Literature review and considerations for effective capture and relocation of freshwater fish for in-water projects

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ABSTRACT

LeBlanc, S.G. and Tunney, T.D. 2024. Literature review and considerations for effective capture and relocation of freshwater fish for in-water projects. Can. Tech. Rep. Fish. Aquat. Sci. 3636: vi + 44 p. https://doi.org/10.60825/bhfg-fv47

Capture and relocation (C&R) of fish is a mitigation measure commonly used during in-water projects. The Fish and Fish Habitat Protection Program (FFHPP) has requested scientific information on the use and effectiveness of C&R to inform future development of standards and codes of practice. As such, we conducted an abridged systematic literature review and summarized Canadian government web information on the use of C&R for freshwater fishes. Our review suggested that literature specific to freshwater fish C&R activities is limited. Of the 23 documents retained, 10 concerned larval Pacific Lamprey (*Entosphenus tridentatus*) salvages, and only one study attempted to assess effectiveness of lamprey-specific C&R protocols by estimating mortality. Two other studies reported the effectiveness of capture methods at removing fish from dredging worksites. Based on the results of our review, we present preliminary considerations for the development of freshwater fish C&R guidance, divided into five steps: 1) pre-capture, 2) capture, 3) handling, 4) holding and transporting, and 5) release. These considerations include the ecology of species present, knowledge about gear catchability and mortality, environmental conditions, and features of the release site. Moreover, we include available guidelines, permitting and reporting requirements for C&R of freshwater fishes in Canada, and conclude with recommendations for future research. Overall, this document serves as an initial step in compiling knowledge on freshwater fish C&R activities for DFO.

RÉSUMÉ

LeBlanc, S.G. and Tunney, T.D. 2024. Literature review and considerations for effective capture and relocation of freshwater fish for in-water projects. Can. Tech. Rep. Fish. Aquat. Sci. 3636: vi + 44 p. https://doi.org/10.60825/bhfg-fv47

La capture et la relocalisation (C&R) des poissons est une mesure d'atténuation couramment utilisée dans le cadre de projets en milieu aquatique. Le Programme de protection du poisson et de son habitat (PPPHE) a demandé des informations scientifiques sur l'utilisation et l'efficacité de la C&R afin d'éclairer l'élaboration future de normes et de codes de pratique. Nous avons donc procédé à un examen systématique abrégé de la littérature et résumé les informations disponibles sur le site Web du gouvernement canadien concernant l'utilisation des C&R pour les poissons d'eau douce. Notre examen a montré que la littérature spécifique aux activités de C&R pour les poissons d'eau douce est limitée. Sur les 23 documents retenus, 10 concernaient la récupération de larves de la lamproie du Pacifique (*Entosphenus tridentatus*), et une seule étude a tenté d'évaluer l'efficacité des protocoles de C&R spécifiques à la lamproie en estimant la mortalité. Deux autres études ont rapporté l'efficacité des méthodes de capture pour retirer les poissons des chantiers de dragage. Sur la base des résultats de notre étude, nous présentons des considérations préliminaires pour l'élaboration de lignes directrices sur les C&R des poissons d'eau douce, divisées en cinq étapes : 1) la pré-capture, 2) la capture, 3) la manipulation, 4) la détention et le transport, et 5) la remise à l'eau. Ces considérations comprennent l'écologie des espèces présentes, les connaissances sur la capturabilité et la mortalité reliée à ces engins, les conditions environnementales et les caractéristiques du site de remise à l'eau. En outre, nous incluons les lignes directrices disponibles, les exigences en matière de permis et de rapports pour la C&R des poissons d'eau douce au Canada, et nous concluons par des recommandations pour orienter la recherche future. Dans l'ensemble, ce document constitue une première étape dans l'élaboration d'une stratégie de remise à l'eau des poissons d'eau douce au Canada.

1. INTRODUCTION

The Department of Fisheries and Ocean's (DFO) Fish and Fish Habitat Protection Program (FFHPP) has a **regulatory framework** in place to avoid, mitigate and offset the harmful impacts of **works, undertakings, or activities (WUAs)** occurring in or near water on fish and fish habitat. FFHPP's *Projects near water* website contains a list of avoidance measures that proponents can use to plan their WUAs to avoid actions that can harm fish and fish habitat. When harmful impacts cannot be completely avoided, FFHPP also has a suite of **mitigation measures** meant to reduce their spatial scale, duration, or intensity (DFO 2019). These measures, published on the FFHPP website as **standards and codes of practice**, mitigate harm at the site level and therefore, their effectiveness is a critical (but often overlooked) determinant of the success of broader management policies and programs.

Capture and relocation (C&R), is the process of safely relocating fish trapped within the site isolation work area to an appropriate location in the same watercourse or water body. C&R is also referred to as fish salvage or fish rescue. The C&R concept is similar to mitigation translocation used in wildlife management that intends to relocate animals away from development activities to reduce animal deaths, but differs from conservation translocations that typically aim of to restore populations (IUCN 2013). Fish C&R could thus be considered a form of mitigation translocation, although in many cases for C&R, the isolated/dewatered habitat will be reestablished once the construction is completed and the fish that were relocated into adjacent habitat will regain access to the site.

Fish C&R is a measure practiced internationally in a variety of contexts because of natural and anthropogenic factors. For instance, fish are sometimes relocated to areas with more suitable environmental conditions during droughts to rescue them from lethally high water temperatures and hypoxic conditions (Archdeacon et al. 2020), or moved into an off-site rearing facility before being released back to the waterbody once conditions improve (Beebe et al. 2021). Migratory fish can be moved past manmade barriers (e.g., upstream or downstream trap-and-haul programs past dams, impoundments, and water diversions (Kock et al. 2021)), or past natural barriers (for example, salmon were exceptionally transported by helicopter and trucks above the Big Bar landslide in British Columbia in 2019). As well, fish C&R is used during water-level drawdown events such as canal draining (see Trout Unlimited-led fish rescues from irrigation canals dewatered every fall in southern Alberta since 1998) and flow reductions at dams and hydropower plants (Higgins and Bradford 1996).

The preceding examples describe relatively large-scale fish salvages, but in Canada, C&R is also commonly applied during small footprint in-water projects. C&R involves the capture of fish trapped within an isolated/enclosed work area and their relocation outside of the work area within the same waterbody. This measure is implemented to comply with federal legislation that prohibits against causing the death of fish, other than fishing (*Fisheries Act*, section 34.4 (1); under the act, crustaceans and shellfish are included in the term "fish" and also need to be relocated) and against the killing of an individual of a listed aquatic species at risk (*Species at Risk Act*, section 32 (1)). The

general objective is to mitigate sublethal and lethal effects on fish in areas exposed to pressures associated with WUAs by relocating individuals away from the work location. Despite being commonly applied, there is no available resource that we are aware of that reviews the use and effectiveness of C&R as a mitigation measure. In particular, the effectiveness of different methodological approaches is of interest to management to ensure there is compliance with the *Fisheries Act* and the *Species at Risk Act*. These requirements determine whether broader departmental goals (e.g., the conservation and protection of fish and fish habitat) are achieved (DFO 2019).

The effectiveness of a mitigation measure depends on whether that measure produces the expected outcome when it is applied (Cormier et al. 2022). An effective C&R will capture fish in an area where they are at risk of harm from the pressures associated with a WUA and relocated outside the **affected area**, usually within the same waterbody, in a way that minimizes mortality and harm to fish. While C&R intends to minimize harmful effects to fish, not all methodologies are equal in this regard, and there may be trade-offs associated with types of capture gear, environmental conditions, project types, and other factors. Therefore, it is unlikely that there is a single approach that can be prescribed for all C&R activities. Nevertheless, identifying applications that have been effective, and developing a set of considerations that could be used to guide C&R plans for activities will be helpful in achieving the outcomes desired by management.

Box 1. Key definitions

- **Affected area:** the area where all of the proposed project impacts are likely to occur either directly (i.e., project footprint) or indirectly (i.e., downstream or other surrounding areas).
- **Capture and relocation (C&R):** safely relocating fish trapped within the site isolation work area to an appropriate location in the same watercourse or water body.
- **Mitigation measures:** mitigation measures reduce the spatial scale, duration, or intensity of harmful impacts to fish and fish habitat when such impacts cannot be avoided. The best available mitigation measures or standards should be implemented by proponents. Mitigation measures include the implementation of best management practices during planning, construction, operation, maintenance, temporary or permanent closures, and decommissioning of a work, undertaking or activity.
- **Qualified Environmental Professional (QEP):** a person who is experienced in identifying and assessing potential impacts to fish and fish habitat generated from various WUAs conducted in or near water, and implementing management measures to avoid and mitigate them. QEPs possess a post-secondary degree or diploma in biological, geophysical or environmental sciences.
- **Regulatory framework:** the laws, rules, regulations, and procedures around which regulatory activities are used to conserve and protect fish and fish

Box 1. Key definitions

habitat. Under the legislative framework (i.e., the *Fisheries Act*, *Species at Risk Act*), regulatory instruments (i.e., Authorizations, permits, regulations) and guidance (i.e., standards, codes of practice) are used to manage fisheries and aquatic ecosystems in Canada.

- **Standards and codes of practice:** procedures, practices or standards on incorporating mitigation measures in relation to WUAs. A standard specifies how to design and implement a mitigation measure to achieve its objective; a code of practice specifies conditions and measures for managing risks to fish and fish habitat.
- **Works, undertakings or activities (WUAs):** a human action that may impose one or more pressures on fish and fish habitat (Brownscombe and Smokorowski 2021).

1.1 PURPOSE AND OBJECTIVES

The purpose of this document is to provide science advice to FFHPP on the use and effectiveness of the commonly applied mitigation measure of capturing and relocating fish trapped within an isolated work area. Specifically, FFHPP has requested advice on whether freshwater fish C&R is effective at reducing sub-lethal effects and mortality, and also on methodological factors to consider for a successful fish C&R. This document is specifically focused on finfish and does not include freshwater mussels and crustaceans.

The main objectives of this document are to:

1. Review the primary and secondary literature to determine the state of knowledge on the use and effectiveness of C&R in freshwater ecosystems;
2. Compile and present a preliminary summary of C&R procedures in Canada from DFO, provincial websites and other sources;
3. Provide science-based recommendations that could be used to guide future applications of C&R as a mitigation measure.

2. METHODS

2.1 LITERATURE REVIEW

We conducted an abridged systematic review of the C&R literature in four steps: 1) we developed and tested a list of search terms, 2) searched literature databases using the listed terms, 3) screened documents by title and abstract using the eligibility criteria, and 4) screened full texts using the eligibility criteria. We further searched the reference lists of papers retained. Search terms were organized into four categories following key components of a systematic review (Collaboration for Environmental Evidence 2022), Study organism, Habitat, Intervention, and Outcome. Categories of terms were combined using the “AND” operator, and terms within each category were combined

using the “OR” operator. A list of search terms was retained after some preliminary searches in Web of Science and Google Scholar (see Appendix A.1).

Web of Science and Google Scholar were searched in July 2023. The software “Publish or Perish” was used to search Google Scholar using a modified version of the search terms because of the character limit. This tool was set to return the first 200 search items were searched, and years were limited to 1940-2023 to keep the search manageable and repeatable.

