Researcher and practitioner ratings of priority research questions in freshwater fish habitat science

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Les numéros 1 à 25 de cette série ont été publiés à titre de Records statistiques, Service des pêches et de la mer. Les numéros 26-160 ont été publiés à titre de Rapports statistiques du Service des pêches et de la mer, ministère des Pêches et de l'Environnement. Le nom de la série a été modifié à partir du numéro 161.

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2022

RESEARCHER AND PRACTITIONER RATINGS OF PRIORITY RESEARCH QUESTIONS IN FRESHWATER FISH HABITAT SCIENCE

by

Adam I. Rego, Cody J. Dey, Michael J. Bradford, Keith Clarke, Katherine McKercher, Neil J. Mochnacz, Alex de Paiva, Karin Ponader, Lisa Robichaud, Amanda K. Winegardner, Jonathan D. Midwood, and Marten A. Koops

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ABSTRACT

Rego, A., Dey, C.J., Bradford, M.J., Clarke, K., McKercher, K., Mochnacz, N.J., de Paiva, A., Ponader, K., Robichaud, L., Winegardner, A.K., Midwood, J.D., Koops, M.A. 2022. Researcher and practitioner ratings of priority research questions in freshwater fish habitat science. Can. Data Rep. Fish. Aquat. Sci. 1336: iv + 22 p.

This document includes expert opinion data collected to identify research questions that would support effective management of freshwater fish habitat in Canada. Specifically, we present the scores provided by a group of researchers and practitioners related to the importance of each question to management, the amount of existing knowledge related to each question, and the level of scientific resourcing required to answer each question. Further details related to this project can be found in Dey *et al.* (2021a) and Dey *et al.* (2021b).

RÉSUMÉ

Rego, A., Dey, C.J., Bradford, M.J., Clarke, K., McKercher, K., Mochnacz, N.J., de Paiva, A., Ponader, K., Robichaud, L., Winegardner, A.K., Midwood, J.D., Koops, M.A. 2022. Researcher and practitioner ratings of priority research questions in freshwater fish habitat science. Can. Data Rep. Fish. Aquat. Sci. 1336: iv + 22 p.

Ce document comprend des données d’opinion d’experts recueillies pour déterminer les questions de recherche qui appuieraient une gestion efficace de l’habitat du poisson d’eau douce au Canada. Plus précisément, nous présentons les notes attribuées par un groupe de chercheurs et de praticiens concernant l’importance de chaque question pour la gestion, la quantité de connaissances existantes liées à chaque question et le niveau de ressources scientifiques requis pour répondre à chaque question. D’autres détails relatifs à ce projet se trouvent dans Dey et al. (2021a) et Dey et al. (2021b).

INTRODUCTION

This document contains expert opinion data collected to identify research questions that would support effective management of freshwater fish habitat in Canada. Specifically, we present scores provided by a group of researchers and practitioners related to the importance of each question to management, the amount of existing knowledge and scientific resources required to answer each question. These scores were collected as part of an online Delphi process (Mukherjee *et al.,* 2015) that was used to select priority research questions from an initial list of 334 candidate questions.

Full methodological details, including a description of the data collection methods, are included in Dey et al. (2021a). Briefly, 1045 knowledge gaps were extracted from primary scientific publications, Fisheries and Oceans Canada (DFO) grey literature publications, and select books via literature review. These were supplemented with 858 knowledge gaps obtained via an online survey of researchers and practitioners (primarily DFO-affiliated with few external participants) in the field of freshwater habitat science. The resulting 1903 questions were refined and collated to combine similar knowledge gaps and remove any that were not relevant to the project, before being rephrased as research questions. This process resulted in 334 candidate priority research questions which served as the input for an online prioritization exercise, and were subject to an initial (step 1) and final (step 3) scoring survey. These steps were separated by a feedback process (step 2) that allowed for discussion and revision of the each question .

Data collected through the initial scoring survey (step 1) are presented in Table 1, and were used to reduce the initial list of questions to those considered most important to freshwater fish habitat management. Data collected through the final scoring survey (step 3) are displayed in Table 2, and were used to rank the priority research questions presented. An analysis and discussion related to the results of this project can be found in Dey et al. (2021a). An interactive version of the final scoring data can also be found at https://qecology-dfo.shinyapps.io/ShinyPrioritization/.

These data are presented to support additional analyses beyond those detailed in Dey *et al.* (2021a) and Dey *et al.* (2021b). For example, these data could be used to evaluate the relationship between different criteria used to select priority research questions (e.g. between the amount of existing knowledge or resource requirements and the perceived importance of a question). Furthermore, these relationships or priorities may vary between researchers and practitioners. In addition to enabling future analysis, this document supports the Government of Canada's Directive on Open Government (Government of Canada, 2014) and Fisheries and Oceans Canada's Policy on Scientific Integrity (Fisheries and Oceans Canada, 2019).

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TABLES

Table 1. *Step 1 survey research questions and scores from 59 researchers (n = 33) and practitioners (n = 26), organized from highest to lowest mean practitioner score. Each question was scored by survey participants based on its importance to freshwater fish habitat management in Canada (six-point Likert scale, ranging from 'very unimportant' to 'very important'). The Likert scores were assigned a numeric value (very low = 0, very high = 5), and a mean of all scores submitted for each question was calculated. Research questions were selected to continue on to Step 2 if they met one of the following three criteria: a) All researcher respondents considered it Important or Very Important, b) All practitioner respondents considered it Important or Very Important c) More than half of the practitioner respondents considered it Very Important.*

ID	Question	Researcher Score	Practitioner Score
1	What is the impact of specific types of development and in-water works on fish and fish habitat?	5.00	5.00
177	When, how, and over what scale, should management decisions consider cumulative effects?	5.00	5.00
43	What is the magnitude of habitat loss and degradation in focal systems?	4.60	5.00
4	What is the rate and impacts of different types of land use change on freshwater habitat?	4.33	5.00
158	How can flow management be designed with whole ecosystems in mind?	4.25	5.00
187	What metrics should be used to determine if management measures are achieving their goals?	4.00	5.00
242	When do cumulative impacts on a system lead to tipping points in ecosystem health?	4.75	4.80
267	What is the current availability of critical habitat for species at risk, and what are the vital rates of populations within those habitats?	4.00	4.80
273	What are the best practices to mitigate and compensate the impacts of urbanization on stream and wetland quality?	4.20	4.75
200	Which management measures increase the risk of invasive species introduction?	3.67	4.75
280	How can the impact of large scale projects be quantified and offset?	5.00	4.67
284	What is the effectiveness of common management measures?	5.00	4.67
331	How can issues related to Indigenous rights and title be incorporated into aquatic habitat decisions?	5.00	4.67
286	What are the best practices for offsetting measures in different habitat types, regions, and qualities?	4.75	4.67
315	How can decision-making tools include principles of risk assessment and risk management?	4.25	4.67
22	How do various stressors and activities impact water quality?	4.17	4.67
58	What is the extent to which modifications to aquatic habitat are conducted without permits and permissions?	4.17	4.67
301	How can the principles of Indigenous co-management improve the management of freshwater fish habitat?	3.50	4.67
270	How effective are mitigation measures designed to protect fish and fish habitat?	4.75	4.60
213	How can an accessible, centralized tool be developed to enable the sharing of georeferenced species and habitat data?	4.50	4.60
299	How can communication be improved between science, management and policy-makers in relation to fish habitat?	4.50	4.60

