Strong foundations: Recap and recommendations from scientists regarding the federal environmental and regulatory reviews

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Executive summary

Robust science in the public interest is critical to the welfare, health, and prosperity of Canadians. Science is an essential part of the environmental review: scientific methods provide the data used to determine whether a proposed project may have significant adverse effects and forms the basis of follow-up, monitoring, and adaptive management. In Canada, concerns have been raised repeatedly by academic, government, non-government, industry, and Indigenous sectors, as well as members of the public, about the quantity, quality, and independence of scientific data and methods used in the environmental review process. There is also concern about how scientific evidence factors into decision-making and the lack of transparency with which this information is considered or shared. It is clear that the role of science in Canadian environmental review processes needs a major overhaul.

In June 2017, the Government of Canada released the *Environmental and Regulatory Reviews Discussion Paper*[1] (hereafter 'Discussion Paper'), which provides an overview of guiding principles and steps being considered to modernize environmental review. The Discussion Paper addresses in part some of the concerns regarding science in Canada's environmental review process.

In this report, we provide recommendations to Government about how to strengthen the evidentiary basis and scientific rigour of environmental assessments. The authors of this report have nationally and internationally recognized expertise in environmental science, law, policy, and practice in academic, non-profit, government, and private sectors. We provide scientific recommendations, approaches, and proposed implementation related to the Discussion Paper's "Proposed changes to the project assessment system". Specifically, we outline priorities and gaps within the seven cross-cutting areas of change (Sections 2.1-2.7). In addition, we provide a companion paper specifically about modernizing the *Fisheries Act*.

We ***identify eight priorities*** related to science and available evidence, and offer recommendations to inform how they can be operationalized and implemented:

- **Priority 1**: Assessments should account for the impact of a project on climate change
- **Priority 2**: Assessments should be evidence-based and emphasize a focus at the regional level
- **Priority 3**: Assessments should contain provisions for robust research and monitoring
- **Priority 4**: Funding should be provided for intervenor and stakeholder-led science
- **Priority 5**: Assessments and the assessment process should be supported by open science and data
- **Priority 6**: Assessments should incorporate Indigenous knowledge within the framework of a nation-to-nation relationship
- **Priority 7**: Assessments should include rigorous, independent peer review
- **Priority 8**: Assessments should be more comprehensive, efficient, and complete

[1] www.discussionpaper.ca

A number of critical aspects of environmental and regulatory processes related to the evidentiary basis of assessments were not described in the Discussion Paper. We ***identify seven gaps***, explain their importance, and provide recommendations on how our suggestions can be operationalized and implemented:

- **Gap 1:** Assessments should have expanded temporal and spatial scope
- **Gap 2:** There should be clear triggers for assessment as well as designated impact thresholds that should not be exceeded
- **Gap 3:** The Government should establish clear national objectives and values for decision-making, and communicate full rationale behind decisions including risk tolerances and uncertainties
- **Gap 4:** The precautionary principle should guide the assessment process from the start
- **Gap 5:** The Government should make budgetary commitments to support federal science agencies to conduct environmental research
- **Gap 6:** Assessments should contain commitments to scientific integrity
- **Gap 7:** The Government should address issues of professional reliance

We hope this report is useful as the Government of Canada considers how to strengthen federal environment and regulatory processes. Thousands of Canadian scientists and scientific experts have demonstrated their concern and interest in these matters and would likely be willing to lend their professional expertise in this regard. Through parallel processes, the Government of Canada has shown its commitment to strong scientific foundations for decision-making, innovation, and prosperity (e.g., the Fundamental Science Review, appointing a Chief Science Advisors, and others). We are hopeful that the same commitment will be extended to robust science in the environmental review process by including our recommendations when drafting related legislation, policies, and regulations.

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1 - Introduction

The Discussion Paper mentions some key issues raised by scientists regarding the four environment-related laws under review, including: open data and open science, data validation, Indigenous knowledge, scientific rigour, peer review, and cumulative effects assessment. These aspects were emphasized by concerned Canadian and international experts during the consultation periods for these reviews and in the years before (e.g., Reynolds et al. 2012; Schindler & + 624 co-signatories 2012; Favaro et al. 2012; Gibson 2012; Hutchings & Post 2013; Chan et al. 2014; Gantner 2014; Westwood 2015; Bailey et al. 2016; Moore & + 130 co-signatories 2016; Schindler & + 371 co-signatories 2016; VanderZwaag et al. 2016; Ford et al. 2016; Jacob et al. 2016; Lassonde & + >200 co-signatories 2016; MacLean et al. 2017; Gregr et al. 2017).

Environmental review processes and products rely heavily on scientific input at all stages of assessment, including scoping, collecting baseline data, predicting impacts, planning mitigation measures, evaluating risk, designing and implementing monitoring programs, and reviewing relevant technical and scientific reports. Furthermore, these dimensions of scientific input must feed back into the recursive activity of improving environmental review processes in terms of improved data, modelling techniques, addressing areas of uncertainty, and adaptively managing assessment. Scientific literacy, capacity, and integrity are essential components of effective and trustworthy environmental review and monitoring. Although the Discussion Paper states that "*there is a need for greater transparency around the science, data and evidence supporting decisions,*" it is necessary to transcend transparency.