We also conducted a secondary search of government websites that included the Canadian Federal Science Library Network (containing five partner libraries: Canadian Agriculture Library, Environment and Climate Change Canada Library Services, Fisheries and Oceans Canada Library, National Science Library and Natural Resources Canada Library) and eight United States government databases (see Appendix A.2). These databases limit character use (e.g., the Canadian Federal Science Library Network limit is maximum 300 characters), so the number of search terms was consequently reduced. Canadian provincial government sites were also searched using the terms “fish salvage”, “fish rescue”, and “fish capture and relocation” to find any information on the use of C&R. As some provincial websites searches did not perform properly (too many results (Ontario) or none (Nova Scotia)), an additional search was performed using Google, adding the operator [site:] followed by the provincial website (i.e., “fish salvage” site:ontario.ca).

2.1.2 ELIGIBILITY CRITERIA

Articles found by web searches were screened with the following eligibility criteria in two stages. We started by reading the title and searching for key words or terms such as “fish salvage”, “removal and relocation”, and “capture and relocation”. If an article was perceived as relevant by the authors, then the abstract was read, with similar keyword targets, but further discriminating based on the coherence of ideas with C&R as defined in this manuscript. The term “translocation” was included in preliminary searches but was not retained as it did not yield any pertinent documents related to fish C&R.

Since preliminary searches yielded few studies on the effectiveness of C&R during WUAs, we searched for and retained a broader set of literature to help provide more information on considerations for effective C&R. All studies that discussed the use and effectiveness of C&R of freshwater fish, either because of natural (e.g., droughts) or human related causes (e.g., culvert replacement, stranding during drawdowns, migratory fish captured and moved above or below a dam, lake dewatering for mining projects) were retained. Studies that were focused on any component of the C&R process (i.e., pre-capture, capture, handling, holding and transport, release) were retained provided that they were part of a C&R activity. Any documents that included guidelines, protocols, and/or best management practices for C&R of fish were also retained.

Studies that were focused on, or mentioned, the general catchability or mortality associated with fish capture but were not part of C&R activity were not included in our review, nor were studies on long-term holding and raising of fish or long-distance transport of fish. These studies would likely provide useful science advice for the development of guidance on the use of C&R. However, an in-depth examination on each of these topics would be a review on their own and is beyond the scope of this document.

2.2 NON-SYSTEMATIC SEARCH FOR C&R INFORMATION AND DATA

We conducted a non-systematic search outside the literature review for C&R information (e.g., guidelines or codes of practice, C&R databases) to provide greater knowledge on C&R in Canada. This was conducted by contacting FFHPP employees from various regions, DFO licensing services in Gulf and Maritimes regions, and some provincial agencies to inquire about monitoring data or reports, fish salvage databases, or internal guidance and protocols for fish C&R activities. Some of those findings are summarized in the results section.

3. RESULTS

C&R can be broadly described by a process that is divided into three periods: 1) a planning phase that usually involves a site visit and the development of the C&R plan, 2) during the C&R where the mitigation measure is occurring, and 3) a post C&R period that involves reporting (Figure 1). We present results that focus on information required for a C&R plan. Mostly this refers to activities that occur during the C&R mitigation, although some reference is made to the other periods. A C&R is comprised of five components: 1) pre-capture, 2) capture, 3) handling, 4) holding and transporting and 5) releasing the fish. These five components comprise the bulk of the this section and Section 4, Considerations for Capture and Relocation.

The results presented here focus on two main sections 1) the literature review and 2) state of capture and relocation in Canada. We begin each section with a brief introduction and key findings. In the literature review section, we summarize the retained documents and the literature related to capture and post-capture (handling, holding and release). We end the literature review with a section that presents information on larval lamprey C&R in the Pacific Northwest, which is the focus of a large proportion of the literature retained. We conclude the results section with information on C&R in Canada.

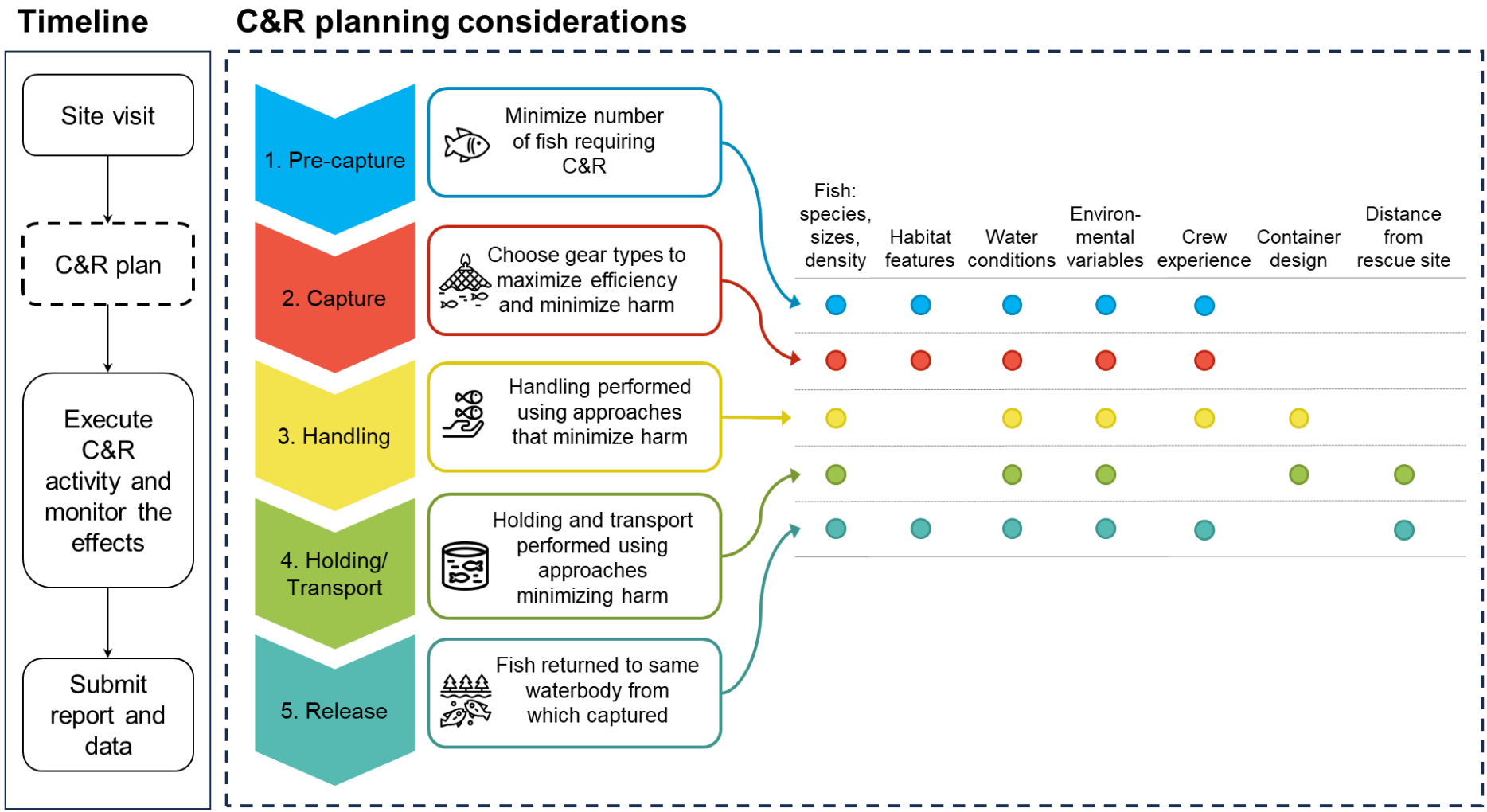

Figure 1. Flowchart of steps for C&R activity. The main body contains considerations for C&R activity. This information can be used to form a C&R plan. Post-capture reports and data can feed back into the considerations to inform future C&R activities.

3.1 LITERATURE REVIEW

KEY MESSAGES:

- There is limited information on C&R within the context of in-water works.
- The literature review on C&R of fish during in-water works demonstrated that the effectiveness of this mitigation measure at reducing sublethal and lethal effects on fish has not been scientifically assessed.
- Of the papers retained, only one study focused on the effectiveness of fish C&R pertaining to mortality, for salvages of larval lamprey burrowed in sediment during dewatering events (Liedtke et al. 2021; Harris et al. 2023).
- Two studies investigated the effectiveness of capture methods at removing fish from dredging sites (Barnucz et al. 2015a; DFO 2015), without any discussion on mortality or sublethal effects on fish.
- The literature search retained 10 documents addressing larval lamprey salvages in the Pacific Northwest.
- Four guidance documents were retained but are not discussed in this section. Some elements of these documents are incorporated into the considerations and are listed in Appendix B.2.

3.1.1 RETAINED DOCUMENTS

Search of Web of Science returned 499 results, and Google Scholar 400 results (498 and 269 respectively, with duplicates removed; Figure 2). Screening for title and abstract, 8 articles were retained from Web of Science and 27 from Google Scholar. For all government database searches combined, 1,269 titles were returned (1,044 with duplicates removed). After screening for title and abstract, 28 documents were retained from the government databases. A total of 54 documents were retained across Web of Science, Google Scholar, and government databases with duplicates removed. After manually screening the full texts, 23 documents were retained for the review, including an additional 9 documents retained from the reference searches. The search focusing on provincial government websites did not yield many results and were not included in Figure 2. Information from these sites will be included in section 3.2,"State of knowledge of capture and relocation in Canada".

Documents containing any information on C&R were kept, and results were categorized according to document type: 1) studies of C&R steps (capture, post-capture including handling, holding, transport and release), 2) articles discussing larval Pacific Lamprey (*Entosphenus tridentatus*) C&R, and 3) best management practices, guidelines, protocols, or methods for C&R.

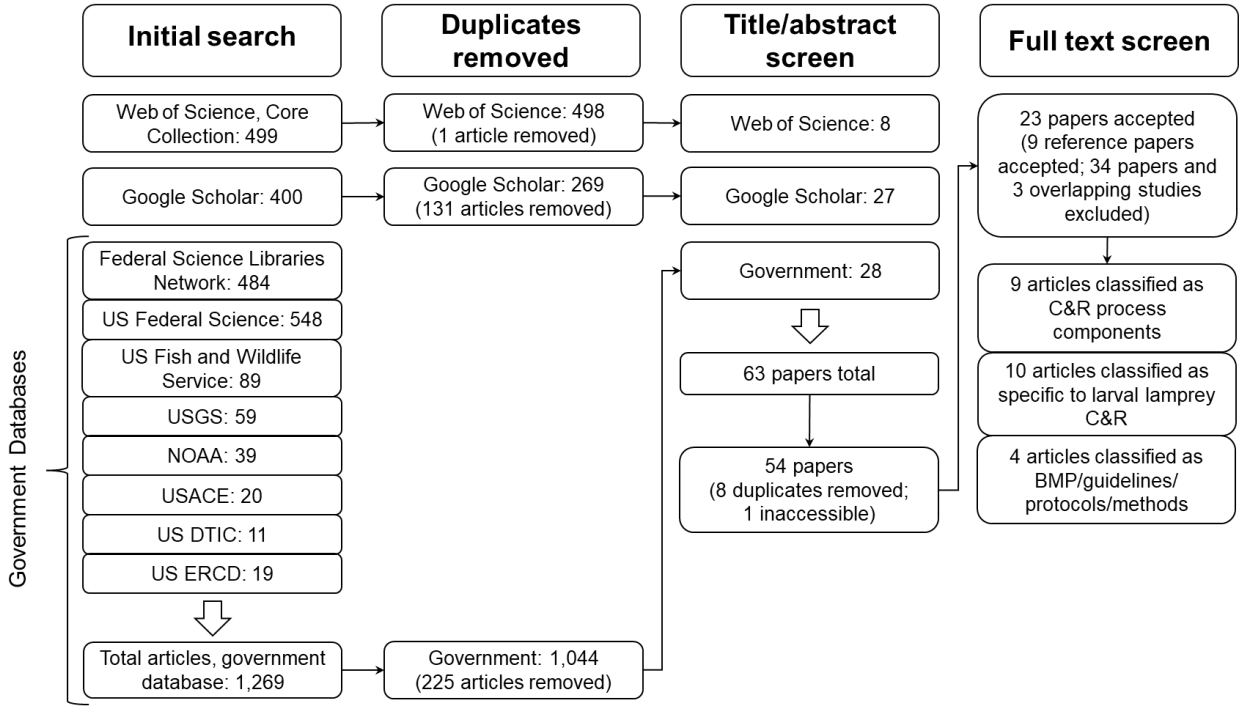

Figure 2. Results of the literature review and selection process with the final number of studies accepted.