ID	Question	Researcher Score	Practitioner Score
165	How will climate change alter freshwater ecosystems and their susceptibility to establishment of invasive species?	4.00	4.60
36	What are the best mechanisms to eradicate or control invasive fishes, and what new technologies could improve eradication and control programs?	2.75	4.60
75	What are the patterns of habitat use and distribution for freshwater fishes?	5.00	4.50
209	What are the best practices for the length of monitoring following different types of habitat alterations?	4.33	4.50
312	How can data sharing between managers, researchers and proponents be increased to improve the management of freshwater fish and fish habitat?	4.20	4.50
183	How do ecosystems respond to small, incremental habitat losses?	4.17	4.50
175	How will climate-mediated changes in flow impact northern waterbodies and species that rely on seasonal flows?	4.00	4.50
253	How can spatial data from different agencies and sectors be better managed to inform freshwater habitat mapping?	4.00	4.50
329	How can large scale experiments be leveraged to improve management and policy?	4.00	4.50
263	How can spatial and individual-based models that functionally link habitat to fish populations be used to increase our knowledge of area-dependent survival?	3.67	4.50
82	How can habitat suitability models be used to classify habitat quality and quantity?	3.60	4.50
215	How can the precautionary approach be better integrated into decision-making?	3.33	4.50
157	How can the movement of larval and juvenile fishes be better tracked?	3.25	4.50
164	How and when should freshwater habitat management consider climate change during decision-making?	4.75	4.40
29	What are the effects of hydropower generation on fish species and ecosystems?	4.50	4.40
141	What is the extent of hydrological connectivity between systems and how does hydrological connectivity impact fish habitat?	4.25	4.40
103	What is the carrying capacity for various habitats and which populations are limited by habitat availability?	4.25	4.40
287	How effective are habitat banks and in which situations should they be used?	4.00	4.40
81	Where do populations of freshwater species at risk continue to persist?	3.50	4.40
26	What are the mechanisms by which habitat changes impact fish populations?	5.00	4.33
294	How can we prioritize habitat types for protection and restoration to maximize productivity and protect rare species?	5.00	4.33
113	How does the cumulative effect of catchment modification impact hydrology and fish productivity?	4.75	4.33
166	How will climate impact water temperature, water supply, and water quality in focal systems?	4.75	4.33
202	How can we improve and standardize monitoring of mitigation, offsetting, and restoration measures to evaluate the success of management measures?	4.60	4.33
207	How can eDNA be used to improve research and monitoring in remote areas?	4.50	4.33
321	When might in-water works improve aquatic habitat?	4.50	4.33
199	What scientific information is needed to design codes of practice for proponent decision-making?	4.40	4.33

ID	Question	Researcher Score	Practitioner Score
285	What is the performance of different habitat offsetting methods?	4.40	4.33
83	How can we measure habitat availability and sensitivity for remote and northern locations?	4.25	4.33
260	How can we best evaluate the tools and predictions produced by proponents?	4.00	4.33
314	How can we develop a science-based risk management framework that can be applied at a national scale?	4.00	4.33
110	What is the capacity of fish populations to adapt to habitat change?	4.00	4.33
2	What are the ecosystem effects of aquaculture operations and how can they be minimized?	4.00	4.33
210	What are the best methods for monitoring large scale projects?	4.00	4.33
212	How can tools be developed that are science-based and that integrate multiple policies?	4.00	4.33
31	How can death of fish be defined and what is the likelihood of death of fish from different types of works?	3.80	4.33
138	What is the connection between groundwater and surface water in focal systems, and what guidelines should be used to avoid impacts to groundwater sources?	3.75	4.33
97	What are the best metrics for quantifying habitat availability and status?	3.50	4.33
117	What is the survival and productivity of fishes in artificial habitats such as municipal drains and hydropower reservoirs?	3.25	4.33
7	How can stressors to fish and fish habitat be mapped in a standardized fashion?	3.83	4.25
136	How do flow regimes impact freshwater habitat and fish population dynamics?	4.50	4.20
296	What does the designation of critical habitat mean and what activities should be permitted in critical habitat?	4.00	4.20
316	What new technologies could help mitigate and recover anthropogenic impacts on fish habitat?	4.00	4.20
15	How can fish mortality be best quantified and considered in management decisions?	3.75	4.20
3	What are the risks associated with new invasive species and their parasites?	3.75	4.20
19	What are the effects of chemical and mechanical removal of aquatic vegetation on freshwater habitat?	3.67	4.20
61	How can early detection of invasive species be improved such that management strategies can be implemented in time to reduce invasion?	3.50	4.20
149	What is the meta-population structure and connectivity among fish habitats?	3.25	4.20
220	How do fish communities and fish habitats change over time?	2.75	4.20
74	What are the habitat requirements for different life stages of freshwater species?	5.00	4.00
179	When should we expect multiple stressors to produce additive, synergistic or antagonistic effects on fish populations?	5.00	4.00
16	How can the impact of stressors on fish and fish habitat be best quantified and assessed?	4.83	4.00
186	What is the effectiveness of common avoidance, mitigation, offsetting and restoration methods?	4.80	4.00
238	Can we define thresholds for acute and permanent habitat modification below which the effects on fish productivity is minimal?	4.75	4.00
282	Should management measures focus on fish species or be an ecosystem based approach?	4.67	4.00

