of the data into the future if one wants to start change monitoring using the current data set. Alternatively, we started doing a change monitoring program in 2000 using a plot-based approach that statistically represents the provincial land base. This might be an option to examine further depending on your data needs. VRI data is provide in Access .mdb format for the attributes and ARC coverage for the spatial files.

Relative Cost
Data purchase / collection: No cost associated with using the data. The inventory is worth approximately $6.00 per ha from photo to database X 98.5 Mha = $591,000,000 replacement cost to remap the province.

Indicator maintenance / development: Cost would be dependent on the operator's knowledge of the database and data structure, size of the unit being evaluated, processing time, complexity of file read.

Total cost: >$50,000 for database labour

Spatial extent/ resolution
The VRI covers the crown land portions of BC within Timber supply areas. Parks have provincial forest inventory coverage although the vintage of that information is usually older than those areas that are managed for and by the forest industry. The VRI is lacking the majority of coverage in Tree Farm Licence areas and large tracts of private lands. The VRI covers the province of 95.8million ha with a coverage of 3.75million polygon shapes. This is usually displayed as a series of 1:20,000 map tiles using the BCGS grid.

Temporal extent/ frequency
Forest inventory information for a specific management unit (usually a TSA or forest district) is replaced on an irregular basis when the business needs justify a new inventory. In some units, this time frame could be as short as 10-15 years; in other units it could be as long as 20-30 years. New disturbances (harvesting, large fires, etc.) are incorporated into the inventory on an annual basis and every year, all of the attributes are 'projected' in that the ages are incremented by one year and the trees are grown in height.

Data Source: Parkinson, E.A., J.R. Post, and S.P. Cox. 2004. Linking the dynamics of harvest effort to recruitment dynamics in a multistock, spatially structured fishery. Canadian Journal of Fisheries and Aquatic Sciences 61: 1658-1670.

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Recreational Pressure	Pressure	Lake	

Data Source
Using creel survey data from 53 lakes in BC and empirical relationships between growth, survival, and density derived from whole-lake density manipulations on nine lakes over a period of 10 years angler effort distribution were predicted for individual lakes. A similar method to what is described in this paper could be used to predict salmon angling effort (i.e., recreational pressure) across the entire province.

Contacts
Eric Parkinson, Ministry of Environment, Tel: (604) 222-6761, Email: Eric.Parkinson@gov.bc.ca

References
Smith, B.D., B.R. Ward, D.W. Welch. 2000. Trends in wild adult steelhead (*Oncorhynchus mykiss*) abundance in British Columbia as indexed by angler success. Canadian Journal of Fisheries and Aquatic Sciences 57 (2): 255-270.

Data Availability
Data that would be required to parameterize the angling effort prediction model includes:

1) Fish supply/abundance. This could be obtained from the salmon escapement database; however the database is incomplete for some areas.
2) Catch per unit effort (CPUE) data. This may be available from creel surveys or it may be possible to use CPUE data from the Steelhead Harvest Questionnaire which is conducted annually by the BC Ministry of Environment (for a more detailed description see Smith et al. 2000).

Relative Cost
Data purchase / collection: Because the data sources that would be used to inform the angling effort prediction models are not known, it is not possible to give a cost estimate at this point in time. However, given that the Provincial government of BC manages recreational fishing and other data sources managed by the province are freely accessible one could assume that data sources on recreational fishing would likewise be freely obtained.

Indicator maintenance / development: Again, without knowing the data sources that would be used it is not possible to estimate costs for indicator maintenance and/or development.

Total cost: Moderate if have the data already (2-4 person months); however, if data is not available and have to find sources cost would be high (4-16 person months).

Spatial extent/ resolution
This approach would provide angling effort predictions for the entire province of B.C.

Temporal extent/ frequency
Dependent on what data sources are used.

Data Source: Survey of Sport Fishing in British Columbia

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Recreational Pressure	Pressure	Lake	Although recreational fishing is not of much concern to sockeye salmon in lakes the survey of sport fishing could be used as a relative index for recreational pressure, where lakes with greater fishing effort would generally have higher levels of recreational pressure.

Data Source
The survey of sport fishing in British Columbia is part of a national framework that tracks basic information on the size, value, socio-economic performance and potential of Canada's sport fisheries. The survey coverage has expanded to meet the changing information requirements of Canada's fisheries agencies over the years. At the same time, the survey has maintained consistent coverage of common areas of interest such as effort, harvest and socio-economic information for comparative purposes. The BC survey provides information on catch, harvest, and angling effort down to the water body level. Information on other recreational activities (camping, hiking, swimming, boating, etc.) is available at the region level.

Contacts
Bob Williams, BC Ministry of Environment, Tel: 250 356 2186, Email: Bob.Williams@gov.bc.ca
Keith Brickley, Fisheries and Oceans Canada, Tel: 613 990 8195

Data Availability
DFO is part of the joint effort to collect the data across the country and has access to the data. This survey of sport fishing has been ongoing for several decades now and will continue to be funded by both provincial and federal governments. A summary of the 2000 survey is available at: www.env.gov.bc.ca/fw/fish/stats/sport_fishing_survey 2000.html.

Relative Cost
Data purchase / collection: There is no cost associated with using the data. The provincial contribution to the survey was $60,000 in 2005. The federal government also pays for a portion of the survey cost (amount not know).

Indicator maintenance / development: Because data on angling effort is collected by water body, angling effort could be grouped by conservation unit which would be of use for the Wild Salmon Policy. Not much effort would be required to develop the indicator and a month or two would be required annually to calculate the metric of interest.

Total cost: Low (1-2 person months annually).

Spatial extent/ resolution
The survey is a national survey that is broken down by province, and subsequently broken down into regions. Some data collected is further broken down to the waterbody level.

Temporal extent/ frequency
Surveys are now repeated every five years. The first survey was conducted in 1976 with a second in 1980, at which point it was determined that surveys would began being conducted on a five year interval (1985, 1990, 1995, 2000, 2005).

Data Source: BC Watershed Statistics

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Watershed: Land Cover Alterations	Pressure	Lake	
Watershed: Hard Surfaces	Pressure	Lake	
Watershed: Road Development	Pressure	Lake	The watershed statistics contain a number of different road metrics, including total road length, total density, number of stream crossings etc.
River Deltas	Status	Lake	The watershed statistics does not currently have any relevant statistics for river deltas; however, absence or presence of a river delta could easily be calculated from the watershed atlas and added to the watershed statistics.
Wetland Disturbance	Pressure	Lake	
Spatial Distribution of Wetlands / Mudflats	Status	Estuary	
Riparian Disturbance	Pressure	Streams	
Watershed: Land Cover Alterations	Pressure	Streams	
Watershed: Hard Surfaces	Pressure	Streams	
Watershed: Road Development	Pressure	Streams	
Wetland Disturbance	Pressure	Streams	

Data Source

Watershed Statistics was produced by the Decision Support Services Branch of the Ministry of Sustainable Resource Management (formerly Geographic Data BC). The Watershed Statistics is currently coordinated by the BC Ministry of Agriculture and Lands. Information from province-wide Geographic Information System (GIS) databases has been summarized on a watershed basis with the results presented in a spreadsheet format. Source inventories include the provincial Watershed Atlas, Fish Information Summary System (FISS), Terrain Resource Information Mapping (TRIM) base mapping, Baseline Thematic Mapping (BTM) land use/land cover, and provincial ecoregion and biogeoclimatic ecosystem mapping.

Contacts

Malcolm Grey, Ministry of Agriculture and Lands, Tel: 250 387-9365, Email: Malcolm.Grey@gems3.gov.bc.ca

Data Availability

The watershed statistics database is available to government employees and is available in ".dbf" format, which can be linked to GIS coverage of watersheds. With respect to reliability of future upkeep of the watershed statistics, the statistics are dependent on other government programs and can only be compiled if mapping of the province continues to occur.

Relative Cost[8]

Data purchase / collection: The watershed statistics are freely obtained from the ministry; there is no cost associated with obtaining the data.

Indicator maintenance / development: The cost of compiling/maintaining all the watershed statistics from provincial maps is estimated at a couple of hundred thousand dollars; however, this cost is not past on to individuals wanting to use the data but rather is a service provided by Integrated Land Management Bureau of the Ministry of Agriculture and Lands. Land cover alteration statistics are calculated from Baseline Thematic Maps.

[8] Relative costs listed are for all the watershed statistics, not just the single statistic of interest that would be used to inform the indicator.

Total cost: Low-Moderate (1-3 person months). Cost of using watershed statistic to inform the indicator is dependent on the amount of effort required to extract the data out of the maps ($100,000 to $300,000); this is assuming you have all the relevant maps needed. Cost of creating new up to date maps is multi-million dollar endeavour.

Spatial extent/ resolution
The geographic coverage of the watershed statistics is the entire province of B.C., with statistics compiled for each individual watershed. Spatial Resolution: 1:250,000 (positional); 1:100,000 (thematic)

Temporal extent/ frequency
The historic coverage of the statistic for a given watershed varies as each watershed was mapped at a different time. Mapping of the province started in the 1980s and analysis and digitization of images is ongoing. The lower Thompson region and the Sunshine Coast are the only area to have been mapped twice, thus allowing for trend evaluation. The rest of the province has only been mapped a single time; consequently there is only a single set of watershed statistics.

Data Source: Broad Ecosystem Inventory (BEI)

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Watershed: Land Cover Alterations	Pressure	Lake	
Watershed: Hard Surfaces	Pressure	Lake	
Lake Foreshore Development	Pressure	Lake	
Wetland Disturbance	Pressure	Lake	There is a potential for misidentification and oversight of small wetland areas due to scale of mapping.
Watershed: Land Cover Alterations	Pressure	Streams	
Wetland Disturbance	Pressure	Streams	There is a potential for misidentification and oversight of small wetland areas due to scale of mapping.

Data Source

The Broad Ecosystem Inventory (BEI) is a method of classifying and mapping broad ecosystem habitats, their suitability (existing productivity with present vegetation) and capability (potential productivity with optimal vegetation for a species) of the land to support various wildlife species. Current coverage is based on landsat imagery, biogeoclimatice mapping, vegetative resource inventory (VRI), and other data sources (BEI does not use BTM for the province). The primary difference between BTM and BEI is that BTM does not have the depth of ecosystem classification that BEI does. For example BTM will categorise a unit as old forest, whereas BEI will categorise the same unit as old forest with details about what kind of old forest it is, deciduous or coniferous, as well as the species of trees that make up the forest. Mapping classification the BEI classes have 3 components: plant community or association, successional status and site modifier (Resources Inventory Committee 2000). The BEI is coordinated by the BC Ministry of the Environment.

BEI is the classification that defines the Broad Ecosystem Units (BEU). Broad Ecosystem Units are permanent areas of the landscape that support distinct types of dominant vegetative cover, or distinct non-vegetative cover such as lakes or rock out-crops. Each vegetated unit is defined as including potential (climax) vegetation and any associated successional stages. The Broad Ecosystem classes have been created based on the integration of vegetation, terrain (surficial materials), topography, and soil characteristics. This approach emphasizes those site characteristics that determine the function and distribution of plant communities in the landscape (Resources Inventory Committee 2000).

Contacts

Tony Button, Ministry of Environment, Tel: 250 387-9795, Email: Tony.Button@gov.bc.ca

References

Resources Inventory Committee. 2000. Standards for Broad Terrestrial Ecosystem Classification and Mapping for British Columbia (Version 2.0). Ecosystems Working Group, Terrestrial Ecosystems Task Force, RIC, Victoria BC. 212 pages. http://ilmbwww.gov.bc.ca/risc/pubs/teecolo/bei/index.htm

Data Availability

BEI data and 42 species interpretations are publicly available (except for 6 species' which are not yet completed) and need to be requested from the Ministry of the Environment. With regards to reliability, MOFR needs to update their Vegetation Resource Inventory (VRI) data yearly as BEI data uses it as its base. If funding can be provided ($3,000 yearly Oracle support and $2,500 yearly salary costs for a total of $5,500) it is likely that new BEI data could be generated into the future.

Relative Cost[9]

Data purchase / collection: There is no cost associated with obtaining the data; however, MOE and DFO would have to sit down and discuss what exactly is desired and what would be required by both parties. An estimated breakdown of data collection is: $10,000-12,000 for GIS programming - one time cost; $5,000-7,500 for a terrestrial ecologist - one time cost; and $7,000-9,000 for an Oracle programmer - one time cost.

Indicator maintenance / development: The cost of maintaining and developing this indicator would be a reoccurring cost of $3,000 for an Oracle programmer to support running habitat capability-suitability calculations.

Total cost: Low: 2 to 3 weeks (~$5,000 in salary) for the first year to calculate the habitat indicator (land use – habitat alteration). After the first year it would take roughly 1-1.5 weeks (~$2,500 in salary) to calculate the indicator.

Spatial extent/ resolution

The BEI covers the entire province of BC at a spatial resolution of 1:250,000. The BEI for BC is composed of 66,000 polygons.

Temporal extent/ frequency

The BEI is updated annually when and if funding permits. Data coverage of the BEI is of the 1990s.

[9] All price quotes are for updating the BEI using VRI data. Costs of updating BEI using landsat imagery are estimated to be slightly higher but could not be quantified. The BC government buys landsat imagery annually (T. Button, pers.comm.), consequently the cost of updating BEI from landsat imagery would only include the labour and analytical costs.

Data Source: GVRD Stormwater Management Reports 1997-2002

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Watershed: Hard Surfaces	Pressure	Lake	
Watershed: Hard Surfaces	Pressure	Stream	

Data Source
Data on impervious surfaces was collected by the GVRD and released in a report in 1999. The report presented an assessment of the condition of watersheds and catchments in the Greater Vancouver Sewerage and Drainage District (GVS&DD) area and provides an estimate of the future condition of the area using status quo management practices. Total impervious area was measured in two ways for this assessment. The first involved using orthophotos to directly measure rooftops, pavement, roads, parking lots, and other impervious surfaces. The second method involved the application of typical percentages of total impervious area to various land use classes.

The report can be found at: www.gvrd.bc.ca/sewerage/stormwater_reports_1997_2002/rpts.htm

Contacts
Mark Wellman, Greater Vancouver Regional District, Tel: 604 436 6933, Email: Mark.Wellman@gvrd.bc.ca

Data Availability
The data used to inform the calculations of impervious surface for the GVS & DD area is available to DFO; however, considering that the data was last used in 1999 it has most likely been archived and will take some time to track down.