3.1.2 INFORMATION ON THE C&R STEPS

3.1.2.1 CAPTURE

KEY MESSAGES:

- Conditions for capturing fish can vary greatly depending on the site; larger sites and/or sites with deeper water can be more challenging (Barnucz et al. 2015b).
- More than one capture method is usually required for effective capture of all fish species and sizes (McEachern 2003; Ackerman 2005). Therefore, consideration of the freshwater community is needed when choosing among capture methods.

The six papers retained discussing capture methods were from a disparate range of projects, from a diversity of habitats (lakes, irrigation canal, agricultural ditch, stilling basin), with or without isolation/dewatering, and all using different capture methods.

Two studies on the impacts of WUAs focused on fishes listed under the *Species at Risk Act* in Ontario waterbodies and considered the effectiveness of fish exclusion and salvage techniques in lacustrine (Barnucz et al. 2015a) and riverine habitats (Barnucz et al. 2015b). The first study is on the use of depletion trawling for fish salvage as a mitigation strategy during maintenance dredging in Lake St. Clair, and was deemed ineffective for C&R (Barnucz et al. 2015a). Three repeated trawls showed no significant difference in fish abundance between trawls for all 54 sites sampled (i.e., no depletion). No exclusion methods were used during the study. In contrast, a second study that

used sonar in a large agricultural ditch scheduled for maintenance dredging found that the use of isolation nets and depletion seining was effective at removing most fish and excluding them from a hypothetical work site (Barnucz et al. 2015b). Two hauls of a bag seine deployed by boat removed an average of 80% of fish in the isolated area. Channel width and water depth were identified as variables that could impact fish exclusion from the work site, with larger channels and deeper water making exclusion more challenging (Barnucz et al. 2015b).

A study on fish entrainment rates into an irrigation canal in southern Alberta used a mark-recapture experiment to estimate the efficiency of a fish rescue in the upper 10 km of the canal (van Poorten and Post 2004; Post et al. 2006). Marked White Suckers (*Catostomus commersonii*) were intentionally entrained in the facilities located at the beginning of the water management project (headworks), so that a rescue of these fish could be attempted. A 9-day fish rescue operated in October over 7 km of the 10 km canal using electrofishing and isolation nets. An estimated 41.4% (95% confidence limits: 30.3-59.4%) of all White Suckers present in the study area during the fish rescue were caught (van Poorten and Post 2004).

Finally, two reports were retained that described C&R activities for in-water projects. Capture methods, number and type of fish captured, and mortalities were recorded. A fish rescue in a lake being dewatered for open-pit mining in the Northwest Territories (McEachern et al. 2003) used very different active and passive capture methods than in a stilling basin below Tieton Dam, Washington (Ackerman 2005). One hour gillnet sets were the most efficient capture method in the lake setting, but mortality rates were much higher than that of trap nets and minnow traps (55.4% vs 1.5% and 5.3% respectively, for 5,050 fish caught in total). Minnow traps caught few fish but were still recommended for use as they capture fish not targeted by the other capture methods (McEachern et al. 2003). McEachern et al. (2003) emphasize the importance of minimizing fish handling to increase fish survival. During the dewatering of a stilling basin, Ackerman (2005) first used a combination of tangle nets, a beach seine and dip nets, and completed with electrofishing to capture almost 10,000 fish with minimal reported mortalities. The greatest number of fish injuries and mortalities were observed during electrofishing.

3.1.2.2 POST-CAPTURE (HANDLING, HOLDING, TRANSPORT, RELEASE)

KEY MESSAGES:

- Survival of relocated fish is impacted by unfavorable water conditions at the capture and release sites (Mosser et al. 2013; Archdeacon et al. 2020).
- Reducing the severity and duration of multiple stressors throughout the activity is vital in reducing physiological stress on the fish caught (Cho et al. 2009).

A similar lack of studies was found that reported on the post-capture component of C&R. Below we summarize these studies.

In some cases, post-capture activities can be a major source of mortality for freshwater fishes. A C&R of 26 adult Chinook Salmon (*Oncorhynchus tshawytscha*) that had ceased migration were studied in Butte Creek, California (Mosser et al. 2013). The fish were captured with a seine net, equipped with esophageal radio-tags, and transported upstream in a hatchery truck to continue migration into holding/spawning habitat. However, no fish were determined to have survived to spawn despite this effort. Specific causes of mortality were not identified, but potential contributing factors included differing habitat conditions, exposure to high water temperatures at capture and release sites, and/or handling treatments (Mosser et al. 2013). The study suggested some best practices to avoid similar outcomes including early intervention, minimizing air exposure and thermal shock, and monitoring environmental conditions to choose appropriate release sites.

Since 1996, federally listed Rio Grande Silvery Minnow (*Hybognathus amarus*) in New Mexico stranded during channel drying are rescued and returned to areas in the river with perennial surface flow (Archdeacon 2016). Archdeacon et al. (2020) estimated post-rescue survival by transporting fish rescued from drying pools to indoor tanks and held for 5-7 weeks. Even with seemingly optimal post-rescue holding conditions (i.e., sterile, predator-free laboratory conditions with optimal water quality and access to food), survival rates for fish rescued from intermittent flow conditions (June-August) ranged from 1.4% to 8.9%. In contrast, survival rates for the control group collected during spring continuous flows ranged from 74% to 100%. Factors including high ambient temperatures, low dissolved oxygen, and crowding in isolated pools were considered as causing stress on fish, making it likely that fish were already physiologically compromised before being rescued. Handling, confinement, and transport are additional stressors that can further limit fish survival, especially in the context of this rescue as fish were exposed to broad daily water temperature fluctuations (>10°C on average in a 8 to 12 hour period, during June-August) (Archdeacon et al. 2020).

Cho et al. (2009) studied three physical stressors on Rio Grande Silvery Minnow in a laboratory setting: handling (fish dip netted and exposed to air for 30 seconds), confinement (crowding at a density of 100 kg/m^3 for 3 hours) and transport (fish placed in plastic bags at a density of 40 kg/m^3 for 3 hours). Changes in plasma cortisol, glucose and osmolality were observed over 24 or 48 h post treatment, for each stressor studied separately and for stressors studied consecutively (handling only, handling plus confinement, and handling plus confinement and transport). While changes in plasma cortisol were not detectable and changes in plasma glucose and osmolality were moderate for individual stressors, the changes in plasma glucose and osmolality were highest with three consecutive stressors. Within 48 hours, plasma glucose and osmolality were returned to unstressed levels. Cho et al. (2009) recommend reducing the severity and duration of the individual stressors and releasing the fish in favorable environmental conditions.

These studies suggest that cumulative stress on fish should not be underestimated in the context of C&R, and that it is important to consider all stages of C&R as a source of

stress on fish. Summer fish mortality rates were extremely high in both Archdeacon et al. (2020) and Mosser et al. (2013). For both studies, fish were stressed even before being caught due to low flows, high water temperatures, low dissolved oxygen and crowding. The cumulative stresses caused during capture, tagging, handling, confinement, and transport likely contributed to the mortality of fish, as well as environmental conditions at the release site for adult Chinook salmon (Mosser et al. 2013). Cho et al. (2009) demonstrated that Rio Grande Silvery Minnow has a stronger secondary stress response when subjected to three consecutive stressors. The fish in the study were kept in optimal conditions pre- and post-manipulations and were able to recover after 48 hours. While manipulations in this study were not necessarily representative of typical C&R activity for in-water works, it demonstrates the importance of reducing the severity and duration of individual stressors throughout the activity.

3.1.3 LAMPREY CASE STUDY

KEY MESSAGES:

- There are C&R considerations specific to native larval lampreys living in the substrate. Many age classes are often present on a site within the sediment and a single dewatering event could have a significant impact on the local population (Streif 2009).
- Water temperature plays an important role in mortality of relocated fish (Liedtke et al. 2021).
- Lamprey-specific capture protocols using electrofishing can reduce mortality during dewatering events (Harris et al. 2023).

We retained 10 documents that discussed lamprey-specific C&R in the Pacific Northwest of the United States, including two effectiveness studies. These studies represent a substantial portion of the literature that was retained from our review, so we provide more specific information on this example of C&R. For brevity, not all 10 documents are discussed but are listed in Appendix A.3.

Pacific Lamprey are anadromous, migrating into freshwater to spawn in gravel-bottomed streams and dying shortly thereafter. The filter-feeding larvae (ammocoetes) drift downstream of the spawning sites to areas of low velocity and fine substrates. They burrow in fine-grained substrates and become filter feeders for 3-7 years before metamorphosing to the juvenile phase. Juveniles leave the substrate, enter the water column, and migrate downstream to the ocean between late fall and spring (Streif 2009).

The focus of C&R research on native Pacific Lampreys stems from conservation concerns in the U.S., with population abundance and distribution declines throughout the species range (Luzier et al. 2009). Dewatering of freshwater habitats (e.g., management of hydropower facilities) can cause stranding and mortality of burrowed larval lampreys and has been identified as a threat to lamprey populations (U.S. Fish

and Wildlife Service 2019). Therefore, efforts have been made to research lamprey larvae salvage (Streif 2009).

During dewatering events, Harris et al. (2023) used four treatments of increasing intensity within test enclosures to estimate larval mortality. The first treatment had personnel walking on the sediment post-dewatering followed by a 2-hour exposure period during which larvae were left lying on the surface of the sediment. Treatment two included one round of lamprey-specific electrofishing before dewatering, and one round of modified lamprey electrofishing ("dry-shocking") after dewatering; treatment three was similar but with a second round of both types of electrofishing. Prior dewatering, the fourth treatment included walking on the sediment, three rounds of standard electrofishing and two rounds of lamprey-specific electrofishing; after dewatering, the site was walked on again followed by two rounds of modified lamprey electrofishing. Mortality in the fall salvages was minimal even for the most intensive treatments compared to the summer salvage (Harris et al. 2023). Summer mortality rates were attributed to high air and water temperatures, limited field crews and highly variable timing for dewatering (Liedtke et al. 2021). This suggests that factors beyond capture gear such as environmental factors are important considerations for C&R of larval lampreys.