ID	Question	Researcher Score	Practitioner Score
102	How does the quantity and quality of habitat relate to fish productivity?	4.60	4.00
327	How can fishing efforts be managed to maintain sustainable wild fish stocks?	4.50	4.00
12	What are the current and potential stressors acting on focal aquatic systems?	4.50	4.00
73	What is the availability, distribution, and quality of habitat for a given species, and how can this habitat be better mapped?	4.50	4.00
306	Is it possible to rehabilitate degraded habitat and reintroduce species at risk?	4.40	4.00
104	How do habitat changes impact fish population vital rates?	4.40	4.00
145	What is the natural range of hydrological and other environmental conditions for a given system?	4.40	4.00
201	How can the broad effects of different policies and management practices be assessed and reported?	4.33	4.00
5	How is fish productivity impacted by changes in water quality, and are there thresholds for water quality change before impacts are observed?	4.33	4.00
27	What are the impacts of different agricultural practices on stream habitat quality?	4.25	4.00
181	How can ecosystem or populations models, and landscape-scale data sources, better inform cumulative effects assessments?	4.25	4.00
89	How important is habitat variability for ecosystem resilience and how can habitat variability be incorporated into decisions?	4.25	4.00
70	What are the current and potential impacts of aquatic invasive species on large water bodies?	4.25	4.00
268	How can freshwater habitats be classified in a way that is meaningful for managers and fish species?	4.25	4.00
99	How can we predict where fish species might occur based on spatial data?	4.20	4.00
197	What management measures can be used to increase connectivity, and how do they perform?	4.20	4.00
204	How can existing and new methods, technologies, and tools be used to improve monitoring?	4.20	4.00
328	How can we improve knowledge of understudied systems and species through monitoring and research?	4.17	4.00
6	What are the direct and indirect effects of invasive fishes?	4.17	4.00
163	How will climate change impact fish physiology, community structure, and population dynamics?	4.00	4.00
302	How can Indigenous communities be involved in habitat monitoring programs?	4.00	4.00
8	How do weathering, erosion, sedimentation and siltation impact fish habitat, and how can these effects be managed?	4.00	4.00
108	How does productivity vary among different habitat types for a given freshwater species?	4.00	4.00
80	How can habitat use, habitat requirements, and fish distributions be better understood in northern and remote areas?	4.00	4.00
92	How does the quality of freshwater habitat relate to the long-term viability of fish populations?	4.00	4.00
278	How can long-term sustainable growth of cities be integrated with protection of fish habitat.	4.00	4.00
148	How can fish passage around hydropower facilities be improved?	4.00	4.00
176	How will rapid warming in northern areas impact freshwater fish communities and productivity?	4.00	4.00
180	What is the mechanism by which different stressors interact to influence fish or fish habitat?	4.00	4.00

ID	Question	Researcher Score	Practitioner Score
21	What is the effect of shoreline hardening (including revetments) on freshwater ecosystems?	4.00	4.00
146	How do nutrients and water flow between terrestrial and aquatic ecosystems?	3.83	4.00
178	What are the cumulative effects of different types of pollutants on fish and fish habitat?	3.83	4.00
309	How can we include social and economic benefits of fish habitat in risk assessment and management?	3.83	4.00
60	What are the impacts of discharging large volumes of water into aquatic systems?	3.83	4.00
279	How can we prevent the introduction of invasive species in restored habitats?	3.80	4.00
62	How can decision making tools and codes of practice improve outcomes for small habitat alterations?	3.80	4.00
290	Does applying the natural channel principles counterbalance the impacts of lost channel length and infill of existing channel footprint?	3.75	4.00
48	What physical, chemical and environmental factors influence how diluted bitumen will interact with aquatic habitat, and how do these factors determine the vulnerability of systems to diluted bitumen spills?	3.75	4.00
77	What is the relationship between habitat availability and habitat use for focal species?	3.75	4.00
198	How can we evaluate different ecosystem indicators?	3.67	4.00
219	How can ecosystem feedbacks be better incorporated into models and decision-making tools?	3.50	4.00
25	How can habitat status and vulnerability indicators be developed for individual watersheds?	3.50	4.00
326	How can policies support the achievement of net environmental gains?	3.25	4.00
131	Under what conditions will fish find and use new spawning habitats?	3.00	4.00
264	How can habitat mapping be improved through remote sensing?	3.00	4.00
160	How can fish body shape be used to predict entrainment and impingement risk?	2.60	4.00
159	Can new technologies be used to evaluate physical conditions experienced during passage through turbines?	2.50	4.00
304	What are the best practices for habitat restoration projects?	4.75	3.83
78	What are the traits of good and sub-optimal spawning habitats for anadromous fishes?	4.25	3.80
182	How do the cumulative effects of multiple barriers impact migrating species?	4.00	3.80
293	What methods and tools can improve habitat valuation?	4.00	3.80
111	What are the water temperature niches for native and invasive species, across all life stages?	3.75	3.80
244	How should we define populations or management units for freshwater and anadromous species?	3.25	3.80
162	How will climate change impact habitat connectivity/fragmentation and how can connectivity be maintained despite predicted climatic changes?	4.17	3.75
140	What are the best practices for barrier removal when barriers also prevent the movement of invasive species or create headpools with high fish densities?	3.83	3.75
137	What are the movement patterns and capabilities of different fish species?	3.67	3.75
125	What is the reproductive behaviour for freshwater fishes, and what environmental factors trigger reproduction?	3.33	3.75

ID	Question	Researcher Score	Practitioner Score
50	How can we predict the response of focal fish populations to new invasive species?	3.33	3.75
120	What are the vital rates for all life stages of freshwater fish populations?	2.75	3.75
170	How will climate change impact broad patterns of freshwater distribution?	4.80	3.67
266	How can spatial tools and mapping technology be better used to classify freshwater habitats and standardize those classifications across Canada?	4.75	3.67
190	What are the recovery potentials for various fish populations with and without interventions?	4.60	3.67
235	How can uncertainty associated with population assessments and predictions be quantified and considered?	4.60	3.67
254	How can ecosystem and habitat models be used to guide habitat restoration and offsetting activities?	4.40	3.67
203	How can we conduct more long term monitoring studies to inform habitat management?	4.33	3.67
14	How important is flooding to fish and fish habitat, and how can the negative effects of flooding and flood prevention be mitigated?	4.25	3.67
115	What buffer area around a waterbody or watercourse should be protected to ensure the conservation of an aquatic ecosystem?	4.20	3.67
134	What are the barriers to movement in freshwater systems for each species and life stage, and how can they be mitigated?	4.17	3.67
105	How can we develop standardized indicators or proxies for habitat health and fish productivity?	4.00	3.67
317	How can we use existing data to report on the state of fish and fish habitat?	4.00	3.67
135	How do physical parameters in rivers impact the spatial distribution of fishes?	4.00	3.67
79	How can the spatial resolution of fish and fish habitat data be improved?	4.00	3.67
308	How can assessments and decisions integrate multiple goals and multiple types of information?	3.60	3.67
311	How can compliance and enforcement be standardized and integrated with indigenous environmental management processes?	3.20	3.67
323	How can species be protected in the face of economic incentives that drive their declines?	3.00	3.67
276	What are the best practices for fish-outs?	2.50	3.67
189	How can freshwater habitat data from other sources and jurisdictions be better leveraged to inform DFO's research and management activities?	4.25	3.60
206	How can effective monitoring be conducted in the face of limited resources?	4.25	3.60
168	When should the effects of climate change on water temperature and availability be considered in project reviews?	4.00	3.60
274	What is the effectiveness and best practices for impact mitigation and avoidance in winter?	4.00	3.60
101	What are the human caused and natural factors limiting population growth for focal species?	3.75	3.60
262	How can we develop mechanistic models relating fish habitat to fish populations and communities?	3.75	3.60
174	How can estuary planning incorporate aquatic habitat concerns given sea level rises?	3.50	3.60
188	How can data science and data mining improve assessments of management?	3.25	3.60
236	How can stock assessments consider the complexity associated with mixed-stock fisheries and the potential for overharvest on small populations?	3.25	3.60