The Government of Canada can now commit to high-quality science, data, and evidence throughout the entire process. Additionally, because science itself does not make decisions, we argue that decision-making needs to be guided by overarching national strategy, reflecting the values of Canadians, which gives guidance on how the Government will weigh the synergies and tradeoffs among economic, environmental, cultural, social, and health-related objectives.

In this report, we synthesize our diverse expertise in science (inclusive of natural and social sciences), law, and policy related to environmental assessment and fisheries protection to identify priorities and gaps within the principles and proposed changes outlined in the Discussion Paper. Although we recognize that the Discussion Paper is intended as a general overview, it will likely guide amendments and updates to statute, policy, and regulations in each of the four relevant Acts (*Canadian Environmental Assessment Act 2012*, *National Energy Board Act, Navigable Waters Protection Act*, and *Fisheries Act*). Drawing from our respective fields and other jurisdictions, we describe how these best practices in science can be operationalized across the seven cross-cutting objectives. In the companion *Supporting Paper: Recommendations for modernizing the Fisheries Act* (p. 25 of this document), we give specific suggestions for reform to legislation and guidance relating to the *Fisheries Act.*

2 - Rebuilding trust in the project assessment system

The Government's Discussion Paper identifies principles that will guide the modernization of Canada's environmental review system, and organizes them into seven cross-cutting themes. Within these themes, we identify ***eight priorities*** as well as ***seven outstanding gaps.***

2.1 - Addressing cumulative effects

The Government of Canada is considering *"a deliberate approach to the assessment and management of cumulative effects, working collaboratively with provinces, territories and Indigenous Peoples to develop and implement it*" (Discussion Paper, p. 9). The assessment of cumulative effects helps to inform whether levels of development are within or exceeding thresholds of impacts, and should be used to inform project approvals and conditions (Ford et al. 2016). Given recent scholarly attention to the weaknesses in Canada with respect to scientific capacity for, attention to and regulatory oversight of cumulative effects assessment, this is highly desirable focus (Fox et al. 2016; Fraser & Racine 2016; Sinclair et al. 2017). The consequences of this attention in the Discussion Paper for increases to federal scientific capacity are to be noted (see below, Gap 5).

Priority 1: Assessments should account for the impact of a project on climate change

Including climate change as a mandatory part of the assessment process is widely supported by the scientific literature, academics, non-governmental organizations, and industry. Since climate implications of projects (including climate implications of mitigation and adaptation measures related to the project) affect Canada's national and international climate commitments, approvals and conditions should reflect this. The Discussion Paper proposes that i) the *Pan-Canadian Framework for Clean Growth and Climate Change* be used to evaluate contributions of projects to climate change across the life cycle, and ii) this legislation as well as other environmental frameworks be subject to strategic assessment and broadly strengthened (p. 9).

A modern framework for including climate change in impact assessment needs to specify (1) when potential climate implications of a proposed project trigger assessment; (2) what information needs to be gathered about direct and indirect life-cycle emissions or consequences of the project; (3) what climate-related commitments are the proposed activity (and its alternatives) measured against; (4) how the proposed activity affects international efforts; and (5) how are climate implications of the project affecting, and affected by, future climate change.

For an example of (5), considering a potential project in light of climate change should also entail not merely counting greenhouse gas (GHG) emissions (or credit/offsetting), but also assessing how a project will influence the capacity of social-ecological systems to adapt and mitigate oncoming climate change. For example, intact coastal habitats will become increasingly important in protecting ecosystems and people as the sea rises (Arkema et al. 2013). Similarly, the ranges of unique ecoregions (and associated species) are predicted to shift poleward, but development along the northern edge of these ecoregions may restrict ability to migrate (Gibson

et al. 2009; Coristine & Kerr 2015). Interdisciplinary work across the social and natural sciences has stressed the need for social-ecological systems analysis of climate change, including in the field of resilience (Lynam & Walker 2016). Consistent with the Discussion Paper's proposed broadening of impact assessment to include social, economic, and health aspects alongside environmental, the climate change aspects of assessments must be similarly robust.

Although there are some recommendations for incorporating climate change into environmental assessment in Canada (for example: Geissler et al. 2015; Municipal Engineers Association 2016) project-level environmental assessments alone are most likely insufficient for helping Canada meet its greenhouse gas (GHG) emissions commitments (Ho & Tollefson 2016).

Priority 2: Assessments should be evidence-based and emphasize a focus at the regional level

The Discussion Paper proposes regional assessments be used to guide planning and management of cumulative effects, including effects on biodiversity and species at risk. It also suggests using an integrated open science and data platform to inform environmental frameworks and regional assessments (p. 9). To ensure regional and strategic assessments are based on robust evidence, supporting data must be interoperable and freely exchanged between jurisdictions, requiring regional databases that are federally coordinated and comparable. See Section 2.4 for suggestions about data storage and warehousing.

With regard to biodiversity and species at risk, regional assessments need to identify protective thresholds (e.g., limits to fragmentation or water withdrawal). Once these thresholds are reached, no new projects should be approved until another project is finished and reclamation has occurred. This will require detailed cooperation and data-sharing across jurisdictions (e.g., provinces and territories).