In a report by Lampman and Beals (2019), it was estimated that despite high effort, only 30-40% of larval lampreys were captured and relocated by electrofishing at high density sites (40,000 in one canal) during annual water diversion rescues. The survival rates for the relocated lampreys were unknown. Yet even with these low rescue rates, the lamprey salvages are considered critical because the irrigation canals are dewatered for the winter, so it is assumed that without salvage all lampreys are lost.

Studies of lampreys demonstrate the importance of ecological knowledge during dewatering events to optimize collection methods, ensuring minimal stress and mortality. As for other fish species, lamprey salvages rely on planning that considers site characteristics, environmental factors, estimated population densities of all fish, knowledge of migration and spawning timing, and an adequate number of personnel with local field experience for the number of fish/lampreys to be salvaged (Lamprey Technical Workgroup 2020).

Table 1. All articles retained, in the order presented in the literature review (section 3.1).

Authors (year)	Gear	Habitat	WUA/ reason for C&R	Fish species
Barnucz et al. (2015a)	trawl	lake	dredging	26 species caught, incl. 1 Species at Risk
Barnucz et al. (2015b)	seine by boat	creek (agricultural drain)	dredging	39 species caught, incl. 5 Species at Risk

Authors (year)	Gear	Habitat	WUA/ reason for C&R	Fish species
van Poorten and Post (2004); Post and van Poorten (2006);	backpack electrofisher and isolation nets	irrigation canal	dewatering	White Sucker
McEachern et al. (2003)	gillnets, trap nets, minnow traps, angling	lake	dewatering	Cisco, Round Whitefish, Lake Trout, burbot, Arctic Grayling
Ackerman (2005)	tangle nets, beach seine, dip-netting, backpack electrofishing	river (stilling basin below a dam)	dewatering	6 salmonid species, dace, sculpin, sucker and Redside Shiner
Mosser et al. (2013)	seines	river	move migrating fish above dam	Chinook Salmon
Archdeacon et al. (2020)	seines	river	rescue fish from isolated pools during warm months	Rio Grande Silvery Minnow
Cho et al. (2009)	n/a	laboratory, recirculating system	rescue fish from isolated pools during warm months	Reared Rio Grande Silvery Minnow
Liedtke et al. (2021); Harris et al. (2023)	backpack electrofisher	river (hatchery rearing pond & irrigation diversion)	dewatering	Pacific Lamprey
Lampan and Beals (2019)	backpack electrofisher	river (irrigation diversion)	dewatering	Pacific Lamprey

3.2 STATE OF KNOWLEDGE ON CAPTURE AND RELOCATION IN CANADA

This section provides information on the use of C&R in Canada, including available guidelines, a brief overview of permitting conditions and reporting, and preliminary searches for available data. The information in this section is part of a non-reproducible search for unpublished information and data on C&R in Canada, and may be incomplete. Hence, care in the interpretation is warranted.

3.2.1 FFHPP CAPTURE AND RELOCATION

Fish C&R is included in FFHPP's mitigation measures, within the in-water site isolation standard (guidance related to cofferdams, turbidity curtains, pump arounds, flumes,

diversion channels) and the municipal and agricultural drain maintenance code of practice. Both state the following:

1. Fish trapped within an isolated/enclosed work area are to be captured and safely relocated to an appropriate location in the same watercourse or water body.
2. Dewater gradually to reduce the potential for stranding fish.
3. Capture and relocate any fish as per applicable permits.

3.2.2 GUIDELINES

Through our searches and communications with FFHPP, we determined that there are no specific national guidelines for fish C&R, but best management practices can be included in a Letter of Advice. Regulatory conditions are included in a *Fisheries Act* Authorization, in a *Fisheries Act* Authorization that also acts as a *Species At Risk Act* permit, or in a stand-alone permit under the *Species at Risk Act*. "A review of fish sampling methods commonly used in Canadian freshwater habitats" (Portt et al. 2006) was recommended as it helps in the selection of appropriate gear used in stream, river and lake littoral habitats based on gear efficiency and limitations. Our secondary literature search on Canadian provincial government sites uncovered some guiding information (see Appendix B.1 "Provincial documents"):

- best practices within fish rescue/salvage provincial permit terms (BC, AB);
- fish collection/sampling standards/guidelines (BC, AB, NS);
- electrofishing policy (AB);
- standard operating procedures for fish capture with live return to water and electrofishing (QC);
- specific guidelines for capturing, handling and salvaging Species at Risk for Nooksack Dace (*Rhinichthys cataractae* spp.) and Salish Sucker (*Catostomus* sp.) in British Columbia (Pearson 2015a; Pearson 2015b).

3.2.3 PERMITTING FOR C&R ACTIVITY

The search for C&R data showed various permitting situations depending on the province in which the activity is conducted. There was also variability in C&R reporting and no standardized data requirements. Because of this, obtaining C&R data was challenging. Compiling data and analysis was beyond the scope of this report. Therefore, we unfortunately did not gain additional insight into the effectiveness of C&R measures using C&R data in Canada.

Requirements

Our search for C&R data showed various permitting situations across Canada. Fish C&R requires a provincial permit in British Columbia (BC), Alberta (AB), Saskatchewan (SK), Manitoba (MB), Ontario (ON), and Quebec (QC). Where there is no provincial permit authorizing fish C&R, a licence to fish for e*xperimental, scientific, educational, aquatic invasive species control or public display purposes* under Section 52 Fishery

(General) Regulations is issued. In some circumstances, both a provincial permit and a Section 52 are necessary (i.e., salmon bearing rivers or streams in BC). In addition to issuing a Section 52 licence, some DFO regions also issue a licence to authorize the release and transfer of live fish into fish-bearing waters under Section 56 Fishery (General) Regulations, even for fish that are immediately returned to the water in which they were caught. Other permits/licences/authorizations may be required (for example a permit relating to *Species at Risk Act*); it is the responsibility of the proponent to ensure all required permits/licences are obtained.

Reporting

Provincial fish salvage or rescue permits are issued in BC, AB, SK, MB, ON and QC (Table 2). Each province has mandatory information requirements (we could not confirm for MB) that include waterbody type and coordinates, gear type used and effort, and species caught by gear (number caught, mortality). Some examples of data templates available online include: BC Fish Data Submission template, AB Fisheries Loadform, and ON Mandatory collection report.

Table 2. Provincial licence/permit requirements for C&R of fish during in-water works. Additional federal licences/permits might be required.

Province	Licence/permit for C&R
British Columbia	-Scientific fish collection permit, fish salvage activity, for freshwater fish from non-tidal inland waters. -A Section 52 is required for eulachon or salmon other than kokanee, and for salvage in marine waters.
Alberta	Fish research licence, fish rescue
Saskatchewan	Special collection permit for fish salvage
Manitoba	Live fish handling (general) permit
Ontario	Ontario Licence to collect fish for scientific purposes, with fish salvage during in-water infrastructure works. Conditions are set out in Ontario Fish Licensing regulation 664/98 (section 34.1)
Quebec	Scientific, Educational or Wildlife Management (SEM) licence

We made data requests to provinces requiring licences for fish C&R (BC, AB, SK, MB, ON and QC) by contacting provincial ministries responsible for fisheries management over the timeline we had to develop this report. Ultimately, we received data from BC (1998-1999, 2001, 2004-2021) and AB (1991-1992, 1997, 1999-2022). Analysis of these data is beyond the scope of this document. However, as an example of the information available, Alberta reports that a total of 809,771 fish were captured and relocated over the 27-years of data. Three families of fish represented 91% of all fishes captured and relocated: Leuciscidae (52%), Gasterosteidae (29%), and Salmonidae (11%). A total of 677 mortalities were reported over the time period, including one event with 492 fish mortalities reported.
We also tried obtaining data from reporting for licences under Section 52. Below is an example of a search for those data from two DFO regions.

1. **Gulf Region**: A summary report on the project activities must be submitted to DFO for activities under a Section 52 licence. There are no guidelines for information requirements in this region, although since 2022, an Activity Report Form (Excel spreadsheet) has been included with the permit but is not mandatory to complete. We reviewed 10 years of licences (2013-2022) and found 34 licences issued for fish salvages, with 12 C&R reports returned in total.

2. **Maritimes Region**: Since 2013, a Report Form (Appendix A of licence) must be completed in the format provided by DFO. A Section 52 blanket licence is often issued for a variety of activities (e.g., salvage, fish assessment, monitoring), but the Report Form does not specify the activity type for the fish capture. We reviewed reports from 2023, but were unable to determine if the activity was for C&R and did not inquire further.

Other C&R data sources include reports submitted for Species at Risk permits and Authorizations through FFHPP's Program Activity Tracking for Habitat (PATH) system. These reports would need to be opened one at a time in order to extract the C&R data. An analysis of this database is beyond the scope of this document due to limited time and resources.

4. CONSIDERATIONS FOR CAPTURE AND RELOCATION

In this section, we present some of the main considerations in guiding the development of C&R plans and the use of C&R activity. Key points are presented for each of the components of the C&R process (i.e., planning, pre-capture, capture, handling, holding, transport and release, and reporting; Figure 1).

KEY MESSAGES:

- A site visit and C&R plan with specific objectives and goals are a critical part of any C&R process. This includes pre-identification and gathering of local knowledge on proposed sites of C&R efforts.
- Fish capture must involve the consideration of catchability and mortality risks from differing gear types, and an understanding of the factors that may influence these processes (e.g., fish species present, physical structure of the habitat, environmental conditions).
- Fish handling should be minimized during C&R efforts and led by experienced individuals using best available practices to avoid harm (e.g., minimizing air exposure, using wet hands).
- Holding time of fish should be minimized and monitored. Water quality, fish density, and container design are among several important factors to consider when holding fish.
- The time taken for transport and release should be minimized. Identifying release sites during the initial site visits prior to fish capture is critically important to maximize efficiency during C&R efforts.

- Reporting must be done according to permit conditions; well-designed reports enable quantitative analyses of the effectiveness of C&R activities, which ultimately benefits fishes by limiting future harm.

4.1 PLANNING

Having a C&R plan with clear and specified objectives will improve the overall effectiveness of the measure. A well-planned fish C&R can reduce overall fish stress, injury and mortality. For example, a site visit before the C&R activity to gather knowledge of fish species/densities and site-specific habitat features will help in choosing the appropriate gear, site of release, equipment and crew size. Information on fish distributions can also be obtained via some online mapping applications in certain provinces or by contacting the provincial ministry or department responsible for freshwater fish management. Check fish distribution data for potential aquatic Species at Risk and Aquatic Invasive Species in your area. Most permits or licenses require C&R activity details specific to a single project (location, gear type, fish captured, handling protocols, etc.). Sometimes, a blanket licence (i.e. covering a certain period of time with no specific project specified) may be issued. In such a case, a consultant might have little time to plan for the C&R activity because of short notice from the project proponent. Nevertheless, site assessments and well-developed, informed capture plans are needed before the activity begins.

The project proponent is responsible for the fish C&R, and often hires environmental consultants to perform the activity. Having **Qualified Environmental Professional (QEP)** on the C&R site will ensure appropriate training and experience to conduct C&R, and in some provinces, a requirement of the provincial permit. All participants of a C&R activity should be briefed before the C&R activity starts; each participant should have a clear outline of their role and responsibilities and be aware of safe work procedures. A C&R plan should describe best management practices to decontaminate equipment to prevent the movement of plants and animals between waterbodies.