ID	Question	Researcher Score	Practitioner Score
139	How can knowledge about hydrodynamics and fish swim performance be used to make decisions around fish passage?	3.00	3.60
269	What is the likelihood of arrival, establishment and spread of various aquatic invasive species?	3.00	3.60
184	Can a new framework for cumulative effect review be created or adapted for ffhpp?	4.67	3.50
332	How can the results of focused scientific studies be scaled-up to inform decision making at larger scales?	4.50	3.50
288	What spatial scale should be used for considerations about offsetting?	4.25	3.50
226	What are the basic ecosystem structures and functions in northern aquatic environments?	4.17	3.50
127	What are the feeding habits of freshwater fish species and how do these affect habitat use?	4.00	3.50
152	How do wetlands impact hydrological and nutrient flows in different sized watersheds, and how do wetland management practices impact these processes?	3.80	3.50
132	What is the migratory phenology of Canadian fish populations?	3.75	3.50
46	How do various stressors and habitat changes impact the abundance and type of aquatic invertebrates?	3.67	3.50
126	What is the life history and abundance for early life stages of freshwater fishes?	3.33	3.50
313	How can we use an ecosystem based approach to understand how the function of restored habitats will change over time?	3.33	3.50
57	Which areas in large lakes are most susceptible to eutrophication?	3.25	3.50
243	How much genetic diversity is there in fish populations in Canada and is it important to protect?	3.17	3.50
234	What is the demographic structure of a given fish population, and what factors are driving demographic changes?	2.83	3.50
91	What are the life history differences between lacustrine and riverine populations of freshwater fish?	2.33	3.50
255	How can mixed-effects models be used to improve estimates of fish abundance?	2.00	3.50
322	How can science and other evidence better inform management?	4.75	3.40
123	What are the basic life history details for freshwater fishes?	4.25	3.40
56	How do some ecosystems function and remain healthy under conditions of intense human use?	3.75	3.40
55	Are invasive parasites a significant threat to fish populations?	3.00	3.40
171	How might climate mediated changes in water quality and flow impact fish sensory systems and modify fish behaviour?	3.00	3.40
150	How should habitat connectivity be considered in offsetting?	4.80	3.33
295	Where should new aquatic protected areas be located to best protected aquatic biodiversity?	4.75	3.33
239	How can we develop appropriate targets or benchmarks that would guide management?	4.67	3.33
191	How can ecosystem health be best quantified?	4.50	3.33
300	How can management objectives incorporate the views of local stakeholders and other agencies?	4.50	3.33
251	How can a national DNA database for aquatic species be maintained and inform habitat management?	4.25	3.33
86	What are the distributions and life histories of small-bodied fishes?	4.20	3.33

ID	Question	Researcher Score	Practitioner Score
45	When should the removal of invasive species be considered an effective offsetting or restoration measure?	4.00	3.33
291	How can existing frameworks for identifying ecologically and biologically significant areas be applied in various freshwater system?	3.83	3.33
297	How does the distribution of species, habitats and threats relate to current aquatic protected areas?	3.83	3.33
167	How can we identify and protect thermal refugia?	3.75	3.33
214	How can tools improve decision-making when there is high uncertainty or a lack of data?	3.75	3.33
17	How does life history and physiology relate to the vulnerability of species to stressors?	3.75	3.33
240	How can thresholds for habitat alteration consider uncertainty and ecosystem complexity?	3.60	3.33
245	How is stocking success impacted by source population genetics and adaptations to local conditions?	3.60	3.33
153	What is the availability of fluvial habitat in different systems and how applicable are fluvial models across systems?	3.50	3.33
241	What are the tolerances and population responses of freshwater fish to changes in dissolved oxygen and nutrients?	3.50	3.33
155	When should natural barriers (such as landslides) be removed?	3.40	3.33
51	How will diluted bitumen spills influence aquatic habitat in low temperature and ice conditions?	3.25	3.33
169	How can changing baselines be considered and addressed in management decisions?	4.00	3.25
10	What are the impacts of noise and light pollution on fish health and behaviour?	3.50	3.25
85	What fish species have individual home ranges and what are the ecological characteristics of those home ranges?	3.00	3.25
227	What is the relationship between trophic richness and nutrient trapping and release by reservoirs?	2.50	3.25
13	What are the levels of reported and unreported harvest on focal fish populations?	3.75	3.20
24	How can we improve, systematize, and validate pathways of effects models?	3.50	3.20
303	How can the knowledge of seasoned employees be incorporated into improvements and modernization of management programs?	3.50	3.20
23	What are the impacts of pharmaceuticals on fish and fish habitat?	3.50	3.20
259	How can citizen science data be used to improve estimates of fish abundance and habitat quality?	3.50	3.20
18	What are the mechanisms by which introduced fish species cause population declines in native species?	3.25	3.20
261	How can predictive models help identify sites and vectors at risk from invasive species, and how they would respond to management measures?	3.25	3.20
118	How does nearshore coastal habitat contribute to the function of large lakes?	3.00	3.20
39	How can we ensure that Canadian freshwater ecosystems have a natural resilience towards invasive species?	3.00	3.20
40	What is the current distribution and extent of suitable habitat for invasive freshwater plants?	2.33	3.20
192	How can management objectives continue to be effective under environmental change?	4.75	3.00
142	How do different types of barriers impact passage by different fish species?	4.50	3.00