The federal Government is responsible for identifying, assessing and recovering wildlife species at risk of extinction or extirpation though the *Species at Risk Act* (SARA). Environmental assessment procedures for determining whether species at risk are present and at risk of harm need clear scientific standards with peer evaluation of methods used (e.g., locations monitored, survey effort, sampling design; see Section 2.4 about peer review). The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) should be involved in evaluating evidence related to species at risk, and can compare with its own internal records of occurrences.

Critical habitat identified under SARA is considered necessary for the recovery of threatened and endangered wildlife species. Therefore, assessment of cumulative impacts should make explicit the need to consider impacts to critical habitat. Given recognized gaps and delays in the SARA process (McDevitt-Irwin et al. 2015; Mooers et al. 2017), including (1) listing delays, (2) biases in the SARA listing process, (3) delays in recovery strategies and action plans, and (4) a lack of critical habitat designation in many recovery strategies, we recommend that the likelihood of impact on species at risk and/or critical habitat include species listed by the

relevant Conservation Data Centres/NatureServe as Vulnerable, Imperiled, or Critical Imperiled,[2] even if they are not yet listed on SARA's Schedule 1 regulations.

Gap 1: Assessments should have expanded temporal and spatial scope

Environmental assessments must be accurate and sufficiently broad to assess all impacts across time and space. Temporal and spatial scopes need to be defined in terms of technical details of a project (e.g., life-span), and scientific evaluation of the spatial and temporal scale of environmental risks (e.g., contaminant dispersal and animal movements). Scope also needs to be determined by Indigenous and local communities whose traditional livelihoods and culture have been, are, and will be affected. Indeed, it is also important to look beyond our borders: Canada must recognize the global environmental impacts of our activities as well as the potential externalization or leakage of those impacts (Moran & Kanemoto 2016).

For example, as part of the "Interim Principles" (Discussion Paper, p.4) it is stated that "*Direct and upstream greenhouse gas emissions linked to the projects under review will be assessed*". However, there is no mention of "downstream emissions", which can also include broader consequences such as the social (including health), environmental, economic, and cultural effects (and their interactions) of burning fossil fuels. In addition, projects that stand to produce a net-reduction in downstream emissions (e.g., wind farms, carbon capture and storage, biogas) should be considered accordingly. For related information about assessing cumulative effects, see Priority 1.

Impact assessment should define and mandate specific targets of recovery that are then measured and evaluated over appropriate time scales. For large-scale impacts, recovery may well take over 50 years, and monitoring and remediation must account for the likely time scale until land capability is restored (e.g., Ford et al. 2016). In the US, failure to account for downstream emissions has led to both environmental and legal consequences.[3]

2.2 - Early engagement and planning

Priority 3: Assessments should contain provisions for robust research and monitoring

The Discussion Paper proposes that clear guidance be given to industry and other proponents regarding what will be assessed and how (p. 10). Although it establishes the need for early assessment, there is no statement of the overarching principles that should guide environmental review. During early assessment, project proponents should be required to explain how their project is consistent with existing regional and strategic undertakings, and these should be linked to explicit triggers for regional assessment.

[2] http://explorer.natureserve.org/nsranks.htm

[3] For example, Montana Environmental Information Center et al. v US Office of Surface Mining, CV 15-106-M-DWM, Aug. 14, 2017

For a project-level assessment, an essential principle for establishing the scientific rigour is that study methods be explicit and match best practices. Industry must be given guidance on what methods are required to produce robust data, who is qualified to collect and report these data (e.g., accredited professionals, but see Gap 7), as well as how data will be stored and shared. Thus, policies related to assessment and monitoring should give guidance on standards for the conduct of scientific surveys. Ideally, arms-length oversight by qualified experts would evaluate compliance with these standards. At an early stage the proponent must be told (1) how long monitoring must occur, (2) how baseline conditions will be identified before project construction begins, (3) the threshold of change necessary to engage in adaptive management, (4) what adaptive management options are available, and (5) how to measure the success of mitigation.

Gap 2: There should be clear triggers for assessment as well as designated impact thresholds that should not be exceeded

It is important that potential projects that might pose risks to the environment, economy, and people receive assessment. The Discussion Paper does not give insight into the methods of composition for the Project List, but it is necessary that triggers for environmental assessment include not only size and type of project, but also the environmental setting. For example, the assessment trigger for a jet fuel tank located in the Fraser River estuary cannot be the same as one proposed for the Calgary International Airport.

The types of projects triggering assessment should be based on evidence rather than management decisions. The Project List should consider if the proposed activity has the potential to (1) hinder Canada's efforts to meet international commitments on environmental issues such as climate change, biodiversity, ozone layer protection, mercury, persistent organic pollutants, hazardous waste, and others, and (2) hinder the implementation of key federal policies. Thus, the Project List should be developed within a national environmental framework (see Gap 3) to guide individual assessments as well as strategic and regional assessments. The Project List should be reviewed on a periodic basis explicitly specified in legislation.

Impact thresholds prescribe limits on the allowable social and ecological costs an approved project could incur, and if impact thresholds are exceeded, this will trigger adaptive management or project shut-down. Ideally developed in concert with national objectives and values (see Gap 3), thresholds need specific, evidence-based delineation. Examples of explicit impact thresholds might include a specific degree of health effect, maximum allowable effects that require immediate remediation if exceeded, changes in project footprint or lifespan, impact on species at risk, magnitude of environmental effects, GHG emissions, and others.