4.2 PRE-CAPTURE

Minimizing the number of fish requiring C&R prior to works being conducted (if conditions permit) provides benefits to both the fishes to be rescued and project proponent. This can be done by passively removing as many fish from the site as possible (herding, corralling, or scaring the fish out of the work area), or by providing an escape route prior to dewatering. When passively removing fish from the site, if connectivity is maintained during construction (e.g., diversion channel), fish can be herded upstream or downstream. For example, block nets are often installed upstream to isolate sections of stream habitat, and the second isolation net is used to herd fish downstream (see WSDOT (2023) for guidance on the use of block nets). If connectivity is not maintained (e.g., pumping water around the site while following end-of-pipe fish protection to protect entrainment and impingement of fish), consider whether the fish should be herded upstream or downstream. Conditions upstream should be suitable for the duration of the works, considering seasonal flows and amount of habitat available.

4.3 CAPTURE

The objective of C&R is to protect fish by efficiently removing them from a work area for immediate relocation, with the emphasis on minimizing stress, injury and mortality. On the other hand, collecting data for fish population or community assessments (e.g., fish distribution, abundance and species richness) requires accurate and precise measurements using standardized sampling protocols to ensure data consistency and comparability over time. Capture considerations and constraints in the context of C&R as a mitigation measure will thus be somewhat different than for monitoring programs.

For instance, fish C&R is often planned and conducted under tight timelines. Fish are captured within an isolated work site (e.g., inside a cofferdam, between exclusion nets, or behind a turbidity curtain), moved outside the site, and then the C&R crew will monitor the site for any fish that become stranded during dewatering. C&R crews must be able to adapt to changing conditions (e.g., unexpected hot weather or heavy rain) or unanticipated events (e.g., inadequate or failing equipment) by having contingency plans in place.

Several types of non-lethal gear are required to maximize the efficiency of fish capture, ensuring all habitat types and fish species and sizes are targeted, and harm is minimized. According to conditions set out in the Ontario Fish Licensing regulation 664/98 (section 34.1), gear for C&R is limited to dip nets, seines, fyke or trap nets, baitfish or Windermere traps, electrofishing units, and buckets. The Government of British Columbia (2022) recommends using at least three collection methods on a risk hierarchy from passive to active techniques (Box 2). For active collection, a minimum of two consecutive passes that produce a zero catch must be completed for a 95% or greater fish removal (Government of British Columbia 2022). Most guiding documents for fish capture (Appendix B) are focused on standardized sampling methods, but still provide valuable information for C&R activity. For example, discussions on gear efficiency, habitat considerations and the effect of gear on fish injury/mortality can be found in Portt et al. (2006) and Dextrase et al. (2014).

Box 2. Gear types commonly used during C&R

Passive gear	Active gear
• trap (minnow, Windermere) • fyke net • trap/hoop net	• electrofisher (backpack, boat) • seine (beach, straight, pole, bag) • angling • dip net

The Washington State Department of Transportation (WSDOT) has the most comprehensive C&R guidance document for in-water construction retained in our review (WSDOT 2023). The document includes information on fish exclusion, capture and relocation protocols. Generally, in-water construction isolation has the following steps:

work area isolation, maintaining of downstream flows, performing fish C&R, and dewatering. The C&R plan should already have considered features specific to the work site that will influence the sequence of activities during the capture event. For example, on small sites with shallow water and absence of complex habitat features (i.e., potential areas where fish may hide such as undercut banks, large woody debris, aquatic vegetation), it might be possible to remove most fish before dewatering. Conversely, a larger site with deep water and a variety of habitat will be a challenge for fish capture. It might be necessary to start dewatering before or in conjunction with fish C&R. Pumping water off the site will help concentrate fish in pools for dip netting or seining.

A key variable to consider in choosing among capture gear for C&R is knowing which fish species are present on the site. This is because the effectiveness of the gear will depend on fish characteristics, including but not limited to behavior, body shape and size, habitat and depth preferences, and life stages of individuals (e.g., juvenile vs adult). For example, backpack electrofishing is an effective collection method for a benthic species like the slimy sculpin (*Cottus cognatus*) (Gray et al. 2018) while a seine is more effective at capturing mid-water species like yellow perch (*Perca flavescens*) (Lyons 1986). Further, the presence of Species at Risk requires a more targeted approach, compared to C&R for more widely distributed and abundant species, to ensure capture of all individuals (see Portt et al. (2008)).

Other factors that ought to be considered include water conditions, environmental variables, and habitat characteristics. Water temperature is a critical consideration during capture as higher temperatures can increase stress and mortality rates of fish. To minimize stress during warmer periods, fish should be captured during the coolest part of the day (e.g., early morning or late evening). Rain events change water levels, flow rates and clarity of water, affecting effectiveness of capture. Higher water velocities make capturing fish more difficult for example nets with fine mesh would be hard to pull in strong current, or wading during electrofishing might become dangerous. High winds and turbidity can reduce visibility making electrofishing less effective, so seining may be preferred in such conditions. Substrate composition is another important factor to consider as it might affect gear effectiveness. For example, complex substrate with obstructions and debris will make beach seining ineffective as the net will get snagged.

4.4 HANDLING FISH

To increase survival and minimize stress of captured fish, handling must be kept to an absolute minimum. Handling can remove the protective mucilaginous layer and increase stress, making fish susceptible to disease or infection. Proper planning will help minimize the amount and duration of handling. For example, having enough experienced handlers for the anticipated number of fish caught will expedite the C&R process so the fish can be released sooner.

When landing and handling fish, use dip nets made of soft and non-abrasive material (i.e., preferably knotless rubber) to minimize abrasion, fin fraying, bleeding, mucus loss

and scale loss (Barthel et al. 2003; Colotelo and Cooke 2011). Minimize exposing fish to air as much as possible, even more so during very warm days, as it causes physiological stress and physical damage (Cook et al. 2015). In their literature synthesis on the effects of air exposure on fish in commercial and recreational fisheries, Cook et al. (2015) recommend reducing air exposure to less than 10 seconds.

Handle fish with clean hands free of any substances that could harm fish (i.e., insect repellent, sunscreen, creams, nicotine). Keep hands wet to reduce fish mucus removal or use non-abrasive gloves (Brownscombe et al. 2017). Hold fish properly by ensuring necessary support. For example, large fish should be kept horizontal, with one hand cradled under the belly, and the other around the caudal peduncle. Avoid direct contact with the gills and eyes, and avoid scraping the mucus. During winter or extreme weather, transfer fish from capture gear to holding tank by keeping fish in water to avoid freezing eyes and/or gills.

If a Species at Risk is caught, extra precautions should be taken to ensure their well-being. Additional efforts can be made to process the fish more rapidly and released as soon as possible.

4.5 HOLDING

All C&R events should minimize holding time. Necessary holding equipment should be prepared in advance in a well-organized area to improve the efficiency of the operation. Water to water transfer should be prioritized (i.e., no extra netting). Fish recuperation after capture should be done in optimal conditions to minimize physiological stress and physical harm.

Water quality is one of the most important contributors to fish health and lower stress levels during short-term holding of fish (Portz et al. 2006). Water temperature and oxygen levels during holding should be as close as possible to those from which the fish were captured. As a general rule, temperature changes should not exceed more than 2-3°C (Canadian Council on Animal Care 2005). Water conditions should be monitored regularly, and holding containers should be kept out of direct sunlight. The use of an aerator is encouraged to maintain oxygen levels. In certain settings, it might be possible to set holding buckets, temporary holding tanks, or nets directly in the stream or lake.

Fish should not be overcrowded as this can increase water oxygen depletion and should be sorted by size and species in separate holding tanks to minimize aggression and predation. Smaller C&R activities can be done using buckets, lidded coolers and small temporary aquaria. During larger activities, consider installing larger basins with circulating water. Continually monitor fish for signs of stress, for example surface gasping, increased jumping, rapid gill movements, and unusual body posture (tilted, upside-down) caused by loss of equilibrium.

Extra precautions are necessary if C&R is conducted in extreme weather. If the C&R is conducted when it’s cold or windy, consider working out of the elements (wind break,

shelter, heated sampling tent) as cold hands can slow down the C&R process. Also, it is best to not expose fish to air by keeping them in water during transfers. Consider using insulated holding tanks, and keeping them out of the elements. During warm summer months, keep holding tanks in the shade, reduce density of fish and use aerators.

4.6 TRANSPORT AND RELEASE

Fish should be returned to the same waterbody from where they were captured as soon as possible, at release sites determined prior to capture and included in the C&R plan. If fish cannot be released immediately into waters in which they were caught, a Section 56 Fishery (General) Regulations for introduction and transfers is required. If an aquatic invasive species is caught, take a photo, note the location with GPS coordinates and reported it to provincial/territorial or federal provincial/territorial or federal government agencies.

Fish should be released immediately upstream or downstream of rescue site if possible, and as previously mentioned, migrating fish should be released above the worksite if passage is not provided (e.g., pump around). Consider the quantity of fish being released: it is best to choose more that one release site in advance in case larger quantities of fish are caught, as to not overcrowd fish already at the receiving site. If fish are released upstream, ensure receiving habitat is suitable for the duration of the construction project. For example, in smaller streams, habitat conditions upstream might become unfavorable due to low flows, resulting in elevated water temperatures and low dissolved oxygen levels.

Buckets or containers are often used to transport the fish upstream or downstream and similar considerations apply as holding fish (i.e., do not overcrowd fish, maintain water quality, etc.). If a lot of fish are captured, certain situations might permit the transfer of fish directly from the salvage area to the waterbody using a smooth PVC pipe with flowing water (see Transfer fish section in Fish salvage).

The release sites should be easily accessible and potential construction-related disturbances (e.g., noise, vibration, light pollution) at these sites should be considered. The receiving habitat should be as similar to the capture site as possible. Water temperature is a very important parameter and should be as close as possible to the capture site to prevent thermal shock (no more than 2-3°C difference, Canadian Council on Animal Care (2005)). Dissolved oxygen is another important parameter to consider (see Canadian Water Quality Guidelines for the Protection of Aquatic Life Guidelines for dissolved oxygen in freshwater).

Other factors to consider at the receiving site include available cover and refuge (i.e., presence of rocks, vegetation and submerged logs), water flows that aren't too strong and/or available resting areas nearby for fish to recover effectively, and adequate water depth to accommodate fish. Also consider fish densities at the release site. In case there is ice cover, ensure enough water and oxygen are available under the ice for fish

transfer. This may require drilling multiple holes and measuring dissolved oxygen at multiple depths.

Ensure that fish are capable of remaining upright when released, properly orient larger fish with respect to water flow and gently release all fish. Use water to water transfers whenever possible.