ID	Question	Researcher Score	Practitioner Score
71	What are the biological and chemical responses to various stressors in freshwater systems, and how can these responses be used to assess the level of stress in a system?	4.50	3.00
72	How can biological control be best used to manage aquatic invasive species and other stressors?	4.40	3.00
334	How can the timeline regarding providing protections to species at risk be streamlined to ensure that once a decision is reached by COSEWIC, protections are afforded to the species under SARA in a more timely manner?	4.00	3.00
144	What are the effects of fishways on fish species, and how can they be made more effective while posing less risk?	4.00	3.00
30	What is the quality of agricultural drains as fish habitat and how do different drain management practices impact fish populations?	4.00	3.00
95	What is the importance of substrate to aquatic flora, fauna, and ecosystem functions?	4.00	3.00
147	What are the effects of periodic low flows on fish community structure?	3.83	3.00
256	How do life-history or habitat-based models perform in predicting escapement in locations with multiple stocks or stocks with mixed life-histories?	3.80	3.00
196	What are the minimum informational needs to predict the response of a species to harvest?	3.75	3.00
28	What are the impacts of harmful algal blooms on freshwater ecosystems and how can they be avoided or mitigated?	3.75	3.00
106	What is the mechanism and form of density-dependence acting on freshwater fish populations?	3.67	3.00
35	What are the effects of dredging on freshwater fish habitat in terms of habitat quality and susceptibility to the spread of invasive species?	3.67	3.00
333	What are the best practices for species at risk listing for economically important fish?	3.60	3.00
9	What are the physiological and behavioural effects of toxic substances on fishes?	3.50	3.00
281	How can a common scale be used to compare project impacts to the result of management measures, and how can this guide decisions around equivalency?	3.50	3.00
172	How can we downscale climate models to understand predictions and uncertainty of effects on specific systems?	3.50	3.00
42	How do invasive plants and algae influence habitat quality for native fishes?	3.50	3.00
230	What is the link between biodiversity and fisheries productivity?	3.17	3.00
69	What are the risks posed by invasive aquatic invertebrates?	3.00	3.00
143	How do reservoir drawdowns and erosion impact fish habitat?	3.00	3.00
47	Which species are exposed to pollutants and other stressors during migration?	3.00	3.00
66	What are the impacts of invasive aquatic mussels on nutrient cycling?	3.00	3.00
37	What are the densities of invasive species at different sites and how do differences in density modulate their impacts?	2.75	3.00
208	How can non-lethal methods be used to monitor fish populations?	2.67	3.00
283	What tools can help prioritize species actions vs habitat actions?	2.50	3.00
246	What is the population composition in various mixed-stock fisheries?	2.00	3.00
307	Can sediment eDNA help guide restoration efforts in impacted ecosystems?	1.60	3.00
310	How can multiple management objectives be considered and addressed?	3.75	2.80

ID	Question	Researcher Score	Practitioner Score
121	How do fish habitat use, life history, and physiological tolerances differ throughout a species' range?	3.50	2.80
265	What is the extent of macrophyte coverage in aquatic systems?	2.75	2.80
195	What should the target population abundance be for fish reintroductions in various waterbodies?	2.50	2.80
319	How does variation in environmental conditions and behaviour impact the encounter rates of fish and sampling gears?	2.50	2.80
289	How does food web structure impact the effectiveness of offsetting?	2.33	2.80
107	What is the productivity of focal fish populations?	3.67	2.75
119	How can the total pool of limiting nutrients be estimated for focal systems?	3.60	2.75
233	What is the current population size and trajectory for a given fish population, and how does it relate to historic levels or the carrying capacity?	3.33	2.75
116	What factors drive recruitment and productivity in large, complex aquatic systems such as the great lakes?	4.33	2.67
88	How do measures of habitat suitability and connectivity relate to the movement of fishes during biologically significant periods?	4.25	2.67
185	When might impacted habitat still be considered to be high value?	4.00	2.67
205	How can monitoring for water temperature, hydrology and water quality be improved?	3.80	2.67
38	What native and introduced fish species are present in each waterbody in Canada?	3.50	2.67
96	What characteristics make certain pelagic areas important habitats for fish populations?	3.40	2.67
318	How can engagement with private landowners be improved to encourage responsible land use related to riparian and aquatic habitats, and to conduct research and monitoring on private land?	3.25	2.67
44	How do pathogens affect fish health and behaviour, and will the impacts be more pronounced under environmental change?	2.50	2.67
324	What are the interactions between different ecosystem services provided by Canadian rivers?	2.25	2.67
53	How often and where are invasive fishes released into natural waterbodies in Canada?	2.25	2.67
93	What is the niche differentiation and competitive relationship between closely related fish species?	2.25	2.67
193	What processes can support adaptive management practices that are updated based on past results?	4.50	2.60
223	What is the effect of natural predation on species of management interest?	3.50	2.60
252	What is the frequency and magnitude of catastrophic events in freshwater ecosystems?	3.00	2.60
114	Are egg deposition rates a good indicator for population productivity and can they be applied across systems?	2.00	2.60
109	What should the targets be for recruitment and escapement for various anadromous fish populations?	4.33	2.50
271	How do pulsed flows impact water quality and fish behaviour, and what are the best methods to mitigate the negative impacts?	3.83	2.50
292	How does the establishment of aquatic protected areas impact freshwater community structure and modify the impact of stressors?	3.83	2.50
122	How do vital rates vary among populations of the same species, and what factors drive that variation?	3.00	2.50
59	What is the impact of lowering winter water levels on species that burrow and hibernate?	2.75	2.50