Evidence-based assessment triggers and impact thresholds would provide a useful tool for both strategic assessments as well as providing proponents certainty in the process. Currently, when predicting environmental impacts, the definition of "significant adverse environmental effects" is estimated using statistical tests. This qualifier of significance, called a p-value, considers projects only to have a significant adverse environmental effect if the effect is predicted to occur with 95% certainty (where the p-value based on statistical significance testing is less than 0.05).

Under this model, even if an effect is predicted with 94% certainty, the project is *not* considered likely to have a significant adverse environmental effect.

Recent research in British Columbia demonstrates the problem of significance testing in provincial environmental impact assessments (Clarke Murray et al. In Review).. Here, even where quantitative thresholds for significance were exceeded, practitioners argued that negative impacts were non-significant. Arguments used include many raised in this report and others (e.g., Ford et al. 2016), including baseline information, professional judgement, and model uncertainty. We do not know of any reason why this pattern would not be repeated for environmental impact assessments at the federal level.

The scientific community has observed serious drawbacks of using p-values for significance testing (Colquhoun 2014; Halsey et al. 2015; Claridge-Chang & Assam 2016; Lazzeroni et al. 2016; Gardner & Altman 2986). Instead, a number of the authors of this report recommend that confidence intervals be used to set a range of "unacceptable adverse environmental effects". Confidence intervals are a statistical technique which indicates a range of possible impacts. Then, this range of possible impacts is compared to the established impact threshold, and if the impact threshold is exceeded, the project should be considered as having "unacceptable adverse environmental effects". This approach is consistent with the precautionary principle (see Gap 4), ensures that impacts are understood and acceptable, and puts the onus on the proponent to demonstrate that they will stay below designated impact thresholds. This changes the process from the status quo (i.e., projects will *only be stopped* if it can be proven with certainty that they *will* cause significant adverse environmental effects) to a precautionary, safety-minded update (i.e., projects can *only proceed* if they can prove that they *will not* cause unacceptable adverse environmental effects).

2.3 - Transparency and public participation

Here, we refer to transparency as transparency in the decision-making process. Transparency as it pertains to the scientific process of collecting, analyzing, and interpreting data is dealt with in *Section 2.4-Science, evidence, and Indigenous knowledge.*

Priority 4: Funding should be provided for intervenor and stakeholder-led science

The Discussion Paper proposes to improve and expand eligible activities for funding Indigenous peoples and the broader public during the review process (p. 11). Current environmental review legislation does have some provisions to support meaningful public participation (e.g., CEAA 2012 supports individuals at up to $12,000 each), however, this often leaves participants forced to choose between gathering evidence and seeking legal support to assist them in the hearing process. Ideally, improved standards for research during the EA process would result in robust and independent data collection and reporting, thus lessening the need for stakeholder-led research. However, as recognized in the Discussion Paper, it is important to support intervenors in evidence-gathering. Thus, improving and expanding eligible activities for funding should explicitly include provisions for the collection, analysis, and interpretation of independent

scientific data by qualified professionals. It is important to note that resources for monitoring and gathering evidence should not be intertwined with impact-benefit agreements to Indigenous communities, as is current common practice.

Though CEAA 2012 specifies specific dollar amounts, this may not be appropriate. There are a number of factors to consider, including: type of hearing (e.g., formal vs. informal; location); complexity of issue; and number of participants, among others. Participant funding or assistance is an essential part of the process, and money (and monetary decisions) need to flow early in the process so that contributors can effectively engage, with a full understanding of budgetary constraints. For discussion on practices in public participation, see Fitzpatrick & Sinclair (2016) and Sinclair & Diduck (2016), and for principles of meaningful public participation, see the findings of the Multi-Interest Advisory Committee[4].

Gap 3: The Government should establish clear national objectives and values for decision making, and communicate full rationale behind decisions including risk tolerances and uncertainties.

A commitment to evidence-based decision-making is laudable, but science does not make decisions, it only informs them. Thus, evidence-based decision making does not mean evidence determines decisions, but rather that decisions are made with the best available evidence. Because assessments will always contain uncertainty, decision-making will always be grounded in questions of probability, risk tolerance, and values. The Government should establish clear values that will be used to drive environmental decision-making (e.g., adherence to national or international climate commitments; transition to renewable energy), set limits to risk, and communicate full rationale behind decisions to the public. This commitment to transparency must include explicit, clear, and consistent information about how tradeoffs have been evaluated across different valued components (e.g., costs, benefits, and risks to threatened species, economy, human or ecosystem health at different scales).

One potential method of dealing with uncertainty during decision-making is the technique of *expert judgement elicitation* (Morgan 2014), which provides a formal procedure to (1) engage in structured dialogues with people who hold knowledge about a topic, and (2) clarify both their assumptions and areas of agreement and disagreement. Expert judgement processes can add significant clarity and transparency and, can often reduce differences of opinion among experts. We emphasize, however, that expert judgement processes are not a “low-cost, low-effort alternative to conducting serious research and analysis” in decision-making (Morgan 2014).