4.7 REPORTING

Data and subsequent reports need to be submitted according to permit conditions. Most provinces have minimum mandatory data collection requirements. Management could consider requesting some of the following information:

- Permit number(s) (provincial, DFO permits)
- Company or agency name
- Biologist name
- Date of the fishing activity
- Location (coordinates, waterbody, province)
- Waterbody type
- Why the fish were collected (salvage, assessment, presence/absence)
- Gear type used and description (e.g., net length/depth and mesh size)
- Fishing effort (e.g., sampling start time and end time)
- Electrofishing: water temperature and conductivity, voltage, amperage, frequency, length of site electrofished, mean width of site
- For each gear type used: species name, total number caught, length data (could be minimum and maximum size)
- Number of fish released
- Number of mortalities

5. MANAGEMENT TOLERANCE

The intent of C&R is to minimize death and other harmful effects on fish to a level that is tolerated by management. What are tolerable levels of fish mortality during C&R? Answering this question is a management activity. However, scientific information will be important in determining what the tolerances will be. Koops et al. (2022) lists factors to consider during decisions related to the authorization of the death of fish under the *Fisheries Act* that could be used to set limits for mortality rates for C&R activities:

- Size and status of fish populations affected, with smaller population or those in decline likely to be more negatively impacted by additional mortality.
- Life history of fish populations, with long-lived species typically being more impacted by mortality on adults, while short-lived species are typically more impacted by mortality on early life stages (i.e., eggs, larvae, juveniles).
- Management objectives such as impacts of fish mortality on fisheries or on Species at Risk.
- Timing of mortality, with the impact of mortality depending on fish life-history.

- Interactions with other sources of mortality.
- Ecosystem impacts with mortality acting on multiple species are likely to lead to more severe ecosystem impacts than single species mortality.

6. CONCLUSIONS, STUDY LIMITATIONS AND FUTURE CONSIDERATIONS

This document provides an initial review of the use and effectiveness of C&R for freshwater fishes as it relates to in-water WUAs, along with initial considerations for mitigating harm during C&R activities. We were unable to determine the effectiveness of C&R as a mitigation measure as the review produced limited scientific information pertaining to C&R activities. Nevertheless, we summarized the retained literature from our searches to provide initial considerations for planning and conducting C&R activities. We found the C&R process could be presented in five key steps: 1) pre-capture, 2) capture, 3) handling, 4) holding and transporting, and 5) release. The considerations for each step include; the ecology of species present, knowledge about gear catchability and mortality, environmental conditions, and features of the release site.

Our literature search is extensive within the scope of freshwater fish C&R but like any review, our search doesn't capture all potentially relevant material. Material on mitigation translocations was not retained in our search, but interestingly, a recent review of wildlife mitigation translocations underlines that their effectiveness is difficult to determine because they are poorly documented (i.e., lacking proper monitoring and reporting) and largely absent from the scientific literature (Germano et al. 2015). This inability to draw conclusions about effectiveness from a similar activity aligns with the findings of our C&R review. One of the factors that may contribute to unsuccessful mitigation translocations is that they are planned and conducted on timelines that are set by development projects, not the requirements for translocations themselves. The authors suggest however, that for mitigation translocations, proper documentation could help to improve success despite limited timelines by recognizing which conditions and methodologies lead to successful outcomes (Germano et al. 2015). This is an important consideration because we expect similar time constraints for C&R for freshwater fish. Such constraints may add to the challenge of executing these mitigations effectively and similarly, more knowledge on C&R may help to plan these activities efficiently.

A preliminary search of C&R activities in Canada revealed that guidance and reporting vary across the country and among agencies. If understanding effectiveness of C&R is an objective of management, an effort should be made to look at monitoring, reporting, and post-project evaluation activities across Canada. We are not aware of any formal compilation of C&R activities on a national level. However, with nationwide information in hand, syntheses may be done to answer specific questions about C&R activities. For example, it may be desirable to identify the species involved in C&R across the country and the mortality associated with capturing and relocating them. A review of this material could also be used to determine the need for further scientific research and guidance from management.

Due to a lack of study of C&R activities in Canada and elsewhere, there are many opportunities for future research. Literature review or field studies that target specific steps of C&R activities may be useful for providing further guidance for planning. For example a review of the effectiveness of different gear types could provide more detailed guidance for the capture step of C&R. The long term fate of fish after release is another aspect of C&R activities that is often unknown and an important factor in determining effectiveness. Currently in Canada, only mussels that are identified as species at risk require post-release monitoring (see Mackie et al. (2008)). Post release studies of fish would require considerable effort. While intensive post release monitoring is not required of proponents conducting C&R in Canada, such study by scientists using standardized methods and designs should be beneficial to evaluating C&R effectiveness.

Effective mitigation measures like C&R are required to achieve the broader management goals of protection and conservation of fish and fish habitat. While we have presented some considerations to plan for more effective C&R, monitoring is required to evaluate specific practices or assess the usefulness of C&R in general as a mitigation measure. Therefore, it is important to continue to assess and better understand C&R to determine if guidance is leading to C&R activities that achieve their expected outcomes.

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APPENDIX A. LITERATURE SEARCH INFORMATION

A.1 LITERATURE SEARCH TERMS

Search terms used in literature review of C&R using Google Scholar and Web of Science. Search strings were created using the "AND" operator between categories.

Categories	Terms
Study organism	fish* OR Acipenserid* OR Anguillid* OR Catostomid* OR Centrarchid* OR Clupeid* OR Coregonin* OR Cottid* OR Cyprinid* OR Cyprinodontid* OR Escosid* OR Esocid* OR Gadid* OR Gasterosteid* OR Hiodontid* OR Ictalurid* OR Leuciscid* OR Moronid* OR Osmerid* OR Percichthy* OR Percid* OR Petromezontid* OR Salmo* OR Umbrid*
Habitat	Freshwater OR "Fresh Water" OR River OR Stream OR Creek OR Brook OR Estuar* OR Lake OR Pond OR Ditch OR Canal OR Channel
Intervention	"Captur* and Relocate*" OR Rescue OR Salvage OR Relocat* OR "fish rescue" OR "fish salvage" OR "fish capture and relocation" OR "fish recovery and rescue" OR "fish removal and relocation" OR "removal and exclusion of fish" OR "fish exclusion" OR "fish removal"
Outcomes	injur* OR death OR mortalit* OR stress OR "sub-lethal" OR "delayed mortality" OR survival OR effective* OR efficiency

A.2 SECONDARY LITERATURE SEARCH SITES

Government databases used for literature search.

Government and provincial databases	Web address
Federal Science Libraries Network	science-libraries.canada.ca
US Federal Science	science.gov
US Fish and Wildlife Service (US FWS)	fws.gov
US Geological Survey (USGS)	pubs.usgs.gov
National Oceanic and Atmospheric Administration (NOAA)	library.noaa.gov
US Army Corps of Engineers (USACE)	usace.army.mil
US Defense Technical Information Center (DTIC)	discover.dtic.mil
US Army Engineer Research and Development Center (ERDC)	erdc-library.erdc.dren.mil
British Columbia	www2.gov.bc.ca/gov/content/home
Alberta	www.alberta.ca/index.aspx
Saskatchewan	www.saskatchewan.ca/
Manitoba	www.gov.mb.ca/
Ontario	www.ontario.ca
Quebec	gouv.qc.ca
New Brunswick	www2.gnb.ca
Nova Scotia	beta.novacsotia.ca
Prince Edward Island	www.princeedwardisland.ca
Newfoundland and Labrador	gov.nl.ca
Northwest Territories	gov.nt.ca
Nunavut	gov.nu.ca
Yukon	yukon.ca

A.3 LAMPREY DOCUMENTS RETAINED

All lamprey-related articles retained during literature search

Year	Authors	Title
2009	Streif	Considering Pacific Lampreys when implementing instream activities
2019	Lampman and Beals	Exploring techniques to reduce lamprey and salmonid entrainment into canals
2019	Skalicky et al.	Evaluation of changes in abundance and methods for salvage of larval lamprey during a “slow water” drawdown and dewatering in Leaburg Reservoir, OR
2020	Beals and Lampman	Intensive monitoring of larval/juvenile entrainment in the Yakima Subbasin, 2018
2020	Harris et al.	Effects of dewatering on behavior, distribution, and abundance of lampreys
2020	Lamprey Technical Workgroup	Best Management Practices for native lampreys during in-water work
2020	Liedtke et al.	Evaluating dewatering approaches to protect larval Pacific lamprey
2021	Liedtke et al.	Evaluation of larval lamprey survival following salvage: a pilot study
2023	Harris et al.	Salvage using electrofishing methods caused minimal mortality of burrowed and emerged larval lampreys in dewatered habitats
2023	Liedtke et al.	Synthesis of larval lamprey responses to dewatering: State of the science, critical uncertainties, and management implications

APPENDIX B. VARIOUS GUIDING DOCUMENTS

B.1 CANADA

1. **Fish and Fish Habitat Protection Program (FFHPP) best practices**

    - Avoidance measures to protect fish and fish habitat: https://www.dfo-mpo.gc.ca/pnw-ppe/measures-mesures-eng.html
    - Standards and Codes of Practice (mitigation measures): https://www.dfo-mpo.gc.ca/pnw-ppe/practice-practique-eng.html

2. **Provincial documents**

    British Columbia
    - Standards and Best Practices for Instream Works (BC 2004)
    - Fish Collection Methods and Standards, version 4.0 (BC, RISC 1997)
    - Appendix A: Fish collection permit terms (BC 2022) **document available below*
    - Guidelines for the Capture, Handling, Scientific Study, and Salvage of the Nooksack Dace (*Rhinichthys cataractae*) (Pearson 2015b)
    - Guidelines for the Capture, Handling, Scientific Study, and Salvage of the Salish Sucker (*Catostomus* sp.) (Pearson 2015a)

    Alberta
    - Standard for Sampling Small-Bodied Fish in Alberta (AB 2013)
    - Electrofishing Policy Respecting Injuries to Fish (AB 2012)
    - Alberta Fish Research Licence Application – Fish Rescue application form (AB 2018) **document available below*

    Québec
    - Procédures normalisées de fonctionnement:
        - Capture et remise à l'eau de poissons vivants (QC 2021)
        - Pêche électrique (QC 2022)

    Nova Scotia
    - Guidelines for the design of fish passage for culverts in Nova Scotia, Appendix F: Fish rescue guidelines (DFO 2015) **document available below*

3. **Government of Canada publications**

    - Portt, C.B., G.A. Coker, D.L. Ming, and R.G. Randall. 2006. A review of fish sampling methods commonly used in Canadian freshwater habitats. Can. Tech Rep. Fish. Aquat. Sci. 2604. V + 51 p.
    - Mandrak, N.E. and L.D. Bouvier. 2014.Standardized data collection methods in support of a classification protocol for the designation of watercourses as municipal drains. DFO Can. Sci. Advis. Sec. Res.Doc. 2013/077. V + 27 p.

Fish salvage permit terms (BC)

APPENDIX A
FISH COLLECTION PERMIT TERMS

Any Variation of the following terms will require explicit authorization by the appropriate regional Fish & Wildlife Section Head.

PROVINCIAL TERMS

1. This collecting permit is **only** valid for species listed as threatened, endangered, or extirpated under the *Species at Risk Act* (SARA) **in conjunction with a permit issued under Section 73 of SARA from Fisheries and Oceans Canada.**

   NOTE: Contact the Department of Fisheries and Oceans for fish collecting permits for salmon or eulachon https://www.pac.dfo-mpo.gc.ca/fm-gp/licence-permis/forms/licence-sci-permis-eng.pdf or for SARA listed species https://www.dfo-mpo.gc.ca/species-especes/sara-lep/permits-permis/index-eng.html#apply.