ID	Question	Researcher Score	Practitioner Score
221	What are the ecological interactions between focal fishes and other members of the community?	2.67	2.50
250	In populations with variable life histories, what proportion of the population uses each life history strategy?	2.33	2.50
211	What is the sampling effort required to identify given species or assemblages in agricultural drain habitat?	1.33	2.50
229	What is the overlap in habitat requirements between different species of management interest?	3.75	2.40
216	How can principles of adaptive management help to refine decision-making tools over time?	3.50	2.40
218	What is the relationship between community composition and productivity?	3.00	2.40
68	How has the intentional introduction of gamefish impacted other ecosystem components?	2.75	2.40
94	What is the source of fish found outside of their historical ranges?	2.25	2.40
257	Which freshwater fishes can hybridize with closely related species and under what conditions does hybridization occur?	2.25	2.40
298	How can local, traditional, and Indigenous knowledge be better integrated in science advice and management decisions?	4.25	2.33
65	What are the patterns of dissolved gas supersaturation related to hydroelectric dams?	4.00	2.33
129	What is the relationship between natural and total mortality for freshwater fishes?	3.60	2.33
84	How do habitat requirements and fish distributions change throughout the year?	3.40	2.33
247	What is the minimum viable population size for a given population?	3.00	2.33
49	What are the sublethal impacts from catch-and-release fishing during both summer and winter?	2.75	2.33
20	What is the impact of escaped fish as competitors and genetic contributors to native populations?	2.25	2.33
232	How do aquatic animals modify their habitats?	3.00	2.20
272	How can avoidance and mitigation measures be standardized across Canada?	4.17	2.00
154	Where will fish passage become more difficult as a result of droughts?	4.00	2.00
277	Which locations are most suitable to be used for ballast water exchange?	3.83	2.00
217	How can we better understand the structure and productivity of lower food webs, and their links to upper food webs?	3.80	2.00
63	What are the impacts of lampricide on early life stages of native fishes?	3.75	2.00
98	Can the area-per-individual for fishes be estimated from life history and ecological characteristics?	3.67	2.00
76	What is the life history and habitat use patterns of fishes in winter?	3.60	2.00
224	What are the vital rates of hatchery and wild fish populations, and how does competition among populations impact these measures?	3.50	2.00
305	How does the quality and stability of created wetland habitat compare to that of natural wetlands?	3.50	2.00
231	Are changes in fish community structure a good indicator of changes in habitat quality for keystone species?	3.00	2.00
32	How does boat traffic impact fish behaviour and health?	3.00	2.00
151	What environmental variables impact migration success?	2.75	2.00
128	What is the fecundity for freshwater species and what is the quantitative relationship between fecundity and body size?	2.50	2.00

ID	Question	Researcher Score	Practitioner Score
156	How do stocked fishes disperse from their original stocking locations within and around the great lakes?	2.50	2.00
248	What are the risks from genetic introgression in fish populations?	2.50	2.00
67	What is the abundance, distribution and behaviour of seals, and how do they impact fish populations?	2.25	2.00
33	What are the impacts of incidental baitfish harvest on populations of small-bodied fishes?	2.20	2.00
54	What is the impact of accumulation of hydrated lime in bottom sediments on benthic communities?	1.50	2.00
64	What is the impact of ultraviolet radiation on juvenile fishes?	2.67	1.80
11	How does plastic move through aquatic ecosystems, and what are the impacts on fish and fish habitat?	2.50	1.75
222	What is the degree of competition between various fish species and how does it impact population dynamics?	3.40	1.67
325	How can more fish counting facilities be installed in remote locations?	3.00	1.67
34	What are the impacts of fishing gear to aquatic habitat?	2.75	1.67
87	What is the area-per-individual requirements for focal species and how does it change with latitude?	2.67	1.67
100	Does migratory behaviour systematically varying with latitude?	2.67	1.50
275	How does salvage logging affect flow and freshwater habitat?	2.67	1.50
161	Are water levels in large lakes expected to increase or decrease over time?	2.60	1.50
258	How can dynamic systems theory help inform ecosystem tipping points, early warning signals, stability and resilience?	3.33	1.33
41	What are the effects of underwater cables on fish behaviour and health?	3.00	1.33
130	How does the reproductive success of stocked populations compare with natural populations?	2.50	1.33
249	What is the taxonomic relationship within families of small bodied fishes?	1.00	1.20
90	What are the depth preferences for various fish species?	3.00	1.00
237	What factors are driving observed changes in body condition for some fish populations?	2.83	1.00
112	What is the role of larval drift for freshwater fish species?	2.50	1.00
52	How prevalent are fish species-at-risk in piscivore diets?	2.25	1.00
228	What are the impacts of predatory fishes on migrating anadromous fishes?	1.67	1.00
194	Should Larkin benchmarks be considered in assessment of status for anadromous fishes?	1.50	1.00
330	How does the Earth's rapidly shifting magnetic field and increasing anthropogenic electromagnetic fields affect fish migration?	1.50	1.00
133	Why do some species have eggs that are mobile in river systems, and does this mobile incubation confer a selective advantage?	0.50	1.00
320	How valid are aging structures and age validation measures of fish species?	2.80	0.50
124	Can vital rates be estimated from life history characteristics and local environmental traits?	2.67	0.00
173	How can we operationalize the concept of regime shifts?	3.60	N/A
225	How does ice chronology impact fish predation by seals, and what local factors impact ice chronology?	2.33	N/A

Table 2. *Results of the final scoring exercise (step 3). Questions (n = 93) are organized by rank within each theme with researcher and practitioners scores displayed separately. Each question was scored by survey participants (n = 48) based on its importance to freshwater fish habitat management in Canada (six-point Likert scale, ranging from 'very unimportant' to 'very important'), the amount of scientific resources they thought would be required to answer the question (four-point Likert scale, ranging from Very Low to Very High), and the extent of existing scientific knowledge related to the research question (four-point Likert scale, ranging from Very Limited to Well Known). Likert scores were then converted to numeric values (0-5 for 6-point Likert scales, and 0-3 for 4-point Likert scales), and a mean of all scores was taken for each metric.*

Research Theme	ID	Research Question	Rank	Practitioner Importance	Researcher Importance	Practitioner Existing Knowledge	Researcher Existing Knowledge	Practitioner Research Requirements	Researcher Research Requirements
Climate impacts on habitat	166	How will climate change impact water temperature, water supply, and water quality in Canadian freshwater systems?	14	4.29	4.68	1.50	1.57	2.19	2.18
	192	How should climate change be considered during offsetting and restoration projects?	32	4.24	4.32	0.94	1.15	2.12	1.81
	176.1	How will climate change impact productivity of freshwater fish habitats?	34	4.19	4.32	1.06	1.26	2.50	2.22
	176.2	How will climate change impact the structure of freshwater communities?	37	4.19	4.21	1.27	1.37	2.47	2.19
	165	How will climate change alter the susceptibility of freshwater ecosystems to invasive species?	46	4.18	4.11	1.44	1.67	2.38	1.89
	175	How will climate change impact patterns of flow (e.g. mean and variance in water levels, seasonality) ?	54	4.06	4.11	1.24	1.37	2.29	1.81
Flow, fish passage and habitat connectivity	141	How does hydrological connectivity impact the quality of freshwater habitats?	19	4.47	4.34	1.82	1.89	2.18	2.00
	136	How do flow regimes impact freshwater habitat?	23	4.28	4.41	2.00	2.07	1.94	2.04
	158	How can flow management be designed with whole aquatic ecosystems in mind?	33	4.33	4.19	1.35	1.36	2.18	2.16
	150	How should habitat connectivity and its influence on productivity be quantified during habitat valuation?	42	4.00	4.33	1.56	1.48	1.88	2.07
	197	What management actions can be used to avoid losses of habitat connectivity?	49	4.22	4.04	2.11	2.15	1.5	1.56
	138	How can impacts to groundwater be managed to protect aquatic habitat?	53	4.25	3.93	1.56	1.46	1.81	1.67