On this topic, it is important to address the role of the National Energy Board (NEB), which presently serves a dual role in both project assessment and life-cycle regulation. It has been overwhelmingly recommended by stakeholders, confirmed by academic analyses (Cleland & Gattinger 2017) and indeed, recommended by the Expert Panel on the Modernization of the National Energy Board (Expert Panel-NEB) themselves that the NEB has fundamentally lost the

[4] http://eareview-examenee.ca/what-weve-heard/multi-interest-advisory-committee/

confidence of Canadians, should be dissolved and its functions be split between other agencies. Despite this recommendation, the Discussion Paper indicates that the Government of Canada intends to retain the NEB. We disagree with this decision. However, we offer some suggestions for improvement regarding its scientific capacity towards informing national objectives.

The Expert Panel-NEB proposed a new Canadian Energy Information Agency (CEIA) to produce regular public reports about all aspects of energy demand, production, and policy in Canada. There is currently no single source for most Canadian energy data; current analyses produced by the NEB are not independent nor comprehensive (for example, data currently available is insufficient to allow for a national estimation of rates and risks of pipeline failures; Belvederesi et al. 2017). Rather than continuing the responsibility of the NEB for producing national energy information products, these responsibilities should be transferred to the proposed CEIA or other Government departments which produce energy-related information (e.g., Environment and Climate Change Canada, Stats Canada, Natural Resources Canada). However, it is essential that such information be available to allow for measurement of the successes and failures towards strategic national objectives.

Gap 4: The precautionary principle should guide the assessment process from the start

In the Discussion Paper, though there is a brief mention of the “precautionary approach” (Discussion Paper, p. 22) in the context of fish habitat protection, it is unclear if this will be an overarching principle reflected in legislation, nor how associated tradeoffs will be evaluated (See Gap 3). In particular, there is no statement of the “precautionary principle”: in the absence of scientific consensus, the burden of proof that a project is safe rests with the proponents. Given the magnitude of environmental threats we are now facing, using precaution as a guiding principle is prudent and responsible (Schindler & Hilborn 2015; Hansen et al. 2007; Lapointe et al. 2014), This should be entrenched as a foundational principle from which all environmental assessment is approached.

Precisely because the precautionary principle comes most into effect when there are critical research gaps and areas of scientific uncertainty, scientific capacity and leadership is needed at the federal level to guide risk assessment and the application of the precautionary principle as part of a robust environmental assessment process (Stirling 2007). The Discussion Paper does not explicitly specify who holds the burden of proof for establishing safety and risk, nor who is responsible for evaluating risk assessment. By requiring the proponent provide the burden of proof for safety (see Gap 2), the precautionary principle legitimately requires risk creators to research and justify the risks they impose on society (Sachs 2011). Risk assessments should then be evaluated by an independent party through a peer review process (see Section 2.4).

2.4 - Science, evidence, and Indigenous knowledge

Priority 5: Assessments and the assessment process should be supported by open science and data

The Discussion Paper suggests moving toward an open science and data platform to access and integrate available science, evidence, and Indigenous knowledge supporting environmental assessment and regulatory processes (p. 12). The six main principles of Open Science are: Open Data, Open Source, Open Methodology, Open Peer Review, Open Access, and Open Educational Resources.[5]

The Government of Canada has committed to principles of Open Government, including Open Information, Open Data,[6,7] and for fundamental science research funded by the Government, Open Access (e.g., the Tri-Agencies).[8] Indeed, the Government has acknowledged the significant competitive advantages for countries using 'big data' and 'open science' (Government of Canada 2014).

In present environmental review processes, Open Science principles do not extend to the research methods and products involved in environmental review. Data gathered by the proponent is often proprietary and inaccessible to the public (although some files may be available to Indigenous or stakeholder groups through data-sharing agreements). This lack of transparency makes it difficult to verify assessments, and hampers related large-scale environment-related research, management, and monitoring (including by and for the Government itself: for example, a Government-established integrated database has been identified as one way to evaluate the impact of SARA; Findlay et al. 2009). This information could be used by industry to inform future development projects, and by both Government and independent scientists and managers.

Revisions to legislation should ensure *all* information is available in full, including but not limited to (1) detailed study methodologies which can be replicated by independent researchers, (2) all raw data collected during assessment, with appropriate metadata, and (3) open, reproducible code for data manipulation, analysis, and visualization (Jacob et al. 2016; Taylor & Westwood 2016). Data should be available during the assessment process for full cross-examination in public by the public, Government agencies, Indigenous Peoples, and other interested parties.

A relatively simple first step to operationalize open sharing of EA information in Canada is to establish a single, central public library (which may build upon the current open data platform)[9]

[5] http://openscienceasap.org/open-science/
[6] http://open.canada.ca/en/content/canadas-action-plan-open-government-2014-16
[7] http://open.canada.ca/en/content/third-biennial-plan-open-government-partnership
[8] http://www.science.gc.ca/eic/site/063.nsf/eng/h_F6765465.html?OpenDocument
[9] http://open.canada.ca/data/en/dataset?subject=nature_and_environment&page=2

that is permanently and freely available. At present, the oldest information available from the current *CEAA* registry is from 2006, however, it is essential that data, metadata, and methods from all past, current, and future environmental reviews be stored and made available in perpetuity and in sufficient detail to allow for scientific scrutiny and to inform large-scale management and planning. The current model of a registry is insufficient: a comprehensive, easily searchable library is necessary.