Relative Cost
Data purchase / collection: Data can be obtained by DFO at no cost. The cost of collecting the data could not be determined easily as much of the cost was born by in-house resources that cannot be quantified.

Indicator maintenance / development: Cost of indicator maintenance/development will depend on the method used to calculated the metric. Current GIS technologies would reduce the cost of maintaining/developing the indicator relative to the methods used in the 1999 study (orthophoto interpretation and land use classification).

Total cost: Moderate (3 person months full time)

Spatial extent/ resolution
The impervious surface study covered all of the GVS & DD areas. Data used to inform the study were collected using one of two methods previously mentioned. Currently, there is no existing or planned broad-scale impervious surface monitoring program for B.C. as a whole or for urban centers.

Temporal extent/ frequency
The data used to calculate impervious surface was collected from 1997-1999; 1999 being the year the results of the study were released. Initially, the GVRD had hoped to repeat the study every 10 years; however, budget cuts have not allowed them to do so and there is currently no discussion of repeating the study any time soon.

Data Source: Digital Road Atlas (DRA) Program

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Watershed: Road Development	Pressure	Lake	
Recreational Pressure	Pressure	Lake	The distance from a road has been shown to be a good measure of recreational pressure (Trombulak and Frissell 2000). Consequently, the DRA coupled with the watershed atlas could be a relatively uncomplicated method by which to calculate an index for recreational pressure.
Watershed: Road Development	Pressure	Streams	

Data Source
The Digital Road Atlas (DRA) is a data management system for all roads in British Columbia. Ultimately it will capture and supply a single road network for the province to support a full range of requirements. Inputs into the system include TRIM and TRIM updates, the Transportation Centerline Network (TCN) and TCN updates, and resource roads and associated updates. The DRA program participates in the federal geospatial-data programs of Natural Resources Canada, (the National Hydrographic Network) and Geobase (the National Road Network). The DRA is managed by the Integrated Land Management Bureau within the BC Ministry of Agriculture and Lands. A program description and any additional information can be viewed at: ilmbwww.gov.bc.ca/bmgs/pba/dra/#overview.

Contacts
Mark Sondheim, BC Ministry of Agricultural Lands, Tel.: 250 387-9352, E-mail: Mark.Sondheim@gov.bc.ca

References
Trombulak, S.C., and C.A. Frissell. 2000. Review of ecological effects of roads on terrestrial and aquatic communities. Conservation Biology 14(1): 18-30.

Data Availability
There are two DRA data products available: 1) Fully attributed – FAR; and 2) Partially attributed – PAR. The two products share road geometry and basic road attributes but have different coverage, pricing and IP ownership. The DRA data products serve different purposes and answering a few basic questions can help determine which product is right for a particular business need: a) Do you require address information? If so, you want FAR data; or b) Do you require resource roads or forest roads, and/or alleyways? If so, you want PAR data.

Relative Cost
Data purchase / collection: Pricing for PAR data is based on a combination of geographical area and whether data updates are required. The annual cost of PAR data for the entire province, includes updates, is $25,000.

Indicator maintenance / development: Updates, QA incoming data, scheduled data deliveries, and error reporting are standard services included in the price of delivery. Custom services such as data filtering, processing to meet target schema requirements, and creation and maintenance of additional related data sets can be obtained (price is dependent on type of service and is to be negotiated between client and DRA). For example depending on what exactly data needs are DRA can pair road data with other data of interest (hydrological, coastal, etc.)

Total cost: Low (1 person month). Effort is minimal as DRA will generate data in database or spreadsheet readable formats for its partners and clients. The average cost to clients in the past is $25,000 to $40,000 (includes membership fee and support services, etc.).

Spatial extent/ resolution
Geographic coverage for the DRA program is provincial (all of BC). The precision is less than one meter; the absolute accuracy is officially plus or minus 10 meters 90% of the time.

Temporal extent/ frequency
Demographic roads are updated monthly. Resource road updates are more variable with some parts of the province being updated every couple of years and other parts being decades out of date. Data has been collected under the DRA program since 1998 and continues to be collected. Historical coverage extends from 1985 to present.

Data Source: Okanagan Foreshore Program

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Lake Foreshore Development	Pressure	Lake	

Data Source
The BC Lake Stewardship Society (BCLSS) operates the *Okanagan foreshore program.* From 2001-2003, the foreshore project was implemented on two lakes in British Columbia. Over 2000 people were contacted during the scope of the project and 200 homesite assessments were completed in the Okanagan, with another 67 done in Christina Lake. In addition, five sites were restored along the Okanagan Lake Foreshore.

Contacts
Kristi Carter, BC Lake Stewardship Society, Tel: 250 717 1212, Email: kristic-bclss@shaw.ca
Carolyn Johns, BC Lake Stewardship Society, Tel: 250-717-1212, Email: carolynj-bclss@shaw.ca

Data Availability
The data collected on foreshore development can be obtained in excel format by contacting BCLSS directly. With respect to long-term reliability, the foreshore program has been terminated meaning that new data will be collected.

Relative Cost
Data purchase / collection: There is no cost associated with obtaining and using the data. Data collection is very time consuming as have to go door to door. This method would be quite costly if it did not utilize volunteer effort.

Indicator maintenance / development:

Total cost: Moderate (5-7 person months per lake).

Spatial extent/ resolution
The Okanagan foreshore program only covered two lakes in the Okanagan region: Okanagan Lake and Christina Lake.

Temporal extent/ frequency
The Okanagan foreshore program collected data from 2001 – 2003. There are no scheduled data updates; the program has been cancelled due to lack of funding.

Data Source: Sensitive Ecosystem Inventory (SEI)

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Wetland Disturbance	Pressure	Lake	
Riparian Disturbance	Pressure	Lake	

Data Source
A Sensitive Ecosystems Inventory (SEI) systematically identifies and maps rare and fragile ecosystems in a given area. The information is derived from aerial photography, supported by selective field checking of the data. SEI mapping methodology is based on original air photo interpretation for SEI polygons, or as an SEI theme based on Terrestrial Ecosystem Mapping (TEM) polygons. The purpose of the SEI project is to identify remnants of rare and fragile terrestrial ecosystems and to encourage land-use decisions that will ensure the continued integrity of these ecosystems. It is intended for use in a variety of land-use planning processes. The ecosystem types identified vary from region to region, according to the natural ecosystems found there, but usually include forested ecosystems, woodlands, wetlands, riparian areas and natural meadows and grasslands. SEI is administered through the Ministry of Environment.

Contacts
Contact information varies depending on SEI project:
East Vancouver Island and the Gulf Islands and Bowen-Gambier - Jan.Kirkby@ec.gc.ca (604) 940-4657
Sunshine Coast - Carmen.Cadrin@gov.bc.ca, (250) 387-2730
Central Okanagan - gis@cord.bc.ca, (250) 868-5267
Bella Vista-Goose Lake Range - info@abnc.ca, (250) 260-4227

Data Availability
The final reports for each SEI project are available from the SEI website (http://www.env.gov.bc.ca/sei/index.html). Access to raw data and shape files must be negotiated with each of the individual groups that headed/commissioned the SEI project.

Relative Cost
Data purchase / collection: Cost of data collection will vary depending on SEI project. It was not possible to determine a cost estimate for any project in particular. There is no cost associated with using the data. It is available on the internet.

Indicator maintenance / development: Cost will vary depending on SEI project and data that was collected.

Total cost: It is not possible to determine the total cost of using this data source due to a lack of cost specific information relevant to the data source.

Spatial extent/ resolution:
SEI projects have been undertaken for the Sunshine Coast, Bowen and Gambier Islands along with several smaller islands in Howe Sound, the Gulf Islands and east coast of Vancouver Island, Bella Vista and Goose Lake Range, and the western and eastern flanks of Okanagan Lake in the Central Okanagan. Spatial Resolution of 1:15,000.

Temporal extent/ frequency
Varies depending on SEI project.

Data Source: Canadian Wetland Inventory (CWI)

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Wetland Disturbance	Pressure	Lake	
Wetland Disturbance	Pressure	Stream	

Data Source
The Canadian Wetland Inventory (CWI) provides an overarching framework for wetland inventory and monitoring in Canada. The Inventory initiative will establish technical requirements -- related to scale, wetland classification, and level of accuracy -- to promote consistent mapping across the country, while leaving some flexibility to meet regional needs. CWI partners will contribute to the national inventory by mapping wetlands according to these standards, for selected study areas. The CWI is governed by a core team representing the Canadian Wildlife Service of Environment Canada, the North American Wetland Conservation Council (Canada), and Ducks Unlimited Canada. The CWI is currently awaiting government approval and funding before it can expand upon its pilot projects. The intention of CWI is to first create a national inventory and then once this has been established to delve into monitoring wetland changes. This would involve incorporating information from such groups as the Wetlandkeepers[10].

Contacts
Kathleen Moore, Canadian Wildlife Service, Tel : 604 940 4660, Email: Kathleen.Moore@ec.gc.ca

Data Availability
Yes what data is there is available, however, it is quite limited and does not offer any information on wetland trends or changes. Access needs to be negotiated.

Relative Cost
Data purchase / collection: It is unknown whether there would be a cost for using the database. With respect to the cost of data collection it was not possible to establish a cost.

Indicator maintenance / development: Due to pilot project nature of the CWI it is not possible to determine the cost of indicator maintenance as they have not yet arrived at this stage.

Total cost: Unknown

Spatial extent/ resolution:
Presently, there are several pilot projects in BC in the Lower Mainland and on Vancouver Island. If the CWI is approved and funding provided the intent is to inventory the entire country.

Temporal extent/ frequency
Currently there are only a dozen pilot case studies across the country that have been inventoried once. Monitoring schedules have not yet been determined.

[10] The Wetlandkeepers do not currently have any sort of central database nor do they themselves conduct monitoring of wetlands. Rather they are focused on educating community groups on how to care for and rehabilitate wetlands. It is up to individual communities to initiate a Wetlandkeepers project. Wetlandkeepers is hosted by the BC Wildlife Federation (website: http://www.bcwf.bc.ca/programs/wetlands/).

Data Source: Ducks Unlimited Canada (DUC) Wetland Database

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Wetland Disturbance	Pressure	Lake	
Wetland Disturbance	Pressure	Stream	

Data Source
Ducks Unlimited Canada (DUC), BC chapter, maintains a wetland database of all the provinces wetlands. The initial intent of collecting the information for the database was to identify wetlands that were of interest to DUC for purchase and/or restoration. There is no element of monitoring to the database as illustrated by the crude level of detail collected (e.g., wetland classification, vegetation types, and size) and the one time assessment of each site. DUC does conduct monitoring of the wetlands they have acquired, however, this information is not in any type of central database and is scattered throughout reports. In general, DUC is prairie centric meaning the bulk of their data collection focuses on the prairie provinces.

Contacts
Nicole Ray, Ducks Unlimited Canada, Tel: 1 800 665 3825

Data Availability
The database would be made available to DFO, however a terms of use agreement would have to be negotiated. The Canadian Wildlife Service already has a similar agreement with DUC

Relative Cost
Data purchase / collection: It is unknown whether there would be a cost for using the database. With respect to the cost of data collection it was not possible to establish a cost.

Indicator maintenance / development:

Total cost: It was not possible to establish a total cost for using this data source

Spatial extent/ resolution
The wetland database covers the intermountain region of BC (the area that is bordered by the Coast Mountains on the west, the Rockies on the east, the US-Canada border on the south, and a northern limit around Vanderhoof, BC. Approximately 5000 wetlands have been identified in BC. Spatial resolution: 1:20,000.

Temporal extent/ frequency
All wetland entries in the database are one point samples of the wetland providing a snap shot in time. The database only contains the most recent data where repeat site visits occurred; however, very few repeat samples were conducted. Database entries extend back to the 1960s.

Data Source: Okanagan Basin Monitoring and Evaluation Program (OBMEP)

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Accessible stream length, barriers	Quantity	Streams	Barriers in the OBMEP study area were identified as a cascade, dam or weir (including beaver dam), culvert, falls, jam, or gradient barrier. The barriers were documented and examined under low summer flow conditions however, if the potential barrier was surmountable by salmon during higher flows experienced in the fall or spring, the barrier status was described as a partial barrier. If the impending barrier was impossible for anadromous salmon to pass during all flow conditions, the barrier was designated as a permanent barrier.
Riparian Disturbance	Pressure	Streams	
Channel stability	Status	Streams	

Data Source

The Okanagan Nation Alliance (ONA) in British Columbia and the Colville Confederated Tribes (CCT) in Washington are working collaboratively to monitor and evaluate this transboundary sub basin. The Okanagan Basin Monitoring and Evaluation Program (OBMEP) is a status and trend monitoring program that extends over a 20 year period focused on field monitoring of physical habitat, water, and fish production parameters in the Okanagan Basin. Physical habitat measurements included stream depth characteristics, habitat type, substrate characteristics, riparian vegetation, and human influences.

Contacts

Howie Wright, Okanagan Nation Alliance (ONA), Email: HWright@Syilx.Org

References

Benson, R., M. Squakin, and K. Wodchyc. 2007. Okanagan Basin Monitoring and Evaluation Program (OBMEP) 2006 Annual Report for Sites in Canada. Prepared by the Okanagan Nation Alliance Fisheries Department, Westbank, B.C.

Walsh, M. and K. Long. 2005. Survey of barriers to anadromous fish migration in the Canadian Okanagan sub basin. Prepared by the Okanagan Nation Alliance Fisheries Department, Westbank, BC.

Data Availability

Summaries of information on barriers / physical condition of streams in the Canadian Okanagan subasin are provided in annual reports freely available from the Okanagan Nation Alliance. Datasets may be obtained on request from the Colville tribe which maintains a combined dataset from sampling for the Okanagan from both sides of the border.

Relative Cost

Data purchase / collection:

The cost of collecting data for physical habitat from selected reaches in Okanagan streams costs approximately $40,000/year.

Indicator maintenance / development:

Maintenance of the data collected by ONA is undertaken by the Colville tribe in the US, as part of a program fully funded by the Bonneville Power Administration.

Total cost

Low (1 week); DFO analyst time to extract and assess the barrier dataset for Canadian Okanagan streams collected by ONA and assembled by Colville tribe.