Research Theme	ID	Research Question	Rank	Practitioner Importance	Researcher Importance	Practitioner Existing Knowledge	Researcher Existing Knowledge	Practitioner Research Requirements	Researcher Research Requirements
Flow, fish passage and habitat connectivity	134	What are the anthropogenic barriers to movement in freshwater systems for each species and life stage?	56	4.11	4.04	1.83	1.74	2.11	2.19
	142	When is fish passage around anthropogenic barriers required?	65	3.83	4.21	2.67	2.08	1.33	1.54
	145	What is the natural variability in flows for river systems?	66	3.94	4.07	2.06	2.29	1.33	1.29
	148	How can fish passage around anthropogenic barriers be improved?	67	4.00	4.00	2.12	2.14	1.41	1.71
	144	What is the effectiveness of different fishways in passing different fish species?	69	4.13	3.85	2.38	1.96	1.63	1.70
	157	What are the movement patterns of larval and juvenile fishes?	80	3.75	3.96	1.67	1.15	2.07	2.15
	14.2	How should extreme flows and flooding be managed to protect aquatic habitat?	81	3.75	3.92	1.80	1.73	1.94	1.77
	14.1	What are the impacts of extreme flows and flooding on freshwater habitat?	83	3.71	3.92	1.87	1.69	1.93	1.81
	159	What new technologies can be used to evaluate the physical conditions experienced by fish during passage through turbines?	92	3.86	2.80	1.54	1.68	1.54	1.44
	160	How can morphological and sensory traits of fish species be used to predict entrainment and impingement risk?	93	3.08	3.18	1.92	2.05	1.33	1.29
Habitat classification	97	What are the best metrics for quantifying habitat quality?	11	4.59	4.46	1.94	1.72	1.82	2.00
	294	What are the priority habitat types for restoration and offsetting?	16	4.47	4.39	1.88	1.72	1.69	1.93
	295.1	What are the desired attributes of new protected areas?	50	4.06	4.18	2.00	1.81	1.56	1.37
	266	How can spatial tools and remote sensing improve habitat classification and mapping?	71	3.76	4.15	2.19	2.19	1.63	1.70
	295.2	Where should new aquatic protected areas be located?	74	3.75	4.11	1.88	1.71	1.53	1.82
	268	What factors should be used to classify freshwater habitat into different types?	75	3.82	4.00	2.18	2.00	1.41	1.28

Research Theme	ID	Research Question	Rank	Practitioner Importance	Researcher Importance	Practitioner Existing Knowledge	Researcher Existing Knowledge	Practitioner Research Requirements	Researcher Research Requirements
Habitat management effectiveness	304	How effective are common habitat restoration practices for achieving their intended outcomes?	3	4.81	4.75	1.50	1.48	1.69	1.93
	285	How effective are different habitat offsetting methods in achieving their intended outcomes?	5	4.65	4.73	1.12	0.93	2.06	2.17
	270	How effective are common avoidance and mitigation measures used in freshwater habitat management?	8	4.47	4.64	1.69	1.46	1.82	1.96
	200	How do management activities influence the risk of invasive species introduction and establishment?	62	4.06	4.04	2.00	1.88	1.59	1.54
Habitat monitoring	210	What monitoring methods are effective for very large projects?	20	4.41	4.34	2.00	1.93	1.31	1.81
	209	How long should monitoring programs be conducted to ensure that projects met their intended outcomes?	22	4.29	4.39	1.65	1.63	1.29	1.57
	202	How can we standardize monitoring to better understand the performance of different management measures?	26	4.24	4.41	1.88	1.90	1.47	1.52
	206	How can monitoring programs be optimized given a set level of available resources?	48	4.12	4.14	2.00	2.00	1.06	1.07
	204	How can existing and new methods, technologies, and tools be used to improve habitat monitoring?	52	4.06	4.14	1.81	1.78	1.65	1.50
Habitat use	74	What are the habitat requirements for different life stages of freshwater species?	13	4.29	4.71	2.18	1.96	1.94	2.04
	73	What is the availability, distribution, and quality of habitat for a given species?	29	4.24	4.36	1.53	1.57	2.29	2.29
	78	What are the features of good and sub-optimal spawning habitats for freshwater fishes?	39	4.00	4.34	2.33	2.03	1.47	1.41
	83	How can we measure or estimate habitat availability at remote sites?	43	4.13	4.19	1.53	1.54	1.93	2.07

Research Theme	ID	Research Question	Rank	Practitioner Importance	Researcher Importance	Practitioner Existing Knowledge	Researcher Existing Knowledge	Practitioner Research Requirements	Researcher Research Requirements
Habitat use	89	How important is habitat heterogeneity for the function of aquatic ecosystems?	60	3.94	4.17	1.81	1.68	1.94	2.04
	82	When and what type of habitat suitability models be used for classifying habitat quality and quantity?	79	3.89	3.85	1.89	2.00	1.47	1.48
	95	What is the importance of substrate to aquatic flora, fauna, and ecosystem functions?	85	3.76	3.72	2.25	2.25	1.31	1.24
	77	What is the occupancy of high, medium, and low quality habitat by different fish species?	90	3.22	3.79	1.81	1.59	2.00	2.07
Habitat, population dynamics and community structure	238	Can we define thresholds for habitat modification below which the effects on fish productivity are minimal?	6	4.67	4.61	1.06	0.82	2.11	2.43
	26	What are the mechanisms by which habitat changes impact fish populations?	15	4.12	4.75	1.88	1.57	2.29	2.61
	102	How does the quantity and quality of habitat relate to fish productivity?	28	4.00	4.60	2.13	1.87	1.82	2.17
	103	What is the carrying capacity for various habitats and which populations are limited by habitat availability?	36	4.17	4.25	1.44	1.29	2.33	2.32
	123	What are the basic life history details for freshwater fishes?	40	4.13	4.21	2.44	2.36	1.44	1.50
	263	How can models effectively link habitat features to fish population dynamics?	41	4.19	4.15	1.63	1.48	1.94	1.70
	110	What factors determine how resilient freshwater fish populations are to habitat change?	47	3.94	4.32	1.59	1.36	1.94	2.25
	108	How does productivity vary among different habitat types for a given freshwater species?	51	4.11	4.11	1.72	1.75	1.94	2.11
	267	How do the vital rates of fishes differ between different quality habitats?	55	3.87	4.30	1.40	0.96	2.21	2.44
	5	How is fish productivity impacted by changes in water quality, and are there	58	4.06	4.07	1.80	1.72	1.80	2.07