Moving to a single common library across *Acts* would reduce overhead, reduce duplication of effort across agencies and jurisdictions, and has been previously suggested by a Parliamentary Committee (e.g., Recommendation 20, House of Commons Standing Committee on Fisheries and Oceans 2017). Research has shown that multiple registries impedes effective participation (Fitzpatrick 2006), and one per project, include information from both the assessment agency and regulators (all data from cradle to grave) adds continuity to the entire process. This library, applying to projects across all four *Acts*, should include (1) notifications of new proposed projects, (2) methods, data, and results of early, regional, strategic, and cumulative effects assessment, (3) revised proposals, (4) methods, data, and results of environmental assessment including the environmental impact statement (EIS), (5) project authorizations and their rationale, (6) interim assessments and associated methods, data, and results, (7) adaptive management plans, and (8) monitoring data and reports subsequently collected as per the terms of those authorizations.

Although a library of notices and reports is technologically simple, storage and provision of all relevant scientific data is more complex. Some best practices should be required of proponents (for more discussion, see Munafò et al. 2017), who should be legally required to produce a Data Management Plan.[10] Original data sources, as well as parties responsible for updates or alterations, must be clearly recorded. Data should be recorded and stored according to scientific standards (e.g., White et al. 2013; Roche et al. 2015), meaning that these data ought to be provided in an accessible data format along with standardized and complete metadata (currently being considered as part of the National Open Data Initiative). These standards should be as consistent as possible to reduce duplication and improve interoperability between jurisdictions in Canada. Data should also be submitted to long-term global repositories (e.g., GBIF[11], Zenodo[12], OSF[13], DataOne[14], KNB[15], Dryad, Figshare). All laboratory testing for samples taken as part of environmental assessment studies should be undertaken at accredited facilities. Chain-of-custody for data and samples should be documented, made publicly available, and it should be indicated if hired professionals are accredited or part of a body attesting to their qualifications.

The Discussion Paper also proposes making science accessible by providing plain language summaries of facts supporting assessments (p.12). The registry portal can also serve the dual

[10] https://www.nsf.gov/bfa/dias/policy/dmpfaqs.jsp
[11] https://www.gbif.org/
[12] https://zenodo.org/
[13] https://osf.io/
[14] https://www.dataone.org/
[15] https://knb.ecoinformatics.org/

purpose of summarizing results and data for laypeople with plain-language summaries, and including an online interactive map plotting all projects by type. The portal can emulate the model of the U.S. National Science Foundation which provides an accompanying digest for data they collect, or use some other type of multi-layer interface design (e.g., Shneiderman 2002).

There are, of course, legitimate concerns about sensitive data (e.g., locations of flagship or endangered species, personal information), and how these will be protected while maximizing data availability. We encourage the Government of Canada to look to models of access control such as those used by the United Kingdom[16] and the Province of Ontario's Open Data Directive.[17] The federal Open Government initiative and Canada's Open Data Principles do not discuss sensitive data except to indicate that public data only include those data which are not personal or confidential. Therefore, explicit consideration needs to be given to what will be considered sensitive data within environmental assessment processes (particularly with reference to Indigenous Knowledge - see Priority 6), and how its availability can be maximized (e.g., anonymizing identities, generalizing locations of species at risk to a grid, etc.).

Finally, the role of Statistics Canada cannot be forgotten when considering the storage and management of data with national importance. Independence for Statistics Canada is essential, and explicit connections should be made with the present overhaul of environmental review with the concurrent legislative process "An Act to Amend the Statistics Act" to clearly define the responsibilities of the Minister, the Chief Statistician, as well as create the Canadian Statistics Advisory Council to ensure the transparency and independence of the agency.

Priority 6: Assessments should incorporate Indigenous Knowledge (IK) within the framework of a nation-to-national relationship

The Discussion Paper proposes incorporating IK alongside other sources of evidence and co-develop tools, guidance, and capacity with Indigenous Peoples to systematically consider and better support IK (p. 12). It also states that IK should be considered and protected alongside science and other evidence. The BC Assembly of First Nations and other Indigenous groups heavily criticized how past environmental assessment processes have including of IK for (1) lack of baseline data, (2) unstandardized methodology, leading to different interpretations by the regulator, and (3) lack of risk thresholds specifically associated with IK, among other issues.

As per Canada's commitment to a nation-to-nation relationship with Indigenous Peoples, as well as commitments made under the United Nations Declaration on the Rights of Indigenous Peoples, there is a critical need to establish information sharing and data ownership protocols with Indigenous Peoples. We defer to Canada's Indigenous Peoples to provide specific direction on how to incorporate, evaluate, and include IK in the environmental review process in a meaningful, comprehensive manner (e.g., see responses from the Assembly of First Nations Technical Committee in the Expert Panel Review of Environmental Assessment Processes

[16] http://www.data-archive.ac.uk/conditions/data-access
[17] https://www.ontario.ca/page/ontarios-open-data-directive

2017), including the critical standards and procedures needed. We reaffirm the value of IK in the environmental review process, as well as its consideration within a nation-to-nation relationship.

Priority 7: Assessments should include rigorous, independent peer review

The Discussion Paper proposes peer reviews of science and evidence during the assessment phase of projects (p. 12). Across all four laws, this will greatly enhance the credibility of gathered data. Provisions for peer review should be mandated in legislation, and exactly what constitutes peer review, who conducts it, what elements of assessment are subject to it, and how reviewers are to be compensated (if at all) must be explicitly described in guidelines.