Spatial extent/ resolution

The OBMEP program in Canada requires a total of 48 stream sites to be surveyed over 20 years. The 48 sites are divided into one annual panel and five rotating panels, each panel consisting of eight sites. The Canadian OBMEP program requires selection of reaches, or sites, selected from a list of possible sites randomly generated from the Environmental Protection Agency's (EPA) Environmental Monitoring and Assessment Program (EMAP) design, as adapted from Hillman (2004). EMAP is a statistically based and spatially explicit site-selection process developed for aquatic systems.

The barrier survey study area was from the Okanagan Lake Outlet Dam in Penticton, BC to the U.S border and was based on the OBMEP study area in Canada. Preference for the barrier survey went towards streams having EMAP sites. A total of 15 streams were included in the barrier assessment.

Temporal extent/ frequency
The annual panel is surveyed yearly and one panel is surveyed every five years commencing in 2005. Each year, 16 sites will be surveyed, consisting of one annual and one rotating panel..

Barriers were surveyed in 2005. Additional surveys of barriers within the Okanagan may be undertaken at future times, but are not scheduled at present

Data Source: Streamkeepers Data Entry Tool

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Large Woody Debris (and In-Stream Cover)	Status	Streams	
Sediment	Status	Streams	Data on stream substrate is entered into the database.
Riparian disturbance	Pressure	Streams	
Channel stability	Status	Streams	

Data Source
The Streamkeepers Central Database stores data gathered using the Streamkeepers methodology. The database can be uploaded, queries can be run, and reports generated, all via the Internet. The database works hand in hand with the Streamkeepers Handbook and Modules, and in particular, the data collection sheets included in modules 1, 2, 3, 4, 7, 11 and 12.

Contacts
Zo Ann Morten, Pacific Streamkeepers Federation, Tel: 604 986 5059, Email: pskf@direct.ca

Data Availability
The Streamkeepers data entry tool is available from the PSK website (http://www.pskf.ca/program/entry.html) or by contacting Zo Ann Morten. Database is not always up to date because it is sometimes difficult to get streamkeeper groups to enter data. Data entry would be more timely and reliable if had a liaison from DFO working actively with groups. All the data is stored in an Access database.

Relative Cost
Data purchase / collection: There is no fee associated with using the database. Data is collected by volunteer streamkeepers; however equipment costs must be covered by PSKF.

Indicator maintenance / development: Would take considerable effort developing the indicator because would have to make sure all the data is up to date as well as having consistent coverage for required indicator across the province. Effort required to maintain the indicator would initially be greater because would have to set up a working relationship with the PSKF. The effort required would gradually decrease over time.

Total cost: Moderate to high initially (4 – 8 person months per year); low- moderate eventually (2-4 person months per year)

Spatial extent/ resolution
The geographic coverage of the PSKF database is for all of BC proportional to urban proximity. Data entries are site samples; would have to determine to what geographic scale could infer the data.

Temporal extent/ frequency
The frequency with which data is collected for a given site varies with sites (daily, monthly, annually). Likewise the historical coverage will vary depending on the site. Data collection began in 1995 when the PSKF was established.

Data Source: Forest and Range Evaluation Program (FREP)

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Riparian disturbance	Pressure	Streams	Indicator can be informed by data collected through the Fish/Riparian Resource Values component of FREP
Channel stability	Status	Streams	Indicator can be informed by data collected through the Fish/Riparian Resource Values component of FREP
Large woody debris (instream cover)	Status	Streams	Indicator can be informed by data collected through the Fish/Riparian Resource Values component of FREP
Sediment	Status	Streams	Indicator can be informed by data collected through the Water Resource Values component of FREP

Data Source

FREP is a multi-agency program to evaluate whether practices under Forest and Range Practices Act (FRPA) are meeting the intent of current FRPA objectives and to determine whether the practices and the legislation itself, are meeting government's broader intent for the sustainable use of resources. For each resource value specified in FRPA and its regulations, a FREP Resource Value Team (RVT) has been formed. Resource stewardship monitoring (RSM) will occur for each resource value specified in FRPA and its regulations. RSM will provide valuable monitoring and assessment data and other information for decision makers responsible for the approval of results and strategies in FSPs. RSM will also determine an overview of resource value status, trends and implementation issues at the district, regional and provincial levels.

Contacts

Peter Tschaplinski, BC Ministry of Forest and Range, Tel: 250 387 3025, Email: Peter.Tschaplinski@gov.bc.ca
Frank Barber, BC Ministry of Forest and Range, Tel: 250 387-8910, Email: Frank.Barber@gov.bc.ca
Martin Carver, BC Ministry of Environment, Tel: 250 356-1923, Email: Martin.Carver@gov.bc.ca

References

Tripp, D.B., P.J. Tschaplinski, S.A. Bird and D.L. Hogan. 2006. Protocol for Evaluating the Condition of Streams and Riparian Management Areas (Routine Riparian Management Effectiveness Evaluation). FRPA Resource Evaluation Program, B.C. Min. For. and B.C. Min. Water, Land and Air Protection. Victoria, BC.

Data Availability

The central database containing all monitoring data from the FREP program is stored in Victoria. The FREP program is relatively new, consequently issues of data availability (i.e., who can access the data and at what cost) have not yet been finalized. There is an external FTP site for the ministry and data will most likely be made available via this mechanism to external users

Relative Cost

Data purchase / collection: At present, no formal cost structure has been established for using the data. Data, if made available will most likely be free. It was not possible to get information on the cost of collecting data for one particular indicator. Monitoring and data collection under FREP is a multi-million dollar initiative. The most expensive part of data collection is transportation to and from sample sites.

Indicator maintenance / development: Maintenance of this indicator will have to be conducted annually to incorporate new data collected. Development of indicator will require establishing a scale at which to roll up the data that is collected for each cutblock (e.g., it will be possible to roll up the individual site data to watershed, conservation unit, or forest district level).

Total cost: It is not possible to determine the total cost of using this indicator at the present time.

Spatial extent/ resolution

RSM only takes place on crown land, in cutblocks that are greater than 2 years old (cutblocks that have been created under FRPA.
Fish/Riparian Resource Value

Currently, monitoring occurs across the entire province in all 29 forest districts. In 2005, only 19 forest districts were monitored, and in 2006 all 29 were monitored. Within each district, 15 different cutblocks are selected for monitoring each year (repeat surveys of cutblocks are not done at the present time). In total, 725 streams have been survey thus far.

Water Resource Value

The sampling and monitoring methodology is currently being developed. One of two strategies will be followed: 1) sample all cutblocks within a watershed; 2) sample a set of cutblocks within a watershed. Watersheds are chosen using stratified random sampling.

Temporal extent/ frequency

Fish/Riparian Resource Value

Monitoring began in 2005 in 19 of the forest districts. In 2006, monitoring occurred in all forest districts. Each district is revisited annually, however, cutblocks within a district are not revisited. The long-term objective is to revisit cutblocks in a couple of years; however, no concrete time frames have been established.

Water Resource Value

Monitoring began in 2006 with a pilot project and is ongoing. Each district is revisited annually; however, cutblocks within a district are not revisited.

Data Source: Field Data Information System (FDIS)

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Channel stability	Status	Stream	
Large woody debris (instream cover)	Status	Stream	
Sediment	Status	Stream	Sampling focused on measuring stream substrates, not suspended sediments.

Data Source
The Field Data Information System (FDIS) is an MS Access data capture and reporting tool for fish and fish habitat data collected. FDIS data files from completed projects are delivered to the Ministry of Environment and loaded into the provincial dataset (see sample data sheet on next page). The data is then made available through ministry web applications for a variety of uses including land use planning, fisheries management and public interest. Field data collected for FDIS is also used to inform the province's Fish and Habitat Assessment Tool (FHAT20) that allows prediction of channel characteristics and fish populations in unsampled reaches.

Contacts
Lynn Miers, BC Ministry of Environment, Tel: 250 387 9564, Email: Lynn.Miers@gov.bc.ca
David Tesch, BC Ministry of Environment, Tel: 250 387-1908, Email: David.Tesch@gov.bc.ca

Data Availability
Access to the FDIS database would have to be negotiated with the BC Ministry of Environment (MOE) (DFO does not presently have access). The reliability of the FDIS database is significantly higher than its predecessor FISS due to increased QA. That being said, with FDIS more recent entries are more accurate than old ones due to improved QA over time.

Relative Cost
Data purchase / collection: The cost of using the FDIS database is not known, as with access to the database, this would have to be negotiated between DFO and MOE. The collection of data is primarily done by the private sector with final inventory reports submitted to the MOE

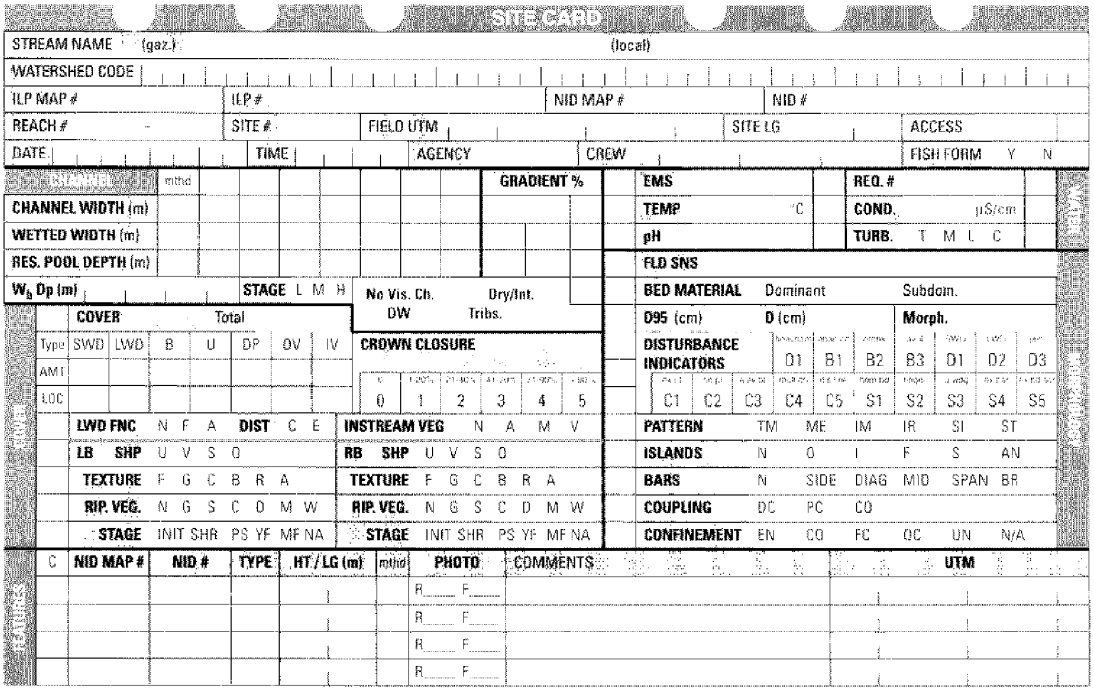
Indicator maintenance / development: Development of an indicator using FDIS may be quite time consuming as will have to determine whether metrics of interest are widely or rarely collected for locations across the province and group data at relevant scale. Maintenance of indicator may also be time consuming as new data is constantly coming in and would have to updating the indicator

Total cost: Low to moderate (2-5 person months).

Spatial extent/ resolution
Intention is to have provincial representation, but because data collected by private sector watersheds with more development activity will have greater coverage. Spatial Resolution: 1:20,000.

Temporal extent/ frequency
Data has been collected by FDIS since its inception in 1995. Historical coverage for a specific site will vary for each site. Likewise, frequency of data updates is dependent on the site; all sites are surveyed different number of times and there is no scheduled frequency.

Example FDIS data entry card



Data Source: Temperature Sensitive Streams Database

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Water temperature	Status	Streams	

Data Source

Stream temperature data from across the province are being collated by the BC Ministry of Environment (MOE) into a centralized database as part of their requirement to designate "Temperature Sensitive Streams" under the Forest and Range Practices Act. Database is the most comprehensive in the province which includes information from many sources (e.g., academia, federal / provincial agencies, and industry). The intention is to use these data, landscape characteristics, and climatic factors to develop stream temperature models to estimate indicators of thermal regimes for watershed polygons across the province.

Contacts

Ted Down, BC Ministry of Environment, (250) 387-9715, Ted.Down@gems7.gov.bc.ca
Eric Parkinson, BC Ministry of Environment, (604) 222-6761, Eric.Parkinson@gov.bc.ca

References

Ministry of Environment. 2007. Temperature Sensitive Streams. See: www.env.gov.bc.ca/wld/frpa/tss/.

Nelitz, M.A., E.A. MacIsaac, and R.M. Peterman. 2007. A science-based approach for identifying temperature-sensitive streams for rainbow trout. North American Journal of Fisheries Management. 27: 405–424.

Marmorek, D.R. and C.A.D. Alexander. 2003. Defining "Significant Fisheries Watersheds" and "Temperature Sensitive Streams" for the New Results-Based Forest Practices Code: Results of a Workshop held Feb. 5th and 6th, 2003. Report prepared by ESSA Technologies Ltd., Vancouver, BC for Ministry of Water, Lands and Air Protection, Victoria, BC. 89 pp.

Data Availability

Although not readily available at this time, the thought is that MOE might host these data through their data warehouse. No assurance that certain locations or time periods will be monitored in the future. Stream temperature models being developed as part of this effort may be appropriate for DFO indicator purposes.

Relative Cost

Data purchase / collection: If data are hosted by MOE's data warehouse, these data could be accessed with no additional cost. Resulting stream temperature models could be used by DFO with no additional cost. Cost of field data collection are not available for these data. Cost of developing database, related products are on the order of $200,000. This is an investment cost, not need to be repeated in the future for DFO.

Indicator maintenance / development: Cost of indicator development / maintenance will depend on the metrics being used. New temperature data need to be added into the database with additional spatial analyses associated with these locations. Estimated that 2 person-months would be required to process data / models for DFO's purposes.

Total cost: Moderate (2 person months).