2. Any specimen's surplus to scientific requirements and any species not authorized for collection in this permit must be immediately and carefully released at the point of capture.

3. Fish collected under authority of this permit must not be used for food or any purpose other than the objectives set out in this permit. Dead fish must be disposed of in a manner that will not constitute a health hazard, nuisance, or a threat to wildlife.

4. No fish collected under authority of this permit must be transplanted unless separately authorized by the Federal/Provincial Introductions and Transfers Committee.

5. The permit holder must, within 90 days (120 days for the Kootenay/Boundary region and Peace region) of the expiry of this permit, submit a report of fish collection activities. Interim reports may also be required and must be submitted as required by the permit issuer. All submissions must be filed electronically to: https://www2.gov.bc.ca/fish-data-submission-process.

   Reporting specifications, information and templates are available from this website and outline the mandatory information requirements. Prior notification of submission or questions regarding data report standards can be made to: fishdatasub@gov.bc.ca

6. The permit holder must comply with all Workers' Compensation Board requirements and other regulatory requirements. The permit holder is responsible for ensuring authorized persons listed on the permit are properly certified for specific sampling methods or activities (e.g., electroshocking).

7. Any workers not listed on the permit must be supervised by the permit holder or one of the authorized persons named on the permit.

8. All sampling equipment that has been previously used outside of B.C. must be cleaned of mud and dirt and disinfected with 100mg/L chlorine bleach before using in any water course to prevent the spread of fish pathogens (e.g., whirling disease) and/or invasive plant species. Any washed off dirt or mud must be disposed of in a manner such that it cannot enter a watercourse untreated.

9. No electrofishing is to take place in waters having a temperature less than five degrees C.

10. No sampling of fish in waters having a temperature greater than twenty degrees C.

11. Electrofishing must not be conducted in the vicinity of spawning gravel, redds, or spawning fish, or around gravels which are capable of supporting eggs or developing embryos of any species of salmonid at a time of year when such eggs or embryos may be present.

12. When work requires de-watering or isolation of the worksite in the stream, a permit for the salvage of fish and wildlife (Scientific Fish Collection permit) must be obtained prior to commencing work. All required salvage permits must be obtained from FrontCounter BC: https://portal.nrs.gov.bc.ca/web/client/home.

PROVINCIAL TERMS CONTINUED

13. Any fish or wildlife salvage must be carried out by a qualified environmental professional registered with a professional association (such as an RPBio). The qualified professional conducting salvage work must adhere to the conditions below in addition to those required in the Scientific Fish Collection permit.

- Salvage activities must be conducted to the Provincial Resource Information Standards Committee (RISC) standards for capture, data collection, handling, and release:

STREAM ISOLATION

- The QP must follow the standards and practices outlined in the Work Area Isolation Appendix found in the Standards and Best Practices for Instream Works. http://www.env.gov.bc.ca/wld/documents/bmp/iswstdsbpsmarch2004.pdf
- A QP must ensure that the worksite has be substantively isolated to prevent any fishes from entering the work area and efforts must be made to exclude fish from entrapment during installation of isolation works. (See section 14.2 of the Standards and Best Practices for Instream Works (MWLAP 2004).
- Dewatering must not result in HADD to fish habitat or the death of fish unless authorized by Fisheries and Oceans Canada.
- While dewatering the work site and dewatering during fish capture, all pump intakes are required to meet the federal COP for fish intake screening guidelines https://www.dfo-mpo.gc.ca/pnw-ppe/codes/screen-ecran-eng.html.

FISH CAPTURE

- Qualified professionals must determine appropriate sampling methods from the RISC standards based on water body type and habitat conditions https://www2.gov.bc.ca/assets/gov/environment/natural-resource-stewardship/nr-laws-policy/risc/fishml04.pdf.
- Qualified professionals must use a risk hierarchy of passive to active and low risk to higher risk in collection methods (e.g., minnow traps, fyke nets, beach pole seines, electroshocking, angling).
- Qualified professional must conduct a **minimum of three** non-lethal collection methods in all fish salvages.
- For active collection methods a minimum of two consecutive passes of each method that produces a zero catch must be completed as per total population removal methodology (at a minimum 95% fish removal must be achieved). (https://www.wildsalmoncenter.org/resources/field-protocols-best-monitoring-practices/).
- Where work site isolation cannot be fully achieved (e.g., fast flowing streams, imperfect seal due to substrate) additional efforts are needed to prevent harm to fish. At the end of each workday, a passive form of fish capture (e.g., baited minnow traps) are to be placed in the isolation site. If fish are captured overnight, you must restart isolation procedures at the start of the workday.
- If species at risk are captured, work must stop until proper permits are obtained.

DATA COLLECTION

- Sampling/data collection is a requirement of the Scientific Collection Permit. Sample size requirements are listed in the table below.
- Scientific Fish Collection Permits require a Fish Data Submission Template to be completed. Step 4 (Stream Site Data) of the Fish Data Submission Template must be filled out for the location where fish are salvaged from. https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/fish/fish-and-fish-habitat-data-information/fish-data-submission/submit-fish-data.

FISH RELEASE

- Fish must be released following RISC standards.
- All species are to be released in the same watercourse downstream of the work areas or a sufficient distance upstream (5 channel widths to a maximum of 100 meters) into waters of equivalent baseline quality and habitat type (pool, riffle, run).

Minimum Standards During Salvage for Fish Collection Sampling Effort*

Fish Species	Age Class	Size range	Minimum Sampling Size for lengths	Sample column required (from Individual Fish Data form)	Notes
Salmonids, including RB, CT(CCT), DV, BT, GR, LT, KO	fry	20 to 80 mm	up to 30 after 30 count	J (if possible), K	
	juvenile	81 mm-250 mm	Measure all fish caught	J, K, L	
	adult	greater than 250 mm	Measure all fish caught	J, K, L, M, N	
Coarse Fish (cyprinids, stickleback, dace, shiner, carp, pikeminnow)		under 200 mm	up to 30 after 30 count	J, K	
	Adult	over 200 mm	All	J, K, L, M	
Sport other (bass, perch, sunfish, walleye, northern pike)		all	up to 30 after 30 count	J, K, L	
Sculpin sp.		0-150mm (total length)	up to 30 after 30 count	J, K	
		Over 150mm	All	J, K, L	
Burbot, Lamprey		0-150 mm (total length)	All	J, K, L, N	
Listed Species (salish sucker, sturgeon, etc.)		All	All		Refer to SAR permit for conditions
All fishes not listed above		All	minimum 10 of each then count only	J, K, L	

Abbreviations for salmonids

- RB-Rainbow
- CT(CCT)-Cutthroat
- DV-Dolly Varden
- BT- Bull Trout
- GR- Arctic Grayling
- LT- Lake Trout
- KO- Kokanee

Fish rescue permit terms (AB)

Appendix A: Fish Research Licence- Conditions

1. The licensee shall advise the District Fish and Wildlife Office and the Area Fisheries Contact of the intended times and places of collection at least FOUR working days in advance of the commencement of field activities.

2. Minnow traps set under the authority of this licence shall be affixed with a weather proof tag, of minimum size 5 x 10 cm bearing the Fish Research Licence number and the name of the licencee, in letters not less than 20 mm high.

3. Trap nets set under the authority of this licence shall be marked at each end:
    a. When fishing through the ice, with a stake, the top of which is at least one meter above the ice surface.
    b. When fishing in open water, with a spar buoy, the top of which is at least one meter above the water.
    c. The stake or spar buoy shall be clearly marked with the fish research licence number and the name of the licence holder, in letters not less than 20 mm high, and have attached to it a blaze orange or red flag not less than 20 x 20 cm.

4. The licencee shall operate in accordance with the "Alberta Fisheries Management Division Electrofishing Policy Respecting Injuries to Fish" located on the ESRD website under Fish Research Licenses.

5. All captured fish are to be handled and disposed of as follows:
    a. All live fish (not approved for retention under this licence) shall be handled in such a manner as to ensure maximum survival and be released to sites determined prior to capture in the waters from which they were collected. (refer to Best Practices)
    b. Any species captured that is not named on the Environment and Sustainable Resource Development (ESRD) List of Native and Naturalized Fish Species in Alberta shall be reported immediately to the Area Fisheries Contact. Voucher specimens and digital photos of the specimens shall be submitted to the Area Fisheries Contact immediately for confirmation purposes, unless otherwise agreed to, and shall be reported as per the data return requirements.
    c. All fish mortalities shall have at a minimum, species, fork length (nearest millimeter) and weight (nearest gram) collected. All sport fish mortalities shall also have an ageing structure, sex, and maturity collected.
    d. All fish mortalities are to be disposed of:
        i. By incineration or disposal at an approved sanitary landfill; or
        ii. In a manner approved by the Area Fisheries Biologist where the collection occurred, if disposal under sub-clause (I) is not practical.

6. All species captured must be identified, enumerated, and a fork length (nearest mm) provided, unless extreme weather conditions dictate otherwise. Where large numbers (>100) of a single fish species are encountered at a sample location, a representative sample of that species may be measured for length using a valid sub-sampling technique.

7. Where an authorized number of individuals have been permitted to be retained in one of the preceding conditions above, if the combined total mortality of those species identified in this Licence is exceeded, the Area Fisheries Biologist must be notified immediately before continued sampling takes place.

8. The tagging or marking of fish is permitted as per the submitted study proposal.

9. The licensee is permitted to transport and temporarily hold live fish within the immediate study area, however, they must be returned into the same waterbody from which they were captured, unless they are to be transported for display or education purposes at an authorized facility which shall require an additional (separate) License.

10. Any proposed release of collected fish outside the immediate sampling area (waterbody) where fish are collected must be submitted to and approved by the Head of Fisheries Allocation and Use of the Fisheries Management Branch and may additionally require a review by the Alberta Introductions and Transfers Committee.

11. All ageing structures shall be marked with the following (for collection, preparation, and ageing of walleye otoliths refer to Watkins and Spencer (2009), for all others refer to Fish Ageing Methods for Alberta by Mackay, Ash, and Norris (1990) **OR** unless otherwise agreed to by the Area Fisheries Contact):
    - Date and location (UTM co-ordinates) of capture,
    - Species,
    - Fork Length (nearest mm), and if a mortality, weight (nearest gram), sex and maturity,
    - Estimated age (number of visible annuli).
    - FRL #

12. Locations where sampling occurred and no fish were captured shall be recorded in the data return spreadsheet. The number of passes/attempts shall be reported.

13. Data return requirements will be satisfied by providing a digital copy of all fisheries data in the appropriate FWMIS loadform format within 90 days following the licence expiry date, as per the FWMIS data submission requirements, to the issuing Area Fisheries Contact. If a report was produced, a copy of the final report of the work (or the portions of the final report that includes all aspects pertaining to the inventory or research project), as well any ageing structures and/or genetic samples, if collected, must be provided within 180 days of the expiry of the license.

14. The use of explosives or pesticide chemicals is not permitted.

15. Any of the proposed activities shall adhere to as a minimum the "Standards for the Ethical Use of Fishes in Alberta".

16. This licence must be in possession and available upon the request of staff from ESRD or Justice – Solicitor General (JSG).

17. This licence is subject to cancellation at any time and shall be surrendered to the issuer upon written notice of its cancellation.

18. This licence is non-transferable.

Appendix B. Fish Research Licence– Best Practices

1. Where fish population data is collected, the corresponding fish habitat information that complies with the Fisheries Management Information System (FWMIS) protocol should be reported.