We suggest peer review be defined in legislation as *"a review of technical and scientific merit by individuals with demonstrated competence and no unresolved conflict of interest."* Here, 'peers' are *"those who have qualifications and expertise equivalent to those of the researcher whose work they review"* and who are *"capable of making an independent judgment of the merits and relevance of the research."* (United States General Accounting Office 1999). The U.S. Government has been incorporating peer review into environmental assessment for the past two decades (Science and Technology Policy Council 2015).

We suggest that peer review be mandated (1) during the early assessment phase, regarding the need for regional or strategic assessment, the schedule of studies, and proposed methods, (2) for reports of studies and underlying scientific or technical products that support Environmental Impact Statements, (3) for reports of studies and underlying scientific or technical products contributed by intervenors or other non-proponent stakeholders, and (4) for monitoring plans, frameworks, and reports.

Increases in federal-level scientific capacity are required, for example, to enhance the role of review bodies such as the Canadian Science Advisory Secretariat in assessing proponent-directed EAs, including at the project level. Peer review should include both Government and independent experts and scientists, and final results should include a response document detailing how reviewer's comments were addressed. The use of external rapid peer review in academia may also provide a helpful model (e.g., "rapid communications" category in Canadian Journal of Fisheries and Aquatic Science; "Biological Opinions" by the Center for Independent Experts). However, it is important the responsibility for peer review not be downloaded onto academics or citizen scientists. As such, an independent review panel or body for environmental assessment processes would be strongly preferred. Some models to look to which are supported, but not directed, by the responsible government agency for reviewing status assessment may include COSEWIC (although not formal peer review) and NOAA Center of Independent Experts (a formal, rigorous review process).[18]

[18] https://www.st.nmfs.noaa.gov/science-quality-assurance/cie-peer-reviews/index

Gap 5: The Government should make budgetary commitments to support federal science agencies to conduct environmental research.

Given the importance of evidence in the decision-making process, we call on the federal Government to build and maintain science capacity in areas needed to support rigorous and sound assessments. To build trust in the assessment process, this capacity should be independent of the proponents. Past capacity that was lost in Government scientific departments from 2011-2015 has not yet been fully recouped (Statistics Canada 2017). Increased funding for Government science means greater Government capacity to do the research necessary to inform environmental assessment. This will lead to greater trust than relying exclusively on research done by the proponent.

Rebuilding capacity at Environment and Climate Change Canada, Department of Fisheries and Oceans, and other federal departments that research our natural and social systems as world leaders in environmental science is a precondition for trust of the assessment system, and requires explicit commitment. Although mentioned regarding the *Fisheries Act* ("*develop scientific expertise on fish and fish habitat protection*", Discussion Paper, p. 22), world-class scientific capabilities should be supported across Government agencies that contribute to EA.

The Discussion Paper does not mention Canada's Fundamental Science Review,[19] which is occurring concurrently. Although environmental monitoring falls under a different jurisdiction than academic science and basic research, there is much overlap and potential for collaboration between sectors. One of the most important connections between basic research capacity and environmental assessment is the development of scientific expertise and trained high-quality personnel necessary to do the assessment work. Canada can only retain a robust science capacity if it financially supports research and training at academic institutions. Further, research (including discovery-based research with no obvious immediate application) must be well-funded so that Canada can build a reputation as a world-leader in environmental science and management. Fully implementing the recommendations made by both the EA Expert Panel report[20] and the Fundamental Science Review[21] will help to create the thriving research ecosystem needed to provide the discoveries, research infrastructure and highly qualified personnel necessary to achieve a science-based environmental assessment process.

Gap 6: Assessments should contain commitments to scientific integrity

Legislative provisions should affirm the principles of scientific integrity. Examples of science integrity and related professional codes of conduct include principles identified by the Science Integrity Project (2015), Canadian legislation regarding scientific discretion of the members of the COSEWIC (see Species at Risk Act: 16(6); SAGE 1999), and scientific integrity policies for

[19] http://www.sciencereview.ca
[20] Building Common Ground: A New Vision for Impact Assessment in Canada, https://www.canada.ca/en/services/environment/conservation/assessments/environmental-reviews/environmental-assessment-processes/building-common-ground.html
[21] http://www.sciencereview.ca/eic/site/059.nsf/eng/home

employees of the United States Geological Survey (USGS 2015) and National Oceanic and Atmospheric Administration (NOAA 2011). We recommend that principles of scientific integrity such as “conducting, interpreting, and communicating” results “honestly, objectively, thoroughly, and expeditiously” be included in regulations.

Gap 7: The Government should address issues of professional reliance

At present, project proponents are responsible for hiring and overseeing the contractors providing environmental assessment. This model of relying on external professionals (skilled and potentially accredited consultants or contractors), termed “professional reliance” has been heavily criticized for introducing bias and skewing risk assessment evidence (Haddock 2014; Smith et al. 2017). Recently, criticisms of professional reliance in British Columbia have spurred the Province of BC to order a review of this model.[22] Though contested by some proponents and industry associations, such criticisms lie at the heart of the EA Expert Panel's central recommendation for a Federal IA Commission, and presumably also the Discussion Paper's reference to a "single agency" (p. 13).