Spatial extent/ resolution

Data in this database have been collected by a variety of monitoring efforts over many years in British Columbia only. There is no existing or planned broad-scale temperature monitoring program for B.C. Database currently contains data for 724 streams / rivers across the province, ranging from small streams to large rivers. Data are available from most regions (Thompson, Okanagan, Cariboo, Vancouver Island, Lower Mainland, Kootenays, Skeena, Peace). However, data are limited / non-existent in the northwest, Vancouver Island, as well as the Central and North Coasts.

Temporal extent/ frequency

These data have been collected by a variety of monitoring efforts over many years. Years of data available span from 1938 to 2006. Early years of data are limited to large rivers. Daily data are available at all locations in the database for a select portion of the year (typically the summer). Some locations also have hourly data available.

Data Source: WATEMP Database

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Water temperature	Status	Streams	

Data Source
In British Columbia, Fisheries and Oceans Canada has developed a centralized database to store historic and some new in-house stream temperature data collected by researchers across the province.

Contacts
Tracy Cone, Fisheries and Oceans Canada, (604) 666-7269, ConeT@pac.dfo-mpo.gc.ca

Data Availability
These data would be available for use in the Wild Salmon Policy. However, most data are included in the data compilation project being initiated by the Ministry of Environment as part of the requirement for designating "Temperature Sensitive Streams". There are no assurances that any locations in the database will be monitored in the future. Accuracy of data are also questioned given that these data have not gone through a QA / QC procedure before being entred.

Relative Cost
Limited information is available on cost of development of the database to-date or past data collection. Currently, DFO spends approximately $3,000 per year on staff expenses and logger upgrades to monitor and maintain 7 data loggers.

Spatial extent/ resolution
Currently, the database stores spatially referenced temperature data from 211 locations across the province. Monitored locations range in size from large rivers (e.g., Fraser River near Mission) to small streams (e.g., Baptiste tributaries).

Temporal extent/ frequency
Most locations have daily maximum, minimum, and average temperatures available for the period of watermest summer temperatures. Version of the database that we reviewed includes data from 1938 to 2000, though earlier years of data are spot measurements (i.e., pre-1950).

Data Source: Yukon Water Temperature Data

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Water temperature	Status	Streams	

Data Source
Several agencies collect water temperature data across the Yukon (e.g., Fisheries and Oceans Canada, Yukon Government, Environment – Water Quality and Hydrology sections). Data are collected opportunistically and are not stored in a centralized location.

Contacts
Al von Finster, Fisheries and Oceans Canada, Tel: 867-393-6721, Email: vonFinsterA@pac.dfo-mpo.gc.ca
Richard Janowicz, Yukon Government, Environment – Hydrology Section, Tel: 867-667-3223
Brian Truelson, Yukon Government, Environment – Water Quality Section, Tel: 867-667-3217

Data Availability
These data would be available for use in the Wild Salmon Policy. Water temperature data can be and is collected at the same time as monitoring of other habitat attributes / water quality parameters. The reliability of data collection at a particular location is not assured given there is no set monitoring program.

Relative Cost
There is some lack of clarity about the the costs associated with maintaining water temperature data given that a centralized storage system has not been developed. Cost of data collection are highly variable. Opportunistic data collection could occur at a cost of $5,000 per year, however if there was a dedicated temperature monitoring program, costs could range form $25,000 to $50,000 per year. Specific costs require better understanding of specific sampling design. Relative cost of collecting data at a single site is relatively low, however, given inexpensive monitoring devices.

Spatial extent/ resolution
A patchwork of temperature data is available across the Territory, which include: Croucher Creek a tributary to Yukon River near Whitehorse, Viceroy groundwater channel a tributary to the North Klondike, Klondike River, Germaine Creek, groundwater channel a tributary to the Klondike River, Michie Creek a tributary to the M'clintock River, and the Yukon River.

Temporal extent/ frequency
Data are available at hourly intervals. First measurements available are from the late 1990s to recent years.

Data Source: Floodplains Mapping Program

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Floodplain Connectivity	Pressure	Streams	

Data Source
The Floodplain Mapping Program was a joint initiative by the federal and B.C. governments (Ministry of Sustainable Resource Management) to provide information to help minimize flood damage in British Columbia. The program identified and mapped areas that were highly susceptible to flooding. These areas were designated as floodplains by the federal and provincial Environment Ministers.

The Floodplain Mapping Program can be accessed at: http://www.env.gov.bc.ca/wsd/data_searches/fpm/index.html .

Contacts
Bruce Boyd, BC Ministry of the Environment
Tel: 250 356-1202, Email: bruce.boyd@gov.bc.ca

Data Availability
Photos of floodplains are available as well as digitized coverage of the boundaries, areas and limits of floodplain mapping, however the available data does not contain isolines or FCLs. The FCL/isoline information was never digitized and must be derived from the original 1:5000 maps (ongoing project). The floodplain mapping program has since terminated the provincial program and flood plain mapping is now under the jurisdiction of local authorities.

Floodplain maps are served up to the public via an interactive GIS web application called the BC Water Resources Atlas http://www.env.gov.bc.ca/wsd/data_searches/wrbc/index.html. The BC Water Resource Atlas displays a suite of information related to the water resources of the Province of British Columbia, such as watersheds, water quantity and quality monitoring sites, aquifers, water wells and flood protection works. The spatial layers of interest for floodplain connectivity are floodplain and floodplain protection. Refer to sheet for the BC Water Resource Atlas for more information on the Atlas

Relative Cost
Data purchase / collection: The data can be freely accessed from the Land Resource Data Warehouse (www.nric.ca/).

Indicator maintenance / development: To determine the cost of indicator maintenance and development one would need to speak with individual local authorities.

Total cost: The original cost of collecting the data and mapping it out is estimated at $200-400K per floodplain. Originally all the data was collected in the field back in the70s, 80s, 90s. Today you could map floodplains using remote sensing technology but the effort required to produce floodplain maps would still be quite intense.

Spatial extent/ resolution
Geographic coverage of the floodplains only includes specific designated floodplain areas in BC and are restricted to the floodway areas of the stream, lake or river that occur within populous areas. Spatial resolution: 1:5,000

Temporal extent/ frequency
Data collected under the Floodplain Mapping Program spans from 1973 – 1998; however the temporal extent for individual floodplains varies. Floodplains were mapped only once by the province; however, individual municipalities may have mapped out floodplains in their jurisdiction a second time.

Data Source: BC Water License Database

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Water Extraction	Pressure	Streams	Overlaying the spatial layers Surface Water Quantity and Hydrometric from the BC Water Resource Atlas could highlight areas that may have water extraction conflicts by comparing total water allocated (water licenses) versus water levels in the system (hydrometric).

Data Source
Managed by BC MOE the Water License Database stores quantities licensed water to a particular individual / entity, but does not monitor actual water use.

Contacts
Rick Hardy, BC Ministry of Environment, Tel: 250 387 6345, Email: Rick.H.Hardy@gov.bc.ca

Data Availability
Water license data (spatial and attribute) are directly available free to the public, in ARC/INFO coverage export file format, shape file or CSV file. Attribute data is available at www.elp.gov.bc.ca:8000/pls/wtrwhse/water_licences.input. It is possible to query for individual licenses at this site. The entire database is also available through the Land Resource Data Warehouse.

Information within this water license database is served up to the public via an interactive GIS web application called the BC Water Resources Atlas http://www.env.gov.bc.ca/wsd/data_searches/wrbc/index.html. The BC Water Resource Atlas displays a suite of information related to the water resources of the Province of British Columbia, such as watersheds, water quantity and quality monitoring sites, aquifers, water wells and flood protection works. The spatial layers of interest for water extraction are Surface Water Quantity and Hydrometric. Refer to sheet for the BC Water Resource Atlas for more information on the Atlas.

Relative Cost
Data purchase / collection: There is no cost to directly access this data.

Total cost: Low - Moderate (1-3 months) The GIS layer has location and attribute information. Cost of analyst time to assemble and merge water license data into desired units.

Spatial extent/ resolution:
Information is available on licenses for the entire province. Spatial Resolution of GIS layers: 1:20,000.

Temporal extent/ frequency
All water licenses in province are accounted for, with greater accuracy on more recent ones. Digitised version of water licenses (maps) started in 1997 - Present

Data Source: Water Survey of Canada Hydrometric Network (HYDAT Database)

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Stream discharge	Status	Streams	Data on the Hydat system include daily and/or instantaneous information for streamflow and water level, suspended sediment concentration, sediment particle size, and sediment load. The data for this information ranges from the year 1850 to the present
Sediment	Status	Streams	Data on the Hydat system include for some gauging sites daily and/or instantaneous information for suspended sediment concentration, sediment particle size, and sediment load.

Data Source

The National Hydrometric Program is a cooperative endeavour between the federal and provincial governments to provide for the collection, interpretation, and dissemination of surface water quantity data and information. This program supports a Hydrometric Network of active water level and streamflow stations being operated under the federal-provincial and federal-territorial cost-sharing agreements.

Contacts

David Hutchinson, Environment Canada, Tel: (604) 713-9548, Email: David.Hutchinson@ec.gc.ca

References

Scott, D., T. R. Yuzyk and C. Whitney, 1999: The Evolution of Canada's Hydrometric Network: A Century of Development. In Partnerships in Water Resource Management, Proceedings of the CWRA 52 nd Annual Conference, Nova Scotia, June 1999.

Data Availability

Under the federal/provincial agreements, the federal government publishes the data that have been collected form the National Hydrologic Network according to national standards. Data not collected to meet national standards are not considered to be under the agreements, but they are often published as "contributed data." All data are stored in the national HYDAT database.

Relative Cost

Data purchase / collection:

Information from the Water Survey of Canada's Hydrometric Network can be obtained from the website www.wsc.ec.gc.ca/products/main_e.cfm?cname=products_e.cfm in a variety of forms without any cost to the user:

1) Real time hydrometric data from 1200 hydrometric data from across Canada
2) Water level and stream flow statistics from selected hydrometric gauging stations: http://www.wsc.ec.gc.ca/sedat/sedflo/index_e.cfm?cname=main_e.cfm)
3) Archived HYDAT sediment data: http://www.wsc.ec.gc.ca/staflo/index_e.cfm?cname=main_e.cfm

Each gauging station is designated as federal, federal-provincial/territorial or provincial/territorial, according to national classification guidelines agreed to by all parties. The federal government pays for the operational costs initially and then recovers the appropriate share from each party based on the station designations. For example, those gauging stations designated as regional water quantity stations are considered shared responsibilities. Such stations are intended to describe the hydrologic character of each region of the country, and the costs are shared on a 50/50 basis by the federal and provincial or territorial governments. While the federal government operates nearly 2300 of the over 2700 stations currently active, the agreements provide that either Canada or a province may construct and/or operate water quantity survey stations with costs being shared according to the established rules. Each additional gauging station in the network costs approximately $10,000/year (basic- road access) to install/maintain with an approximate additional $2000 if real time capable. Maintenance of a gauging station at a remote fly-in station can be considerably more (e.g. $40,000 plus for sites requiring plane or helicopter access) (D. Hutchinson, pers. comm.).

Indicator maintenance / development: A national modernization strategy is currently in place with the goal of providing more efficient and effective data acquisition, processing and dissemination, and providing these services in real-time. Under this strategy, automated state-of-the-art technology is being introduced to all aspects of the field, office, and data delivery elements of the hydrometric program. The program is also well supported by active training of technicians and maintenance of standardized protocols.

Total cost: Low (several months); analyst time to extract and assess datasets from hydrometric stations for BC and Yukon.

Spatial extent/ resolution
Currently, there are 2978 active water level and streamflow stations across the country, including stations in BC and the Yukon. Data for 1445 of the 2978 active stations are transmitted in near real-time (active station locations can be found at www.wsc.ec.gc.ca/hydrometric/results_e.cfm. An additional 5421 hydrometric stations are no longer active, but their data are stored with the active station data in the national HYDAT database. There are about 450 active stations located at various locations across BC and the Yukon.

Most of the stations are located in the southern half of the country where the population and economic pressures are greatest. As a result, the adequacy of the network to describe hydrologic characteristics, both spatially and temporally, decreases significantly to the north. Hydrometric stations are located on lakes, rivers, and streams of many sizes, ranging from drainage basins as small as a few hectares to large watersheds like the Mackenzie Basin (1 680 000 km^2). In general, however, the gauging stations are biased towards larger river systems (100 Km^2 and over) (D. Hutchinson, pers. comm.).

Temporal extent/ frequency
At each station, water level data are recorded continuously, either on graph paper using a mechanical (analogue) recorder, or in digital form using an electronic recorder, or "data logger". The determination of the rate of flow, or discharge, of a river requires several measurements of water depth and velocity across the river to yield the average discharge. Streamflow measurements can be made from a bridge, by wading the stream, by boat, or from a cableway strung across the river. Such measurements are done periodically to define a relationship between water level and discharge, which is used to generate a time series of streamflow data from the recorded water level data. Data collected within the Hydrometric Network generally takes from 15 to 18 months to become available within the Hydat database (D. Hutchinson, pers. comm.).

Data Source: Fish Passage Culvert Database – Cariboo Region, BC

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Accessible stream length, barriers	Quantity	Streams	

Data Source
A centralised database containing stream crossings has been created for the Cariboo Region of BC. The hope is to extend this database and standard techniques for data collection to the entire province. The timeline for completion of the provincial database is dependent on funding; consequently it is not possible to specify a date.

Contacts
Michael Stalberg, Ministry of Environment, Tel: (250) 398-4645, Email: Mike.Stalberg@gov.bc.ca

Data Availability
Data is available in an MS Access database upon request

Relative Cost
Data purchase / collection: There is no cost associated with purchasing the data. The cost of collecting the data for the Cariboo region (involved consolidating data from disparate data sources; no new field collection) was $6,000 – 8,000.

Indicator maintenance / development: The cost of data entry and maintenance was approximately $27,000. The cost of data entry is dependent on the amount of data to be entered and will vary across regions.

Total cost: $35,000 for the Cariboo region. If the province chooses to pursue this for other regions should be able to cut cost down to $25,000 per region as methodologies have been developed and fixed costs (data collection) could be negotiated with independent contractor.

Spatial extent/ resolution
Currently, the culvert database only includes stream barriers in forest districts within the Cariboo Region that are affected by mountain beetle. Stream barriers on private or reserve land are not included.

Temporal extent/ frequency
Includes all stream crossings surveyed after 2000. There is debate surrounding whether the culvert database should included barriers surveyed prior to the implementation of provincial standards/methodologies for surveys of fish passage.