Research Theme	ID	Research Question	Rank	Practitioner Importance	Researcher Importance	Practitioner Existing Knowledge	Researcher Existing Knowledge	Practitioner Research Requirements	Researcher Research Requirements
Habitat, population dynamics and community structure		thresholds for water quality change before impacts are observed?							
	226	What are the basic ecosystem structures and functions in various remote aquatic environments?	64	4.06	4.00	0.94	0.88	2.44	2.52
	116	What factors drive recruitment and productivity in large, complex aquatic systems such as the great lakes?	73	3.73	4.14	1.86	1.74	2.62	2.56
	220	How do fish communities and fish habitats naturally change over time?	87	3.63	3.64	1.56	1.43	2.53	2.25
	117	What are the population dynamics of fishes in artificial habitats such as municipal drains and hydropower reservoirs?	91	3.89	3.12	2.00	1.77	1.69	1.38
Multiple stressors and cumulative effects	242	When do cumulative impacts on a system lead to tipping points (thresholds) in ecosystem health?	1	5.00	4.76	0.40	0.45	2.75	2.86
	177	When, how, and over what scale, should management decisions consider cumulative effects?	2	4.94	4.76	1.00	0.82	2.00	2.43
	113	How do the cumulative effects of catchment modification impact habitat quality?	7	4.59	4.59	1.24	1.11	2.53	2.62
	183	How do ecosystems respond to small, incremental habitat losses?	12	4.76	4.26	0.88	0.85	2.41	2.44
	179	When should we expect multiple stressors to produce additive, synergistic or antagonistic effects on fish populations?	24	4.12	4.55	0.88	0.72	2.31	2.59
	180	What are the mechanisms by which different stressors interact to influence fish or fish habitat?	38	3.94	4.43	1.35	0.96	2.29	2.54
	182	How do the cumulative effects of multiple barriers impact access to habitat for fish species?	68	3.88	4.10	2.13	1.86	1.56	1.89

Research Theme	ID	Research Question	Rank	Practitioner Importance	Researcher Importance	Practitioner Existing Knowledge	Researcher Existing Knowledge	Practitioner Research Requirements	Researcher Research Requirements
Stressors to fish habitat	1	What are the impacts of specific types of works, undertakings and activities on fish habitat?	4	4.88	4.62	2.24	1.93	1.71	2.03
	16	What are the best metrics for quantifying the impact of stressors on fish habitat?	9	4.5	4.61	1.71	1.79	2.12	2.07
	4	What are the impacts of different types of land use change on freshwater habitat?	10	4.63	4.46	2.06	2.04	1.75	2.15
	12	What are the current stressors impacting freshwater habitat in Canada?	16	4.47	4.39	2.24	2.11	1.82	1.93
	31	What is the likelihood of death of fish from different types of work, undertakings or activities in freshwater?	18	4.53	4.32	1.69	1.5	1.71	1.89
	239	What are appropriate targets or benchmarks that can be used to guide habitat management?	27	4.13	4.48	1.8	1.67	1.67	1.7
	212	What types of management tools need be developed to integrate scientific information with policies?	31	4.41	4.15	1.44	1.31	1.27	1.52
	332	How can the results of focused scientific studies be scaled-up to inform decision making at larger scales?	35	4.07	4.41	1.47	1.24	1.6	1.59
	62	What, if any, are the residual habitat impacts from works, undertakings and activities that follow DFO's Standards and Codes of Practice?	44	4.06	4.23	1.59	1.32	1.59	1.54
	314	What factors should a science-based risk management framework for the national scale include?	45	4.18	4.11	1.88	1.96	1.18	1.27
	189	How can freshwater habitat data from other sources and jurisdictions be better leveraged to inform DFO's research and management activities?	57	4.24	3.9	2.18	2.07	1.12	0.93
	254	What tools can be used to identify priority areas for habitat restoration and offsetting?	59	4.12	4	1.76	1.74	1.65	1.64

Research Theme	ID	Research Question	Rank	Practitioner Importance	Researcher Importance	Practitioner Existing Knowledge	Researcher Existing Knowledge	Practitioner Research Requirements	Researcher Research Requirements
Stressors to fish habitat	328	What are the priority systems to monitor to improve knowledge of freshwater fish habitat?	76	4	3.82	1.69	1.93	1.53	1.44
	235	How can uncertainty associated with habitat assessments and habitat responses be considered in decision making?	77	3.5	4.29	1.73	1.7	1.13	1.3
	169	How can the baseline conditions of aquatic ecosystems (e.g. before climate warming, or other anthropogenic impacts) be estimated and considered in decision-making?	78	3.88	3.87	1	1.03	2.06	1.83
	316	What new technologies could help mitigate anthropogenic impacts and promote fish habitat recovery?	82	3.88	3.79	0.92	0.69	2.07	2.15

Research Theme	ID	Research Question	Rank	Practitioner Importance	Researcher Importance	Practitioner Existing Knowledge	Researcher Existing Knowledge	Practitioner Research Requirements	Researcher Research Requirements
Other habitat issues	43	How much freshwater fish habitat has been lost and degraded in Canada?	21	4.59	4.11	1.71	1.63	2.00	2.21
	27	What are the impacts of different agricultural practices on the quality of aquatic habitats?	25	4.41	4.25	2.41	2.21	1.53	1.50
	22	How do changes to water quality impact fish populations?	30	4.24	4.34	2.00	2.07	2.00	1.83
	8	How do weathering, erosion, sedimentation and siltation impact fish habitat?	61	4.18	3.93	2.24	2.07	1.63	1.48
	3	What are the risks to freshwater habitat from invasive species?	63	3.88	4.21	1.53	1.72	2.2	2.03
	36	What existing and emerging technologies can help to protect aquatic habitat from invasive species?	70	4.24	3.74	1.27	1.31	2.07	2.26
	21	What is the effect of shoreline hardening (including revetments) on freshwater ecosystems?	72	4.00	3.89	2.35	2.00	1.24	1.37
	48	What factors influence the susceptibility of aquatic ecosystems to emerging stressors such as diluted bitumen, noise and light?	84	3.88	3.68	1.29	1.11	2.00	1.89
	2	What are the ecosystem effects of aquaculture operations and how can they be minimized?	86	3.62	3.78	2.08	2.04	1.92	1.73
	60	What are the impacts of discharging large volumes of water into aquatic systems?	88	3.65	3.57	2.00	1.96	1.67	1.59
	19	What are the effects of chemical and mechanical removal of aquatic vegetation on freshwater habitat?	89	3.63	3.59	2.20	1.84	1.47	1.44