We strongly recommend moving away from the current proponent-funded, professional reliance model, because put simply, the current model fails to achieve independence, a core aspect of a robust approach to impact assessment. Though accreditation of professions has been pursued in some jurisdictions (e.g., BC’s College of Applied Biology, Alberta Society of Professional Biologists), environmental assessments in these regions have still suffered from substantial conflict of interest issues that undermine public trust in the assessment process.

We propose that the responsible Government agency should, at minimum, act as an intermediary between project proponents and third-party consultants. Supported by proponent resources, the agency would select and hire the group to undertake studies related to impact assessment and develop the EIS. This would reduce the perception that proponents are paying for a desired result, and would contribute to public confidence in (and the reality of) arms-length science-based environmental assessment as the foundation of a science-informed policy framework. Such confidence is a critical issue, and is at the heart of national review exercises (NEB, CEAA) that have resulted in this Discussion Paper. An example of such a model is provided in Taylor & Westwood (2016). However, we would prefer a second, (albeit more resource-intensive) option with the creation of an independent arms-length Government body, funded by project proponents, that directly coordinates the environmental impact assessment under revised legislation. This approach would provide clear barriers between the science and the proponents in order to achieve a higher degree of scientific independence and integrity.

Regardless of approach, individuals that are hired to carry out assessments should have verified qualifications and take an oath to uphold the principles of scientific integrity and to carry out the assessment according to the law and in the best interests of Canadians. Such individuals should have access to an independent ombudsperson in cases where they are being

[22] http://vancouversun.com/news/local-news/ndp-orders-review-of-government-reliance-on-industry-hired-experts

asked to amend their methods or assessments in a manner that is not in keeping with the law or best practices. Environmental assessment is a discipline relevant to health of safety, and like other such disciplines, it should be regulated and enforced.

2.5 - Impact assessment

Priority 8: Impact assessment should be more comprehensive, efficient, and complete

The concept of Ecosystem-Based Management (EBM) in the Discussion Paper (p. 22) relates to a well-described approach (e.g., Stewart & Neily 2009; Hutchings & Post 2013; Rempel et al. 2016) intended to sustainably integrate economic, environmental, and social (including health) objectives. EBM and adaptive management principles officially recognize the interrelated character of socio-economic, cultural and ecosystemic impacts that are assessed in any robust environmental assessment (Esteves et al. 2012; Vanclay et al. 2015). The inherent complexity of socio-ecological systems assessed places a heightened importance on the inclusion of an expanded source of information (including both Indigenous and non-Indigenous affected communities) beyond what is generated by proponent-driven community engagement processes and socio-economic analyses. The responsibility for gathering and assessing and ensuring the due consideration of the information contributing to such analyses will require a coordinated federal scientific capacity drawing on the social, health, and natural sciences.

Thus, for evidence-based decision-making to be truly comprehensive, impact assessment should include not only the economic and environmental impacts of proposed projects, but all salient aspects of the social-ecological system, where salience would be defined by the national objectives and values (Gap 3). Not only predicted impacts should be scrutinized, but also the credibility of key assumptions (such as economic contribution) should be explicitly tested with rigorous scientific standards to demonstrate transparency and build public confidence.

Comprehensive and complete environmental assessment also needs to include specific provisions for follow-up and monitoring. Though impact assessment makes predictions and develops hypotheses, it is during follow up that mitigation effectiveness is actually tested. Scientifically rigorous follow-up and monitoring needs to include post-hoc evaluation of assessment predictions, monitoring programs designed for specific valuable ecological components, and real triggers for adaptive management if impacts exceed acceptable thresholds. Follow-up and monitoring results need to be upheld to the same scientific standards and transparency as all other components of the environmental assessment process, including peer review. Integration of such full-cycle aspects of assessment are integral to principles of adaptive management, and foundational to critical scientific capacity (Gap 5) needed for longitudinal study of, for example, cumulative effects assessment (Sinclair et al. 2017).

2.6 - Partnering with Indigenous Peoples & 2.7 - Cooperation with jurisdictions

With reference to these sections of the Discussion Paper, we reiterate the recommendations we made in *Priority 2: Assessments should be evidence-based, adaptive, and regional* and *Priority 6: Assessments should incorporate Indigenous Knowledge.*

3 - From recommendations to action

We hope that the priorities and gaps we identified will be used to operationalize legislative tools within the four *Acts* being considered for reform. We note that some issues are overarching across all four pieces of legislation, and should be included across all four laws. Commitments to science need to be ongoing: not just during the review process, but provisions should be made for ongoing research, monitoring, and information sharing through the life-cycle of a project. A commitment to studying the long-term impacts of infrastructure projects is a natural part of the federal Government's responsibility to protect the health and safety of Canadians.

Given the expertise of many of our co-authors in fisheries and ocean science, we have also provided a list of specific recommended operationalizations and best practices for revision of the *Fisheries Act* in the Supporting Paper.

We urge the Government of Canada to include the principles of scientific integrity and best practices that we have outlined to construct a truly modern environmental assessment regime for the country. We commend this Government's commitment to establishing scientific leadership (e.g., Fundamental Science Review, the creation of Chief Science Advisor, and Open Data Commitments). We are hopeful that the Government will take this opportunity to specifically legislate robust scientific methods into all stages of environmental assessment processes. This will not only provide the evidentiary basis for assessment to build public trust, but will also ensure forward-thinking stewardship of Canada's natural and cultural heritage under a truly modern environmental assessment system.

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