Data Source: BC Water Resource Atlas

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Water Extraction / Stream Discharge	Pressure	Stream	The themes of interest for water extraction are Surface Water Quantity, Hydrometric, and Water Wells (Contact: Rodney Zimmerman 250 387 9464). In particular under Surface Water Quantity there is a layer that displays where there are water allocation restrictions for the province (Contact: Glen Davidson 250 387 6949).
Floodplain Connectivity	Pressure	Stream	The themes of interest for floodplain connectivity are floodplain and floodplain protection.
Recreational Pressure	Pressure	Lake	The theme of interest for recreational pressure is Recreation and Tourism. In particular, the layer Recreation Features Inventory (RFI) could be used to inform the indicator (Contact: John Crooks 250 387 3213). The RFI identifies areas of land and water encircling a recreation feature or combination of features that support, or have the potential to support, one or more recreation activities. These areas are rated for their significance or importance to recreation and for their sensitivity to alteration.

Data Source

The BC Water Resources Atlas is a comprehensive web-based information tool for use by anyone interested or involved in water protection and management in British Columbia. It is part of an ongoing effort by the Ministry of Environment to improve public access to environmental information. The Ministries' goal is to provide information that will lead to better surface and groundwater management and protection.

The Atlas lets you generate custom maps and display spatial information about watersheds, water quantity, water quality and groundwater resources anywhere in the province.

Contacts

Rodney Zimmerman, Ministry of Environment, Tel: 604 387 9464, Email: Rod.Zimmerman@gov.bc.ca

Where metadata is available it is possible to find the contact person for individual layers. When you click on the name of the layer of interest (only works when the layer is available, i.e., you are at the appropriate scale) the ILMB Discovery Service metadata details will be displayed. Within the details is a contact person for the layer.

Data Availability

The interactive map is available at http://www.env.gov.bc.ca/wsd/data_searches/wrbc/index.html. Where metadata is available access to raw data will be specified. Data for RFI, water allocation restrictions, and ground water wells mentioned above are available in oracle format upon request.

Relative Cost

Data purchase / collection: There is no cost associated with purchasing the data when it is available. Cost of collecting the data could not be determined.

Indicator maintenance / development: The cost of developing and maintaining the indicators using this data source could not be determined.

Total cost: Effort required to use this data source would be low to moderate where metadata and raw data are available (3 – 6 person months per indicator).

Spatial extent/ resolution
Thematic coverage and associated data varies in completeness and accuracy. Data may not be available for some parts of the province, or existing data may not be in a format that the Atlas can use. It is expected that new and existing coverage will be added and enhanced on an ongoing basis.

Temporal extent/ frequency
Varies depending on the layer. For example: Ground water wells was last fully updated in 2003, but is done so on an ongoing basis; Recreation Features Inventory was created in 2004 and is updated on an ongoing basis; and the water allocation restriction layer dates back to 1997 and is also updated on an ongoing basis.

Data Source: QuickBird Satellite Imagery

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Accessible shore length, barriers	Quantity	Lake	
Accessible off-channel habitat area	Quantity	Lake	
Watershed: Land cover alterations	Pressure	Lake	
Watershed: Land cover alterations	Pressure	Streams	
Watershed: Hard Surfaces	Pressure	Streams	
Watershed: Hard Surfaces	Pressure	Lake	60-centimeter pan-sharpened multispectral imagery can be used to measure impervious surfaces, such as roofs, streets, and parking lots.
Lake foreshore development	Pressure	Lake	
Floodplain connectivity	Pressure	Streams	Flood boundaries can be measured to within a few meters accuracy in areas without tree cover using submeter multispectral fused imagery.
Eelgrass Habitats	Status	Estuary	
Wetland Disturbance	Pressure	Lake	
Wetland Disturbance	Pressure	Stream	
Spatial Distribution of Wetlands / Mudflats	Status	Estuary	
Estuarine Habitat Area	Quantity	Estuary	

Data Source
QuickBird imagery is a fine resolution remotely sensed product available to the public through DigitalGlobe and MacDonald Detwiler (two private companies). QuickBird's ultra fine resolution makes this valuable imagery for validation and land cover assessment.

Contacts
Brad Mason, Fisheries and Oceans Canada, Tel: (604) 666-7015, E-mail: masonb@dfo-mpo.gc.ca

Data Availability
Quickbird imagery is available, but must be ordered from a reseller. Images can be drawn from the archives or new images can be requested.

Relative Cost
Data purchase / collection: $17 per km^2 if image is in the archive, $50 per km^2 if request new image (costs are only estimates and may vary).

Indicator maintenance / development: Need image analysis software to analyse imagery ($5,000 – 10,000) if don't already have it. The same software that is used for landsat image analysis can be used for QuickBird analysis. .

Total cost: Low (1 week per image for analysis).

Spatial extent/ resolution
Provincial coverage – if images haven't already been taken can request them for areas not photographed. Spatial Resolution: m.

Temporal extent/ frequency
New images can be taken whenever the satellite passes over the province.

Data Source: Fraser River Environmental Watch Program

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Water Temperature	Status	Streams	
Stream Discharge	Pressure	Streams	

Data Source
The Fraser River Environmental Watch Program (FREWP) provides a weekly report series describing the environmental conditions in the north-eastern Pacific Ocean and the Fraser River during the summer salmon migration period. Reports may include a description of sea surface temperatures, conditions in the tropical Pacific Ocean and river water discharge and temperature. When possible, a 10 day river temperature and discharge forecast is also included. FREWP is administered out of Fisheries and Oceans Canada.

The FREWP can be accessed at: http://www-sci.pac.dfo-mpo.gc.ca/fwh/index_e.htm

Contacts
Dave Patterson, Fisheries and Oceans Canada, Tel: 604 666 5671, Email: pattersond@pac.dfo-mpo.gc.ca

References
Patterson, D.A., Macdonald,J.S., Skibo, K.M., Barnes, D.P., Guthrie, I., and Hills, J. 2007. Reconstructing the summer thermal history for the lower Fraser River, 1941 to 2006, and implications for adult sockeye salmon (*Oncorhynchus nerka*) spawning migration. Can. Tech. Rep. Fish. Aquat. Sci. 2724: iv + 43 p

Data Availability
The data collected by FREWP is available for use with the Wild Salmon Policy.

Relative Cost
Data purchase / collection: There is no cost associated with using the data. The cost of collecting the temperature data is difficult to isolate/determine because a lot of the temperature monitoring work is tied to other field programs, and is difficult to separate. In general, the more remote a sampling location the more expensive it will be to collect data from it.

Indicator maintenance / development: The cost of database development and management depends on the size of the database and whether the data is vetted, documented, and quality controlled.

Total cost: Moderate to High (4-8 person months)

Spatial extent/ resolution
The FREWP covers the Fraser River Basin (12 sites: Stuart River, Shelley, Nechako River, Chilcotin River, Quesnel River, Horsefly River, Ashcroft, N. Thompson River, S. Thompson River, Qualark, Hope, Vancouver.

Temporal extent/ frequency
Discharge data are available from 1912 to the present from Hope or Qualark Creek. Fraser River water temperatures are provided by 10 real-time dataloggers placed at sites throughout the Fraser Basin. Temperature records from Hells Gate date back to 1962 and are presented to provide a long-term historic perspective.

Data Source: Forest Health Mapping

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Watershed: Land Cover Alterations	Pressure	Lake	
Watershed: Land Cover Alterations	Pressure	Stream	

Data Source
Since 1999, the B.C. Ministry of Forests has surveyed the majority of the forested land in the province using the classic sketch mapping technique known as the overview survey method. The purpose of the survey is to record and report the general trends in disturbance patterns across the provincial forested land base (including provincial parks, private land, and Tree Farm Licences but not Federal parks). Data from the BC MOFR survey is also comparable to data collected from 1914 to 1995 by the Canadian Forest Service's former Forest Insect and Disease Survey Unit (i.e., Forest Health Network Archive). The Forest Health Mapping can be accessed at: http://www.for.gov.bc.ca/HFP/health/overview/webmap.htm

The Forest Health Network Archives Pest Data for British Columbia is hosted by Natural Resources Canada. This website archive contains the Forest Health Network aerial detection survey coverages for British Columbia. The "pest" coverage maps are stored as an ArcInfo coverage format and are converted to an ArcInfo export file (.e00) format for FTP purposes. Forest Health Network Mapping Archive: http://www.pfc.forestry.ca/entomology/pests/

Contacts
Tim Ebata, Ministry of Forest and Range, Tel: 250 387-8739, Email: tim.ebata@gov.bc.ca
Alan Thomson, Natural Resources Canada, Tel: 250 363-0632, Email: athomson@pfc.cfs.nrcan.gc.ca

Data Availability
On-line access to the BC Ministry of Forest and Range aerial overview survey data (shape and excel files) is available through the website (http://www.for.gov.bc.ca/HFP/health/overview/webmap.htm) via links to an FTP site for each year. Likewise, access to the archived forest health surveys are available on line at http://www.pfc.forestry.ca/entomology/pests/.

Relative Cost
Data purchase / collection: There is no cost associated with purchasing the data. The cost of data collection is around 0.75 million per year as surveys are done with aerial flight of the entire province. It was not possible to establish an exact cost

Indicator maintenance / development: The cost of indicator development and maintenance would be dependent on what metric is used. The data from the forest health mapping relates to forest only, there would be a cost (estimated to be low) to integrate it with other GIS land cover data sources that included agricultural and urban land use etc.

Total cost: Low (1- 3 person months). Majority of work would be to extract desired information out of shape files to inform the indicator.

Spatial extent/ resolution
Forest Health 'points' and 'polygons' as recorded on the paper mapsheets during the overview survey flight (scale typically 1:100,000 or 1:250,000 but can be larger - Cariboo Region uses 1:40,000 mapsheets for example) will be digitized on an appropriate electronic map base (typically 1:100,000 scale).

Temporal extent/ frequency
Data on forest health and pest distribution ranges back to the 1910s for some species and is available till 1997 in the archive. Current forest health surveys are conducted by the MOFR annually.

Data Source: National Road Network (NRN)

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Watershed: Road development	Pressure	Stream	
Watershed: Road development	Pressure	Lake	
Recreational Pressure	Pressure	Lake	The distance from a road has been shown to be a good measure of recreational pressure (Trombulak and Frissell 2000). Consequently, the DRA coupled with the watershed atlas could be a relatively uncomplicated method by which to calculate an index for recreational pressure.

Data Source
The National Road Network (NRN) is a Canadian Council on Geomatics (CCOG) initiative contains quality geospatial data (current, accurate, consistent and maintained) of Canadian roads across thirteen provincial or territorial datasets. It is National in scope with mid to long term agreements signed between participating partners (federal, provincial, territorial, and municipal governments). The spatial data set includes centerlines for all non-restricted use roads in Canada (i.e., 5 meters or more in width, drivable and no barriers denying access). British Columbia integrates their data into NRN via the Digital Road Atlas (see details in other worksheet), while Yukon relies on the NRN program to update road information. Best to use this data set as it includes information for both Yukon and BC, while also including the best information source from British Columbia.

Contacts
Marcel Sabourin, Natural Resources Canada, Tel: (819) 564-5600 ext 284, E-mail: msabouri@NRCan.gc.ca

References
Trombulak, S.C., and C.A. Frissell. 2000. Review of ecological effects of roads on terrestrial and aquatic communities. Conservation Biology 14(1): 18-30.

Data Availability
Road network spatial dataset resides in the CCOG GeoBase portal, which is publicly available with unrestricted use licenses. See the following: http://www.geobase.ca/geobase/en/data/nrn/index.html

Relative Cost
Data purchase / collection:
All data are available at no cost to users. Cost of data collection varies greatly because each provider has different geographic boundaries and methods of updating information. More detailed information on cost to each jurisdiction was not available.

Data / indicator maintenance:
Relatively low level of effort required to process spatial data to generate summary statistics across the Pacific Region.

Total cost: Low

Spatial extent/ resolution
NRN datasets are comprised of all drivable, accessible and unrestricted use roads at least 5 meters in width. Resources or recreation roads are not mandatory features. Some provincial/territorial providers may or may not distribute them via the GeoBase portal.

Temporal extent/ frequency
The NRN datasets are updated on a minimum yearly cycle. Users of the data set can report back to the producer to include changes during the next update cycle. Program initiated in 1979.

Data Source: Provincial Obstacles to Fish Passage

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Accessible stream length, barriers	Quantity	Streams	

Data Source
The Provincial Obstacles to Fish Passage spatial layer combines records of all known obstacles to fish passage from all provincial corporate fish datasets: The Fisheries Information Summary System (FISS); the Fish Habitat Inventory and Information Program (FHIIP); the Field Data Information System (FDIS) and the Resource Analysis Branch (RAB) inventory studies. The intent of this layer is to have a single source of all known obstacles to fish passage. Note that not all waterbodies have been studied and not all lengths of many waterbodies have been studied. Thus, many real obstacles have not been recorded in this dataset. Meta data are summarized at: http://aardvark.gov.bc.ca/apps/metastar/metadataDetail.do?recordUID=50219&recordSet=ISO19115

Contacts
Gordon Oliphant, Ministry of Environment, Phone: (250) 356-9938, Email: Gord.Oliphant@gov.bc.ca

Data Availability
Barrier layer is freely viewable and accessible by the public through the Land and Resource Data Warehouse (LRDW, http://www.lrdw.ca/).

Relative Cost
Data purchase / collection:
Not available

Data / indicator maintenance:
Not available

Total cost: Low, free access of data, though calculation of indicators requires GIS processing time to intersect provincial blueline layers (preferably 1:20,000) and salmon distribution with permanent provincial obstacles in this dataset.

Spatial extent/ resolution
Provincial obstacles are available from across British Columbia. Several notes regarding data quality: (i) many obstacles are seasonal obstacles only, (ii) not all waterbodies have been examined for obstacles to fish passage, (iii) many obstacles on inventoried waterbodies remain unknown, (iv) some recorded obstacles are subject to movement due to high flows or geological processes (not captured in this layer).