2. Where the following fish species are captured, photographic evidence (preferably through the use of a water filled photographic chamber) should be provided in the Licencereturn for Fisheries Management Branch verification purposes: Brassy Minnow, Deepwater Sculpin, Emerald Shiner, Finescale Dace, Goldeye, Largescale Sucker, Logperch, Mooneye, Mountain Sucker, Northern Pikeminnow, Northern Redbelly Dace, Pearl Dace, Pygmy Whitefish, Redside Shiner, River Shiner, Round Whitefish, Rocky Mountain Sculpin, Shortjaw Cisco, Silver Redhorse, Slimy Sculpin, Spoonhead Sculpin, and Western Silvery Minnow. Photographs should focus on characteristic features of that species. The return should also identify in the species comments section, the meristic features used to identify the above species, particularly in the case where photographic evidence may be by itself inconclusive AND should identify whether the species was captured outside of its expected range according to "Fishes of Alberta" (Nelson and Paetz 1992).

3. Where chemicals are used as an anaesthetic to facilitate fish handling, this use must comply with manufacturer's instructions governing the use of these chemicals and appropriate holding times shall be observed. Where MS222 is used, appropriate consumption advisories must be provided to the public and should follow current Health Canada direction.

4. In an effort to prevent the introduction and spread of aquatic invasive species and fish disease in Alberta, all license holders are expected to adhere to the Government of Alberta Decontamination Protocol when conducting work in water. The most current version of the Alberta *Decontamination Protocol for Watercraft and Equipment* must be followed. To access the Decontamination Protocol and supporting documents, see the Alberta Government website at: Stop the Spread of Whirling Disease (https://www.alberta.ca/stop-whirling-disease.aspx)

    - The Provincial Fish Disease Specialist or Fisheries Biologist may recommend further decontamination protocols depending on the risk posed by the proposed work (Example, QAC solutions may be ineffective for some AIS and fish disease).
    - The use of felt-soled wading boots is restricted unless the felt can be removed and properly decontaminated.
    - Please note that Fisheries Biologists have the authority to add the Decontamination Protocol as a Condition at their own discretion based on the risk of spreading whirling disease.

    Where the Licence authorizes sites within multiple watersheds all sampling equipment must follow these same requirements prior to moving between watersheds. The Provincial Fish Disease Specialist may recommend further disinfection protocols depending on the risk posed by the proposed work.

5. Measures should be taken to minimize the number of fish requiring salvage prior to works being conducted (passive fish removal). This can include but is not limited to herding fish and/or providing an escape route out of the area of operation, prior to and during the dewatering process or other salvaging techniques. Any passive fish removal techniques used should be reported in the project notes of the FWMIS return loadform.

6. Relocation sites should be determined prior to fish being salvaged. The site should mimic the habitat the fish were salvaged from. During ice cover this may necessitate drilling multiple holes in the ice, when it is safe to do so, and testing habitat to ensure enough water and oxygen is available to sustain fish for the duration of the winter.

7. Fish handling times should be kept to a minimum and soft wet gloves used to reduce exposure to air, stress and prevent removal of the protective mucous barrier.

8. Large bodied fish should be supported at the tail and head to reduce internal injury. Where possible, all fish should be kept in their natural horizontal position.

9. If using holding tanks, they should contain a minimum of 15 L per 1 kg of fish and be monitored regularly for oxygen and stress related issues, to ensure maximum fish survival.

10. Fish salvage should occur between -20C to 20C, taking wind and extreme weather conditions into consideration. If it is required to salvage beyond this temperature range and in inclement weather extra precautions should be taken when holding/handling fish to reduce stress (ie. increased frequency of monitoring fish in holding tanks to detect stress induced issues, holding tanks be kept out of the elements; in summer - fewer fish/holding tank, employ aerators; keep in shaded area; in winter – limited/no air exposure (ie. transfer of fish from collection pails and capture gear to holding tanks occur in water or in shelter from the elements), use of insulated holding tanks and heated or insulated sampling tents and wind breaks).

11. In situations where extreme temperatures may injure fish before completion of sampling, it is acceptable to only record numbers and species of fish handled, and not collect length and weight data.

12. All nets (including entanglement gear and dip nets) should be knotless and made of non-abrasive materials to reduce injury to fish.

13. A minimum of 2 consecutive passes of each active gear type (i.e. electrofishing, seining etc.) that produces a zero catch should be completed to ensure all/the majority of fish have been removed from the salvage area.

14. Each pass of a single gear type and its associated catch shall be recorded in the data return. If fish are released immediately due to extreme conditions it should be recorded in the survey comments.

15. When electrofishing, water temperature and conductivity should be measured, recorded, and included in FWMIS loadform return.

16. Testing for fish diseases, pathogens, and parasites should be done according to a protocol specified by the Provincial Fish Disease Specialist within the Fisheries Management Branch. Any deformities or irregularities for measured fish should be noted in the FWMIS data return, and photographic documentation provided.

Appendix F: fish rescue guidelines (NS)

APPENDIX F: FISH RESCUE GUIDELINES

Fish rescues must be performed whenever instream work could harm fish, for example, during required in-water work for culvert or bridge installations. Fish rescues should have a site-specific rescue plan on site and its conditions must be followed. All fish rescues must be conducted in accordance with the *Fisheries Act*, and the *Species at Risk Act* (SARA) and related regulations and recovery plans (see Appendix A). A license to collect and move the fish must be obtained from DFO prior to any fish rescue. This license must be on site.

Please contact DFO through the National Online Licensing System at http://www.dfo-mpo.gc.ca/index-eng.htm.

In addition, there may be a requirement for a SARA section 73 permit (e.g., if the work could harm an aquatic endangered or threatened species). In this case, please email XMARSARA@dfo-mpo.gc.ca for the Maritimes Region or GLF-SARA-LEP@dfo-mpo.gc.ca for the Gulf Region.

Fish rescues must take place before the commencement of any instream work and within the allowable time frame specified in the DFO license.

The following guidelines were prepared by the Nova Scotia Salmon Association (NSSA) with DFO comment and review.

Electrofishing method

The preferred method of fish rescue in flowing freshwater watercourses is by electrofishing.

- The rescue area has to be isolated from the rest of the watercourse to prevent fish from re-entering.
- The fish rescue must be done before or in conjunction with the start of any water diversion.
- Watercourses deeper than 60cm may be coffer dammed and the water partially diverted or pumped to allow for an effective fish rescue. If this is not possible, a seine net can be used to capture fish, followed by electrofishing when the water level is lowered.
- Electrofishing can be conducted in an upstream to downstream, or downstream to upstream direction, as deemed practical by the electrofishing crew.
- Electrofishing rescues should not proceed when water temperatures are above 22°C or below 7°C unless specifically approved by DFO.

- Electrofishing passes should be complete, covering the entire wetted area of the watercourse.
- During water draw down the rescue area will be checked to remove any fish species not collected during the initial electrofishing passes.
- Captured fish should be retained in a container of minimum 30L volume filled with clean water taken from the stream. The retention bucket temperature should not exceed 22°C and not vary from the stream temperature by more than 2°C.
- To maintain sufficient oxygen levels in the container, the container water must be refreshed or changed as necessary.
- Fish should not be overcrowded in the container and the container should be emptied as necessary to prevent stressing of fish.
- Handling of fish should be minimal. Normally just from the dip net into the bucket. If handling is needed, use only clean and wet bare hands to avoid excessive removal of the mucilaginous layer. Improper handling of fish may result in the removal of the mucilaginous layer, oxygen deprivation, and general stress or death of the fish.
- No anesthetic should be used on the fish.
- Fish must be released in the same watercourse of capture and immediately upstream or downstream of the rescue area. If the water is being pumped around the site or fish passage past the site is not otherwise available migrating adult fish should be released upstream of the rescue area, and non-migrating fish should be released downstream of the rescue area.
- Any mortality should be released into the watercourse, downstream of the rescue area, and reported to DFO.
- During summer months when peak air temperatures are high (i.e. above 25°C) electrofishing rescues should be conducted during morning hours.
- When all work in or around the watercourse has finished, barriers or coffer dams must be completely removed.
- Rescue reports must be forwarded to DFO and include all information requested in the fishing license.

Barrier net method

- Barrier nets should be placed upstream and downstream of the work area which includes the pump intake location.

- Netting used for barriers should be maximum ½ inch stretch mesh and be of sufficient length and width so as to reach fully from bank to bank and to prevent over-topping during any high flow.

- Barrier nets should be doubled and held in place with sufficiently-sized substrate or a row of pea stone-filled bags along the stream bottom. The seal along the bottom and banks of the stream must be complete to prevent re-entry of fish into the rescue area.

- All nets must be labeled with a DFO license number and contact information of the license holder.

- Nets must be regularly monitored and cleaned of debris as necessary to prevent clogging and restriction of water flow.

Coffer dam method

- If the water is to be diverted around the site, not pumped, then the work area can be isolated using coffer dams.

- Sandbags filled with pea stone and plastic sheeting can be used for a coffer dam or sheet pile wall.

- Prior to fully diverting the watercourse around the work site, the upstream coffer dam should be partially built. Sufficient flow over the upstream cofferdam should be maintained to provide suitable water depths for electrofishing.

- All fish removed should be released immediately downstream of the work site.

- When the fish rescue is complete the coffer dams can be closed off and the remaining water pumped out.

- Any plastic and sandbags used for the construction of coffer dams must be of sufficient strength to avoid tearing, and/or breakdown or release into the watercourse.

- Other coffer damming techniques are also acceptable.

B.2 UNITED STATES

- Fish Exclusion – Protocols and Standards (Washington State Department of Transportation, 2023 update): guidance for fish exclusion, capture, handling, and relocation to reduce the risk of potential injury to fish during construction.
- Electrofishing Waters Containing Salmonids Listed Under the Endangered Species Act (NMFS 2000)
- Best Management Guidelines for Native Lampreys During In-water Work (Lamprey Technical Workgroup 2020)

The two following 'handbooks' summarize the requirements of programmatic Biological Opinions (BO) for habitat improvement and restoration programs and have work area isolation and fish C&R sections.US Biological Opinions analyze the effects of proposed actions to listed species or designated critical habitat. Any US federal agency proposing an action that may have an effect on a species listed under the *Endangered Species Act* must consult with US Fish and Wildlife Service or NOAA to obtain a BO.

- FY 2023 HIP Handbook, Guidance of Programmatic Requirements and process (HIP: Habitat Improvement Program) for projects in the Columbia River Basin (Bonneville Power Administration 2023)
- Projects Contractors Handbook (NMFS and USFWS 2020)

B.3 OTHER RECOMMENDED DOCUMENTS: BOOKS

- The following chapters in *Fisheries Techniques* (A.V. Zale, D.L. Parrish, and T.M. Sutton (Eds.), 2013, Third Edition):
  - Ch. 6 : Passive Capture Techniques (Hubert et al. 2012)
  - Ch. 7 : Active Capture Techniques (Hayes et al. 2012)
  - Ch. 8 : Electrofishing (Reynolds and Kolz 2012)

- Bonar, S.A., W.A. Hubert, and D.W. Willis (Eds.). 2009. *Standard methods for sampling North American freshwater fishes.* American Fisheries Society. 335 pages.