Temporal extent/ frequency
Resource Analysis Branch data are from 1970 to 1985. FHIIP (Fish Habitat Inventory & Information Program) data are from 1985 to 1996. FDIS data (Field Data Information System) are from 1996 to present. FISS (Fisheries Information Summary System) data are available from 1900 to present. Because all data except FISS are related to an inventory time period, transition years could be in either data set. E.g., 1996 information could be in either FHIIP or FDIS but not both

Data Source: Yukon Biophysical Mapping

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Watershed: Land cover alterations	Pressure	Stream	
Watershed: Hard surfaces	Pressure	Stream	
Wetland disturbance	Pressure	Stream	
Riparian disturbance	Pressure	Stream	

Data Source
The Yukon government is in the early stages of developing biophysical maps for the territory. Current work is focused on establishing standards for mapping. Mapping would be focused on using climatic, physiographic (e.g., soils, geology, etc), and vegetation features of the landscape to delineate terrestrial ecosystems. Biophysical mapping would draw upon a mix of existing datasets (e.g., forest cover layer, National Ecological Framework, Earth Observation for Sustainable Development) and predictive mapping tools. Human disturbances (e.g., mining, agriculture, forestry) on the landscape would receive their own land cover designations. Intention is to build maintenance (i.e., repeat sampling) into the methods for developing biophysical maps. Specific products are very fluid and undefined at this time, though preliminary mapping has been initiated in a small part of the north (see link under references)

Contacts
John Meikle, 867-667-3538, Yukon Government, Environment

References
Sample map available at: http://www.emr.gov.yk.ca/pdf/bmp_biophysical_map_north_yukon.pdf

Data Availability
Mapping products would not be available for another 3-4 years. Once completed, these data sets would available for use by other government agencies. Some source layers are currently available (e.g., soils, high level national forest cover maps).

Relative Cost
Data purchase / collection: Not available at this time; project not complete.

Data / indicator maintenance: Not available at this time; project not complete.

Total cost: Not available at this time; project not complete.

Spatial extent/ resolution
Mapping would cover the entire territory. Spatial resolution of mapping would be dependent on the spatial layers input being used, likely at the 1:250,000 (e.g., soils layer) or 1:100,000 scale. Raster images would have 30 m grid resolution.

Temporal extent/ frequency
Intention is to see repeated long-term updating of input spatial layers (e.g., every 5-10 years). Layers currently being considered (e.g., EOSD - Earth Observation for Sustainable Development) were last updated in 2000.

Data Source: Yukon Water Board - Water Licenses Database

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Water extraction	Pressure	Stream	

Data Source
The Yukon Water Board is an independent administrative tribunal established under the Waters Act which is responsible for issuing water use licences for the use of water and/or the deposit of waste into water. Water licences are issued for placer and quartz mining, municipal use, power, agricultural, industrial, recreational, conservation, and miscellaneous purposes. Database includes data on all licensed quantities of water use in the Territory, but does not monitor the actual amount of water being used as part of that license.

Contacts
Doreen Bicknell, Yukon Water Board (primary data contact)
Judi White, Yukon Water Board, 867-456-3984

References
Summary of Water Use Licenses available at: http://www.yukonwaterboard.ca/ywb_licences.htm
Yukon Water Board home page available at: http://www.yukonwaterboard.ca/

Data Availability
Data are public and would be available for DFO purposes under the Wild Salmon Policy. Given the importance of this information for a variety of purposes, there is a high likelihood that this database will be maintained in the future.

Relative Cost
Data purchase / collection: Information about program cost was not available, though it is not expected to be high.

Data / indicator maintenance: There would be not cost associated with acquiring / using the data.

Total cost: Effort required to summarize appropriate data would be similar to that as required in summarizing information from BC database (i.e., relatively low, several weeks of analyst time).

Spatial extent/ resolution
Information available for all active water licenses in the Territory. This includes all waterbodies where source of water use (i.e., taking) or sources of deposits into water are within Yukon boundaries. For instance, if water users in Alaska were drawing water from the Yukon, they would require a Yukon water license. Currently there are approximately 300-400 active licenses in the database. An active water license does not necessarily mean that the user is actively withdrawing water at any one time.

Temporal extent/ frequency
Database has been maintained for at least the last 7 years and is updated regularly (i.e., any time a new license is issued). Each licensee is required to submit an annual report on water use, though this information is not stored in a central database.

Data Source: Yukon Water Resources Hydrometric Program

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Stream discharge	Status	Stream	

Data Source
In addition to the Water Survey of Canada hydrometric data available for the Territory (see worksheet describing Water Survey of Canada Hydrometric Network) the Yukon Government maintains a hydrometric network (originally initiated by Department of Indian and Northern Development in 1974). Although the program is coordinated with Environment Canada, these data are not available through the Water Survey of Canada (WSC) HYDAT web site. These data are not hosted by WSC because of differences in data collection standards. Data standards being used are still sufficient to warrant use for decision making.

In the context of development activities and fisheries concerns, the purpose of this additional monitoring was to monitor discharge on smaller ungauged drainages because extrapolation of flow trends from large to small watersheds has questionable reliability. The intention is that monitored location can be optimally located with respect to physiographic and climatic characteristics within hydrologic regions to provide some representation of streamflow characteristics within areas of interest.

Contacts
Richard Janowicz, Yukon Government, Environment, Tel: 867-667-3223

References
Yukon Water Resources Hydrometric Program Historical Summary 1975 – 2004 report available at: http://www.environmentyukon.gov.yk.ca/pdf/hydrometricmanual2005.pdf

Data Availability
These data would be available for use by DFO. Data are not stored in a centralized database (see above report), such that the data would be somewhat onerous to compile in a digital format for analysis.

Relative Cost
Data purchase / collection: Operation and maintenance of data collection program is low ($5,000 – $6, 000) which includes staff time and vehicles, but not equipment.

Data / indicator maintenance: Additional effort would be focused on compiling and analyzing data as appropriate for analysis.

Total cost: Relatively low, focused on time required to compile and analyze data to calculate metrics under the Wild Salmon Policy.

Spatial extent/ resolution
Descriptive information is provided for existing / historic hydrometric stations as a relatively small subset of waterbodies across the Territory. Station information includes location (as related to latitude and longitude / nearby highways), drainage area, period of record, and information on flow regulation. The following drainages have been sampled: Blind Creek, Christmas Creek, Clear Creek, Clinton Creek, Contact Creek, Cosh Creek, Granger Creek, Klukshu Creek, Rose River, Tom Creek, Upper Wolf Creek, Vangorda Creek, Wolf Creek, and Yukon River (at Dawson and Marwell).

Temporal extent/ frequency
Data area available since the programs inception in 1975 to present day. However, not all locations have been maintained equally over that time. Frequency of historic data collection also varies due to differences in monitoring technologies. Initially (i.e., 1975), crest stage gauges were used to provide information on a single peak value within a service interval. Ratings curves were then used to interpolate between sampling periods. Early on in the program no winter readings were available. In the late 1970s, gauging technologies were employed that provided continuous records over time (i.e., 15 minute intervals summarized by daily statistics). Further changes to the hydrometric network are expected. Some stations found to duplicate or supply redundant data will be discontinued, while other sites supplying useful new data or have site specific purposes will be established or kept.

Data Source: Yukon Wetland Inventory

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Wetland disturbance	Pressure	Stream	

Data Source
Ducks Unlimited Canada in Whitehorse has been working with its project partners the Canadian Wildlife Service, Yukon Government, and various First Nations to conduct bird (and by association wetland) inventories. This work has involved aerial surveys of wetlands across the entire Territory focusing on waterbird use, specifically breeding, molting, and staging in these habitats. To-date no on-the-ground monitoring has occurred. As well, no measure of wetland area or classification of wetlands (e.g., wetland, bogs, etc) is available through this work. This effort has been focused on wetlands identified by First Nations that will help resolve land claims, or wetlands that have been identified as requiring protection under land use planning initiatives.

Contacts
Amy Leach, Ducks Unlimited Canada, Tel: 867-668-3824
Debbie Van De Wetering, Canadian Wildlife Service, Tel: (867) 667-3930

Data Availability
Data are shared among project partners, although it is unclear whether these data would be available for use by DFO. Release and use of these data requires unanimous approval by project partners. Use of data by any agency to further resolve land claims would be viewed as favourable to project partners.

Relative Cost
Data purchase / collection: It is uncertain whether there would be a cost to access data – depends on specific use and approval of that use by project partners. Cost of data collection to-date has been highly variable – depends on the kind of survey being conducted and number of wetlands being interviewed in a given year. Program costs, however, have generally been high over the course of the project.

Data / indicator maintenance: Cost of using data would focus on the GIS processing time required to summarize spatial data on wetland centroids into appropriate spatial statistics – which depends on the metric.

Total cost: Moderate cost focused on use these data for DFO Wild Salmon Purposes

Spatial extent/ resolution
Inventory provides excellent coverage of the territory with the exception of the north slope and areas around Dawson. To-date, 1000s of wetlands have been identified. Currently, mapping has been focused on locating aerial transect lines and centroids of wetlands in some areas so surveys can be replicated. There is no mechanism for mapping areas or classifying wetlands although this is recognized as a priority for future work. Project partners are working with the Yukon planning commissions to map the landscape and provide such information.

Temporal extent/ frequency
Temporal extent depends on the wetland project and area of the Territory. For instance some areas (e.g., Peel watershed) have multiple years of monitoring (maximum of 3 years) with some replication sites having replication within a season.

Data Source: Yukon Riparian Disturbance Mapping

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Riparian disturbance	Pressure	Stream	

Data Source
Fisheries and Oceans Canada (Whitehorse office) has developed a map of stream reaches that have been disturbed in the past or are currently experiencing disturbance from placer mining activities. These data were collected by interviewing Yukon Placer Mining Secretariat officials and having them map areas of known riparian disturbance. These individuals are the people who visit mining claims and have first-hand experience with riparian disturbances. The original intention of collecting these data was to capture disturbance to riparian areas that are affecting salmon habitats and to use these data in a salmon habitat modelling tool as related to placer mining activities (see Yukon Watershed Mapping worksheet). Areas of disturbance are assigned to stream reaches in the GIS framework being used to model salmon habitat capability. Given a focus on mining activities, these data do not only include impacts on riparian areas resulting from forestry or agriculture.

Contacts
Steve Gotch, Fisheries and Oceans Canada, Tel: 867-393-6715, Email: GotchS@dfo-mpo.gc.ca

Data Availability
These data would be available for use, though with the specific caveats that disturbance mapping is related to only one industry (placer mining development) and does not consider all disturbances. Although useful is does not represent all development activities.

Relative Cost
Data purchase / collection: Disturbance mapping was compiled by Yukon Government Mining Inspectors (14 staff) over the course of approximately 2 months. The costs were absorbed directly by the Yukon Government. There is no anticipated cost of using these data for other purposes.

Data / indicator maintenance:

Total cost: Low

Spatial extent/ resolution
Data are available for 16 watersheds in the Yukon River drainage where riparian areas have been affected by placer mining activities – both historically, and recently. These data are not available for the Liard, Alsek, MacKenzie, or Porcupine watersheds. Disturbance information has been identified on streams mapped at the 1:50,000 scale (implies a minimum stream size).

Temporal extent/ frequency
Data source represents a one-time snapshot of disturbance collected in early 2006. These data include all areas that have been developed and not reclaimed (either through natural or human-induced processes). Some disturbed areas may be 50+ years old. Updating would be possible if additional interviews of field officers were conducted. This information will be updated on an ongoing basis.

Data Source: Yukon Habitat Suitability Model

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Accessible stream length, barriers	Quantity	Stream	

Data Source
Fisheries and Oceans Canada (Whitehorse office) has developed a spatially explicit model to predict suitability of habitats for chinook salmon across the Yukon River drainage. Prediction of reach-scale rearing habitat suitability uses information on barriers (natural and artificial, though only 2 barriers are included), predators, water quality, reach gradient, proximity to known production areas, riparian disturbance, and special concern areas. To-date models have only been developed for chinook, though the intention is to expand the model to chum (in the Yukon drainage), as well as coho and steelhead (in the Alsek drainage only).

Contacts
Steve Gotch, Fisheries and Oceans Canada, Tel: 867-393-6715, Email: GotchS@dfo-mpo.gc.ca

References
ESSA Technologies Ltd. 2007. Yukon Habitat Suitability Model User Guide, Version 7.0. Prepared by ESSA Technologies Ltd., Vancouver, BC for the Department of Fisheries and Oceans, Whitehorse, Canada.

Data Availability
This model would be available for use by DFO for other purposes. In particular, model could be used to calculate accessible stream length to chinook salmon where habitat suitability is greater than zero in the Yukon. Some of the model inputs may not be available for broader application (e.g., special concern areas, water quality, known production areas).

Relative Cost
Data purchase / collection: There was a relatively high cost (>$400,000) associated with planning, constructing, and developing the model and necessary inputs. There would be no cost to DFO for using these data.

Data / indicator maintenance: Processing of model outputs to calculate an accessible stream length would require minimal GIS time (i.e., few days at most).

Total cost: Low cost to use to calculate indicator, focused on GIS time to calculate relevant indicators from model outputs (see above).

Spatial extent/ resolution
The model predicts salmon habitat suitability in 16 watersheds that drain into the Yukon River mainstem. Coverage does not include the Liard, Alsek, Mackenzie, or Porcupine valleys. Habitat suitability predictions are based on 1:50,000 scale stream linework, which implies a minimum stream size. Salmon habitats are associated with an intelligent stream network model that provides prediction of suitability at the reach scale (i.e., 100s of metres).

Temporal extent/ frequency
Model represents a current snapshot of habitat suitability based on a variety of time varying inputs: water quality, known production areas, and special concern areas. There is no set frequency for updating these information sources at this time, though water quality information is measured throughout the year with ongoing updates.

Data Source: Yukon Fire History

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Watershed: Land Cover Alterations	Pressure	Stream	Focus is on land cover changes due to wildfire disturbance. Other land cover changes are not represented.

Data Source
Theses data represent a landscape level GIS coverage of large fires within the Yukon, spanning a period from 1946 to present, updated annually. Spatial coverage represents fire perimeter only. No information is available on fire severity within a polygon.

Contacts
Jason Adams, Yukon Government, Planning Section. Tel: 867-456-3905, Email: Jason.Adams@yk.gov.ca

Data Availability
These data would be available for use by DFO in the Wild Salmon Policy. The only restriction on using these data is that they are not re-engineered and sold. There is a high likelihood that these data would continue to be measured into the future.

Shapefiles and metadata are available for download from: ftp://ftp.geomaticsyukon.ca/fire/. A sample map of Yukon Fire History is available at: http://www.emr.gov.yk.ca/pdf/2004firehistory2b.pdf.

Relative Cost
Data purchase / collection: Cost of purchasing satellite imagery is relatively inexpensive (i.e., few hundred dollars per satellite imagery scene). There would be no cost to DFO associated with using these data.

Data / indicator maintenance: Cost of GIS processing of satellite images depend on extent of fire disturbance during a season (e.g., can range from 2-4 weeks of a GIS technician's time). The Yukon government processes these data in-house.

Total cost: Low cost to use these data as mapping is already completed. Additional effort might be required

Spatial extent/ resolution
Extent of recent fire disturbance is available for the entire Yukon. Coverage varies depending on the time period and technology being used at that time. For instance, disturbance information from the earliest period (1946) is only available for a limited portion of the territory. Data after 2003 are represented by satellite imagery with a resolution of 30 metres.

Original polygon size was limited to 200 hectares, when the first edition of this dataset was completed in 1997. Smaller fires are now being included, especially near communities. In most instances, fire perimeters only were mapped. This means that unburned areas within the perimeter are not accounted for, either in an ecological context or in annual area burned summaries. More recent fires mapped, with the aid of satellite technology may include large unburned patches.

Temporal extent/ frequency
Fire mapping for the Territory is updated annually. Although the temporal scale of the coverage goes back to late 1940's, Yukon-wide fire detection capability was not fully developed until the 1960's. In addition to this, access to regular aerial mapping was not readily available until that same time period. Many fires in the 1940's and 1950's were simply not recorded or poorly mapped, particularly in the north.

Data Source: EQ Win Database

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Water chemistry	Status	Stream	
Sediment	Status	Stream	

Data Source
The Yukon Government, Environment Water Quality Section monitors water quality / chemistry across a number of rivers in the Territory as associated with water licenses. These data are currently being integrated into a centralized database named EQ Win that a number of mines use to store water quality data. Monitored parameters include sediment, water temperature, ph, conductivity, turbidity, dissolved oxygen, fecal coliforms, biological oxygen demand, metals, nutrients, and chlorophyll. Suite of parameters being monitored varies across sites.

Contacts
Bob Truelson, Yukon Government, Environment, Tel: 667-3217

Data Availability
These data would be available for use by outside agencies. A centralized database will not be completed until Oct, but should be in good working condition by the end of summer 2007. Once available, database may eventually be distributed through the web.

Relative Cost
Data purchase / collection: Costs of initial data collection are generally high. There would be no cost associated with using / acquiring these data.

Data / indicator maintenance: Low, once database is available.

Total cost: Low

Spatial extent/ resolution
Database contains water quality information from a relatively limited selection of rivers across the Territory (16 sites – Yukon, Burry Creek, Klondike River, Mackintyre Creek, Kepler River, and other areas). Focus is on monitoring the Yukon and Klondike Rivers. Monitoring is also only focused on locations where water licenses exist for big mines (also monitoring river with a fish farm).

Temporal extent/ frequency
Some sites have been monitored since the 1980s, while most provide data back to the 1990s. Most water quality parameters are collected as spot measurements as frequently as possible (i.e., once / twice a year). Data at a few stations have continuous monitoring (e.g., Klondike River, McIntyre Creek).

Data Source: Yukon Placer Mining Industry Water Quality Objectives Monitoring Protocol

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Sediment	Status	Stream	
Water chemistry	Status	Stream	

Data Source

The Yukon Placer Secretariat maintains a water quality monitoring program to support implementation of and compliance with a new placer mining regulatory regime (i.e., the Placer Regime). This monitoring protocol focuses on answering two questions: (1) Are the established Water Quality Objectives in the new regime being achieved? and (2) If not, are violations due to placer mining activities or other causes?. The program provides water quality information taken at key locations, several times each season. Parameters being monitored include: (i) field measurements of pH, conductivity, water and air temperature, stream flow, as well as (ii) automatic sampler measurements of rainfall, stream flow, air, and water temperature. Grab samples are also sent for lab analysis of total suspended solids, settle-able solids, turbidity, pH, and conductivity. Water quality monitoring participants include Yukon Energy Mines and Resources, Yukon Water Resources, and Fisheries and Oceans Canada.

Contacts

Robert Thompson, Yukon Placer Secretariat, Energy, Mines and Resources, Tel: 867-667-5802
Mark Nowosad, Yukon Government, Client Services and Inspection Branch, Energy, Mines and Resources, Tel: 867-667-3211
Tanya Gates, Yukon Government, Client Services and Inspection Branch, Energy, Mines and Resources, Tel: 867-667-3094

References

Yukon Placer Water Quality Working Group (YPWQWG). 2007. Yukon Placer Mining Industry Water Quality Objectives Monitoring Protocol. Available at: http://www.yukonplacersecretariat.ca/pdf/water_quality_objectives_monitoring_protocol.pdf
Yukon Placer Secretariat home page: http://www.yukonplacersecretariat.ca/index.html

Data Availability

Data collected through this program are public once available in a final form. Therefore, these data would very likely be available for DFO's purposes. The intention is to continue monitoring for the foreseeable future as this monitoring program will support the new Placer Regime to regulating placer mining activities in the Territory. The new regime will be implemented in 2008.

Relative Cost

Data purchase / collection: Per year data collection costs (transportation and wages) are relatively moderate ($50-100K). Most significant annual costs are associated with transportation required to access sites; many sites require helicopter access, driving times and labour costs to access remote sites are not trivial. Initial equipment costs are high -- $5000 per sampler, 20 samplers used in monitoring program. There would be no cost of acquiring these data to use for Wild Salmon Policy purposes.

Data / indicator maintenance: Relatively low cost associated with analyst time needed to query datasets for appropriate indicators / parameters of interest.

Spatial extent/ resolution

This monitoring program targets water quality monitoring for 18 watersheds across the Territory where placer mining activities are active. Watersheds chosen for sampling are divided into primary (high frequency sampling) and secondary/tertiary watersheds (low frequency sampling) (see table below, drawn from YPWQWG 2007). For example in year 1, four primary watersheds (McQuesten, 60 Mile, Klondike, and Indian) and four secondary/tertiary watersheds (Yukon River North, Yukon River South, White River, Mayo River) have been chosen for sampling and analysis. In year 2, the previous year's secondary watersheds become primary watersheds, the primary watersheds from year 1 become tertiary watersheds, and four new secondary watersheds are added to the monitoring program.

Eventually, all 18 watersheds (4 primary and 14 secondary/tertiary) will be sampled in unison every year while the four primary watersheds will be rotated each year.

Watershed	Year 1	Year 2	Year 3
Primary	McQuesten, 60 Mile, Klondike, and Indian	Yukon River North, Yukon River South, White River, Mayo River	Alsek , Big Creek , Bi g Salmon, Forty Mile River
Secondary	Yukon River North, Yukon River South, White River, Mayo River	Alsek, Big Creek, Big Salmon, Forty Mile River	Liard River, Nisutlin River, Nordenskiold River, Pelly
Tertiary		McQuesten, 60 Mile, Klondike, and Indian	Yukon River North, Yukon River South, White River, Mayo River, McQuesten, 60 Mile, Klondike, Indian

Temporal extent/ frequency

Most water quality sampling starts in May and continues to the end of September. Grab samples are collected by ISCO samplers once per day for 24 days at which time sites are visited for collection of water samples. Continuous measurement of some water quality parameters does occur (e.g., water temperature). This monitoring program is relatively new (2 years) though water quality monitoring associated with placer mining has been active since 1997. Earlier data are in a variety of data formats and were collected by different technologies, meaning that historic comparisons are more difficult.

Data Source: Yukon Water Well Registry

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Water extraction	Pressure	Stream	

Data Source
The Yukon Government maintains a database of water wells within the Territory storing information related to location of well, date completed, depth, static level, yield estimate, pH, conductivity, and hardness. Wells are classified according by intended use categories including: domestic, commercial, municipal, geotechnical, recreation, industrial, test, and quality. The availability of this information for each well varies; some wells have good information, while many others have little data.

Contacts
Richard Janowicz, Yukon Government, Environment, Tel: 867-667-3223

References
Summary of Yukon Water Wells available at:
http://www.environmentyukon.gov.yk.ca/pdf/YukonWaterWellsSummary.pdf

Data Availability
The data contact was not available during the period of review, so we are uncertain about data availability for DFO's purposes.

Relative Cost
Data purchase / collection: Information not available.

Data / indicator maintenance: Information not available.

Total cost: Information not available.

Spatial extent/ resolution
Database includes 100s of sites from across the Territory. It is not clear if all wells are included in this database. It is also uncertain if coordinates are available for these wells which would allow for mapping and analysis in GIS.

Temporal extent/ frequency
Database includes wells dating from at least 1973 to present. It is not clear how frequently the database is updated, or how current the information.

Data Source: Yukon Spatial Data Clearinghouse

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Watershed: Land cover alterations	Pressure	Stream	

Data Source

Geomatics Yukon (i) provides corporate coordination, support, and liaison for geomatics activities within the Yukon Goverment and with external partners and customers, (ii) addresses gaps in geomatics activities and data, and (iii) provides a single window to access Yukon spatial data and services. Geomatics Yukon focuses on the acquisition, storage, analysis, dissemination, and management of spatial data, including GIS, remote sensing, GPS, and cartography. Through the Yukon Spatial Data Clearinghouse (http://www.geomaticsyukon.ca/data_download.html), Geomatics Yukon distributes a variety of spatial layers representing relevant land cover changes across the Territory: fire (see Yukon Fire History worksheet), mining, lands & agriculture, oil & gas, and transportation (see National Road Network worksheet). Some of these layers are viewable through the Yukon Mining and Lands Map Viewer (http://www.emr.gov.yk.ca/mlv_jump.html). The Clearinghouse also distributes a series of Landsat mosaics (http://www.geomaticsyukon.ca/imagery.html), which could be used to derive land use statistics as being developed in BC (see Baseline Thematic Mapping worksheet) and as being considered in the Yukon (see Yukon Biophysical mapping worksheet).

Information relevant to generating an indicator of land cover alteration would require spatial information regarding the following land uses:

- Mining: Includes separate spatial layers related to coal, placer, and quartz mining activities. Maps of mining leases, licenses, and claim blocks are mapped and registered with no indication of actual footprint on-the-ground. These layers would include both active and inactive claims.
- Lands & agriculture: **Includes a summary of the agricultural land applications and dispositions by client. Again, no data are available regarding footprint areas, though orthophotos are available that characterize 80% of agricultural land use in the Territory within a 75 km radius of Whitehorse. Although a relatively minor land use, over the last 20 years agricultural activities have grown considerably in the Territory (David Murray, pers. comm.).**
- Oil & gas: Relevant spatial layers include oil & gas dispositions, well locations, and seismic lines (incomplete mapping from 1961 to 1984).
- Transportation: This information is summarized under the National Road Network worksheet.
- Fire: This information is summarized under the Yukon Fire History worksheet.

A general observation is that these spatial data describe administrative boundaries (e.g., leases, claims, dispositions) and do not accurately represent the actual footprint on the landscape of these alternative land uses.

Contacts

Lauren Crooks, Yukon Government, Geomatics Yukon, Tel: 867-393-7084, Email: Lauren.Crooks@gov.yk.ca
Diedre Davidson, Yukon Government, Geomatics Yukon, Tel: 867-667-3036, Email: Diedre.Davidson@gov.yk.ca

Data Availability

These data are publicly available at no charge: See http://www.geomaticsyukon.ca/data_download.html.

Relative Cost

Data purchase / collection: Variable depending on spatial layers being used to generate indicators.

Data / indicator maintenance: Variable depending on spatial layers being used to generate indicators.

Total cost: Variable depending on spatial layers being used to generate indicators.

Spatial extent/ resolution

Entire territory is represented by the above spatial layers. Resolution of the data vary, depending on the layers of interest.

Temporal extent/ frequency

Frequency of updating and availability of historical data vary for each land use layer.

Data Source: British Columbia WELLs Database

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Water Extraction	Pressure	Stream	The theme of interest in the BC Water Resouce Atlas is Water Wells (Contact: Rodney Zimmerman 250 387 9464).

Data Source
The WELLs database is comprised of the location of wells which have been drilled, dug or driven in the province. The WELLs database can be searched for water well records provided that legal descriptions, well locations, or well construction details of the well are known. The purpose of this database is to assist in the management and protection of the groundwater resource. Ground water well locations are identified onto well cards by well drillers as part of the drilling process. There is no statutory requirement for well drillers to submit these records to the Government of British Columbia, therefore not all ground water wells are represented in this dataset. It is uncertain the percentage of wells that are represented, but the best estimate is around 50%. The WELLs database is managed by the Ministry of Environment.
Website: http://www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/wells.html

Contacts
Rodney Zimmerman, Ministry of Environment, Tel: 250 387 9464, Email: Rod.Zimmerman@gems5.gov.bc.ca
Tammy Blair, Ministry of Environment, Tel: 250 387 0014, Email: Tammy.Blair@gov.bc.ca

Data Availability
The WELLs database is available to the public in Oracle format however, it must be requested. The WELLs database can also be searched online at http://aardvark.gov.bc.ca/apps/wells/jsp/public/indexreports.jsp. The database does have copyright constraints, meaning written permission is needed from the Environmental Quality Branch, and the EQ Branch must be acknowledged whenever the information is used. A spatial GIS layer with physical well locations is available from the BC Water Resource Atlas (entered as a separate data source).

Relative Cost
Data purchase / collection (program costs): There is no cost associated with using the data. With regards to data collection, individuals that commissioned the well voluntarily submit information cards with well attributes. The cost is therefore primarily limited to producing the cards and entering the data into the database.

Data / indicator maintenance (start-up costs, operating costs): Cost would be low as the data is already in accessible database form (oracle) and is mapped in a GIS layer by the Ministry of Environment. The cost would depend on what metric for water extraction was used and how it would be informed by the data source

Total cost: Low (>$50,000 and 1-2 person weeks))

Spatial extent/ resolution
The database is for the entire province of BC.

Temporal extent/ frequency
The database was created in 2003 and is in a constant state of update and does not stay static for any length of time.

Data Source: National Air Photo Library

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Watershed: Land Cover Alterations	Pressure	Stream	
Watershed: Land Cover Alterations	Pressure	Lake	
Watershed: Hard surfaces	Pressure	Stream	
Watershed: Hard surfaces	Pressure	Lake	
Watershed: Road Development	Pressure	Stream	
Watershed: Road Development	Pressure	Lake	
River Deltas	Status	Lake	
Wetland Disturbance	Pressure	Stream	
Wetland Disturbance	Pressure	Lake	
Channel Stability	Status	Stream	
Accessible Off Channel Habitat Area	Quantity	Streams	
Foreshore Development	Pressure	Lake	
Floodplain Connectivity	Pressure	Stream	
Accessible Shore Length	Quantity	Lake	
Accessible Off Channel Habitat Area	Quantity	Lake	

Data Source

The National Air Photo Library's collection spans over 70 years of aerial photography in Canada. Imagery from various years can be found for most areas of Canada. Air photos capture residential and industrial areas, road and rail networks, and geographical features including mountains, canyons, flatlands, rivers, lakes, forests, and cropland. Our standard product is a 25cm x 25cm (10" x 10") vertical aerial photograph contact print. Most of these photographs are monochrome (black and white), but some areas are available in colour or infrared. Each photo is cross-referenced to an index map or flight report that indicates the exact flight path and flight altitude, identifies film type, film number, photo centres, and specifies date, time of exposure, camera and weather conditions for that particular run. These photographs can be readily transformed into a variety of other products. The National Air Photo Library is managed by Natural Resources Canada.

Contacts

National Air Photo Library, Tel: 1-800-465-6277, Email: NAPL@NRCan.gc.ca

Data Availability

Photos are available to the public; however one has to order them from the library. They can be ordered either on-line or by sending in a written request to the library. The archive can be searched on-line once an account has been created. http://airphotos.nrcan.gc.ca/index_e.php

Relative Cost

Data purchase / collection (program costs): The price of a 10"x10" monochrome contact print is $14.99. The price of a 300 dpi monochrome digital image is $24.99. For a complete price list see: http://airphotos.nrcan.gc.ca/pdf/napl_price_list.pdf. Additionally, for those clients who require air photo search services, a search fee of $20.00 for simple searches and $50.00/hour for complex air photo searches is charged. For a

limited time, clients will receive a rebate on search fees to be applied toward the purchase of air photo products from NAPL. The rebate will equal the price of the product purchased or the search fee, whichever is less.

Data / indicator maintenance (start-up costs, operating costs): Monochrome would have to be digitised and analysed for desired characteristics. This could be time consuming depending on the number of photographs and what is wanted from them (roughly 1-2 weeks per picture).

Total cost: Moderate to High ($50,000 to < $100,000).

Spatial extent/ resolution
The majority of the Yukon territory and province of BC are covered. Digital aerial photographs are available in Tagged Information File Format (TIFF), at resolutions of 300 and 600 dots per inch (dpi) for monochrome photography, and 600 dots per inch for colour photography. Scale is generally 1:20,000.

Temporal extent/ frequency
Photos in the National Air Photo Library date back 70 years to 1937. That being said the temporal extent for any given location will vary with some areas only having been photographed once.

Data Source: Fisheries Information Summary System (FISS)

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Accessible Shore Length, barriers	Quantity	Lake	
Accessible Shore Length, barriers	Quantity	Stream	
Channel Stability	Status	Stream	
Invasives	Pressure	Lake	
Accessible Off-Channel Habitat	Quantity	Stream	
Water Chemistry	Status	Lake	
Water Chemistry	Status	Stream	
Recreational Pressure	Pressure	Lake	
Stream Discharge	Pressure	Stream	

Data Source
The Fisheries Information Summary System (FISS) provides spatially represented summary level fish and fish habitat data for waterbodies throughout British Columbia and the Yukon. The information is in database format and can be displayed on the 1:50,000 Watershed Atlas. FISS is made up of data and map components. Fish and fish habitat themes included are fish distribution, enhancement and management activities and objectives, gradient and macro-reaches, land use, water use, water quality activities, obstructions, resource use, flow, fisheries potential and constraints, escapement, value and sensitivity, life history and timing, and harvest and use. FISS is a jointly funded project by BC Fisheries and Fisheries and Oceans Canada.

Contacts
Lynn Miers, BC Ministry of Environment, Tel: 250 387 9564, Email: Lynn.Miers@gov.bc.ca
David Tesch, BC Ministry of Environment, Tel: 250 387-1908, Email: David.Tesch@gov.bc.ca

Data Availability
Access to the FISS database is already available as DFO helps administer/serve up the database to the public (website: http://srmapps.gov.bc.ca/apps/fidq/). The system consists of fish and fish habitat, macro-reach and lake classification databases, overlaid on a 1:50,000 digital stream network of British Columbia and Yukon Territory. Information is accessible through queries on the Web. Standardized hard copy maps and reports are also produced.

Relative Cost
Data purchase / collection (program costs): There is no cost to use the FISS database.

Data / indicator maintenance (start-up costs, operating costs): Extracting the desired information out of FISS could be time consuming.

Total cost: Low (< $50,000)

Spatial extent/ resolution
Waterbodies in the province of BC and the Yukon territory are covered by FISS. Maps at 1:50,000 scale display physical locations and attributes of reports in the FISS database.

Temporal extent/ frequency
FISS was initially launched in 1984. It is a continually growing database with new data being summarized and added as it is collected. As new information is received and entered, the breadth and value of information generated from FISS will continue to increase.

Data Source: Yukon Forest Cut Layer

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Watershed: Land cover alterations	Pressure	Stream	

Data Source
The Forest Planning and Development section of the Yukon government maintains a spatial layer with forest harvesting information for the Territory. These data are focused on measuring larger commercially harvested areas. Forest disturbance due to commercial forestry is limited relative to wildfire. As well, a lot of forest harvesting is for personal consumption using very selective methods and low-impact equipment (e.g., dog teams, snowmobiles).

Contacts
Lyle Dinn, Yukon Government, Forest Planning & Development, Energy, Mines and Resources, Tel: 867-456-3813

Data Availability
Data would be available for use by DFO. A restriction on use is that the data would not be available for redistribution and sale.

Relative Cost
Data purchase / collection: Cost of maintaining spatial layer was not available. No cost associated with accessing the data.

Data / indicator maintenance: Minimal cost associated with generating a measure of forest harvesting changes over the landscape.

Total cost: Low

Spatial extent/ resolution
Mapping information is available for the entire Territory, though most harvesting occurs in the Yukon watershed near Hanes Junction, in the Alsek watershed, and in some areas around Dawson and Whitehorse. In general, cut areas smaller than 1 hectare are not mapped which excludes much of the selective logging for personal consumption.

Temporal extent/ frequency
The rate of change in human-induced forest disturbance is very slow. Records of cutting are maintained as harvesting occurs, but the digital layer is updated at irregular intervals, usually once every few years. Cut information is available for approximately the last 10-15 years. Other non-spatial records are available that provide information on that amount of historical logging (e.g., Gold Rush).

Data Source: Mariculture Permitting Database - Alaska

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Disturbance of In-Shore Habitats	Pressure	Estuary	
Disturbance of Off-Shore Habitats	Pressure	Estuary	
Foreshore Disturbance	Pressure	Estuary	

Data Source
The Division of Commercial Fisheries in the Alaska Department of Fish and Game has created a database that houses all the permitting information for aquaculture operations in the state of Alaska. The database has coordinate information as well as acreage information for facilities.

Contacts
Cynthia Pring-Ham, Mariculture Program Coordinator, Alaska Department of Fish and Game, Tel: 907 465 6150, Email: cynthia_pring-ham@fishgame.state.ak.us

Data Availability
The database is available to the public and any agency. Requests are to be sent to Cynthia Pring-Ham. Coordinate information is available in both minutes and decimals. A list of all aquaculture permit holders is available at: http://www.cf.adfg.state.ak.us/geninfo/enhance/maricult/maricult.php.

Relative Cost
Data purchase / collection: There is no cost associated with using the data – it is available free of charge.

Data / indicator maintenance: Little effort is required to import the data into a GIS application, furthermore, acreage of aquaculture operations has already been calculated.

Total cost: Low

Spatial extent/ resolution
The database covers all aquaculture activity in the state of Alaska. Currently, there are only 60-62 aquaculture facilities in the state.

Temporal extent/ frequency
Records in the database include all individuals who currently have permits as well as production information back to 1990.

Data Source: Fisheries and Oceans Canada Commercial Catch Statistics

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Marine Vessel Traffic	Pressure	Estuary	

Data Source
Fisheries and Oceans maintains detailed catch statistics for salmon, groundfish and shellfish that can be used to infer marine traffic for fishing boats based on vessel days within an reporting area.

Contacts
Lia Bijersterveld, A/Fisheries Monitoring Information Coordinator, Fisheries and Oceans Canada, Tel: (604) 666-6501, Email: BijsterveldL@pac.dfo-mpo.gc.ca

Data Availability
Summaries of catch statistics for salmon, groundfish and shellfish by DFO reporting district are available at data (http://www-sci.pac.dfo-mpo.gc.ca/sa/Commercial/AnnSumm_e.htm). Pre-1995 catch statistics reports are available via FTP (ftp://ftp.pac.dfo-mpo.gc.ca/pub/BiaginiL/HistoricCommercialCatchStatistics/) in PDF format. More detailed information on catch statistics at finer spatial scales are available on request from DFO's Regional Data Services Unit at 604-666-2716 (CatchStats@pac.dfo-mpo.gc.ca).

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Relative Cost
Data purchase / collection: There is no cost associated with using the data – it is available free of charge.

Data / indicator maintenance: Little effort is required to import summaries of the catch data for use in analyses.

Total cost: Low

Spatial extent/ resolution
The database covers all DFO fisheries management areas along the British Columbia coast.

Temporal extent/ frequency
Annual summaries of commercial catch statistics date from 1951 to 2007.

Data Source: Nearshore Fish Atlas of Alaska

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Resident Fish	Status	Estuary	As collected for Essential Fish Habitat (EFH) monitoring
Water chemistry	Status	Estuary	As collected for Essential Fish Habitat (EFH) monitoring
Eelgrass	Status	Estuary	As collected for Essential Fish Habitat (EFH) monitoring

Data Source
NOAA Fisheries Auke Bay Laboratory and the Alaska Regional Office designed this web-based Atlas to provide information on the distribution, relative abundance, and habitat use of nearshore fishes in Alaska. Shallow, nearshore waters are some of the most productive habitats in Alaska and the most vulnerable to human disturbance. Using Alaska's Shorezone mapping as the sampling frame, identified eelgrass shore units are randomly selected from coastal areas for intensive sampling. Beach seining is as the sampling method for evaluation of resident fish; currently 98 fish species have been documented in a variety of nearshore habitats in an effort to identify Essential Fish Habitat (EFH). Water chemistry and more detailed information on eelgrass condition and characteristics is also collected at sampled EFH sites. The Habitat Assessment staff of NOAA is presently quantifying and identifying EFH in Alaska through coastal mapping, nearshore fish surveys, and eelgrass monitoring.

Contacts
Mandy Lindeberg, NOAA Fisheries Alaska, Tel: (907) 789-6616, Email: Mandy.Lindeberg@noaa.gov
Steve Lewis, NOAA Fisheries Alaska, Tel: (907) 586 - 7858 , Email: steve.lewis@noaa.gov

Data Availability
The shorezone mapping GIS atlas and supporting imagery (i.e., pictures, videos) is accessible on line at: http://www.fakr.noaa.gov/maps/szintro.htm. Data for specific areas can be obtained from contacts.

Relative Cost
Data purchase / collection: There is no cost associated with using the data – it is available free of charge on-line.

Data / indicator maintenance: Minimal effort would be required to import the data into a GIS application or to download the data into a database. This project has been funded by NOAA and a number of other agencies and organizations in Alaska.

Total cost: Low

Spatial extent/ resolution
Portions of southeastern and central Alaska have been imaged and mapped, more areas will be mapped as funding becomes available. This standardized system catalogs both geomor-phic and biological resources at mapping scales of better than 1:10,000. The high resolution, attribute rich dataset is a useful tool for extrapolation of site data over broad spatial ranges and creating a variety of habitat models.

Temporal extent/ frequency
Records in the atlas date back to 1996. Seine surveys of fish assemblages at each randomly selected site are repeated for three consecutive years. Repeat sampling is then undertaken at a site after 5 years for trend monitoring. The web atlas is dynamic and is updated regularly

Data Source: Shorezone Mapping (Alaska)

Indicators informed by data source

Indicator	Indicator Type	Habitat	Comments
Eelgrass	Status	Estuary	
Micro and macr algae	Status	Estuary	

Data Source
NOAA Fisheries Alaska has employed the same Shorezone mapping methodology employed in BC to identify the quantity and quality of nearshore habitat available along Alaska's coastline. The ShoreZone standardized system catalogs both geomorphic and biological resources at mapping scales of better than 1:10,000. This ShoreZone database include four regions (Southeast, Aleutians, Prince William Sound, Arctic), and will be increased in succeeding years as new mapping and locations are added. Also, this data is linked to the Nearshore Fish Atlas database for Alaska.

Contacts
Scott Johnson, NOAA Fisheries Alaska, Tel: (907) 789-6063, Email: Scott.Johnson@noaa.gov
Jon Kurland, NOAA Fisheries Alaska, Tel: 907 586 7638, Email: Jon.Kurland@noaa.gov
Matt Eagleton, NOAA Fisheries Alaska, Tel: 607 271 6354, Email: Matthew.Eagleton@noaa.gov

Data Availability
The atlas is accessible on line at: http://www.fakr.noaa.gov/habitat/default.htm. Data for specific seine sites can be downloaded from within the atlas.

Relative Cost
Data purchase / collection: There is no cost associated with using the data – it is available free of charge on-line.

Data / indicator maintenance: Minimal effort would be required to import the data into a GIS application or to download the data into a database.

Total cost: Low

Spatial extent/ resolution
To date the majority of sampling has been in southeastern Alaska, but has expanding to included Prince William Sound, the Aleutian Islands, and the Arctic.

Temporal extent/ frequency
Shorezone mapping in Alaska has been ongoing since early 2000's and is continuing. The web atlas is dynamic and is updated regularly