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Pêches et Océans Canada

Ecosystems and Oceans Science
Sciences des écosystèmes et des océans

National Capital Region

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Science Advisory Report 2022/047

SCIENCE ADVICE ON THE USE OF TIMING WINDOWS AS A MITIGATION MEASURE

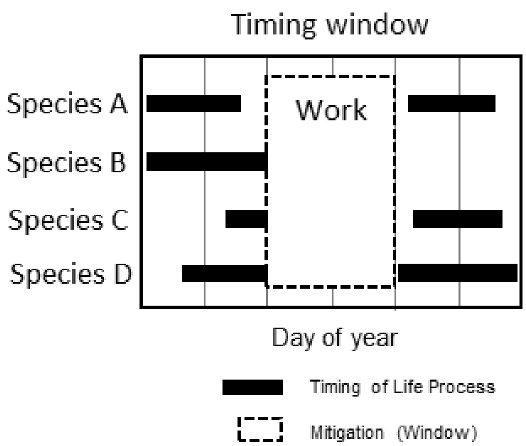

Figure 1. Schematic illustrating how timing windows can be designed to avoid the presence of sensitive life stage of fish. From Tunney et al. in press.

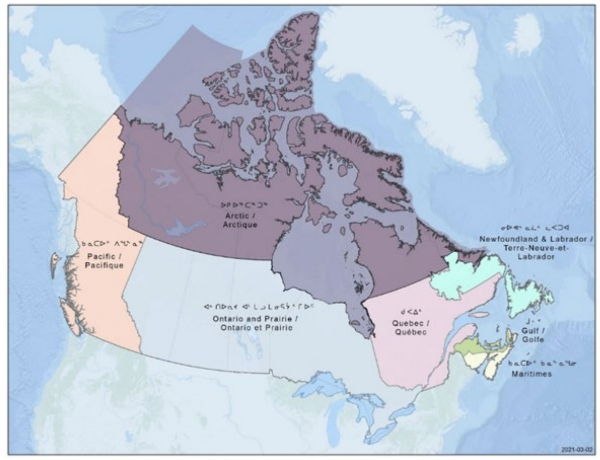

Figure 2. Department of Fisheries and Oceans' (DFO) seven administrative regions.

Context:

Fisheries and Oceans Canada's (DFO) Fish and Fish Habitat Protection Program (FFHPP) has a regulatory regime in place to avoid, mitigate and offset the potentially harmful impacts of works, undertakings, or activities (WUAs) on fish and fish habitat. FFHPP is seeking science advice on the effectiveness of timing windows as a measure to mitigate pressures resulting from WUAs in freshwater, estuarine, and coastal environments. Advice generated by this process will assist FFHPP in the development of a science-based framework that could be used to guide the creation, modification, use, and assessment of timing windows. That framework may assist FFHPP to (a) rationalize the use of timing windows within FFHPP regulatory tools, (b) develop an approach for consistent and scientifically-defensible risk-based application of timing windows for FFHPP-regulated activities, (c) monitor and improve application of timing windows over time, (d) regularly update/amend timing windows to account for changes to the environment (e.g., climate change) or species status in collaboration with other jurisdictions as applicable, and (e) fill gaps and ensure a full nation-wide complement of timing windows. This Science Advisory Report is from the February 14-17, 2022 National Advisory Meeting on Science advice on the use of Timing Windows as a mitigation measure. Additional publications from this meeting will be posted on the [DFO Science Advisory Schedule] as they become available.

SUMMARY

- Timing windows are a mitigation measure that define periods in the year when a work, undertaking, or activity (WUA) can take place because the potential effects of that WUA on fish and fish habitat are reduced relative to other times of the year. Timing windows are an appropriate mitigation measure when the pressures caused by the WUA are transient, and

when there is predictable variation in the vulnerability of fish and fish habitat to WUA pressures over time.

- Considerable variation was observed among established timing windows in Canada, reflecting the diversity of species and habitats across the country. However, there is limited science on the development, use, and effectiveness of timing windows. Thus, there is a need for a scientific process for their development and modification to facilitate their standardization and defensibility, and to validate their effectiveness.
- A conceptual model for the development and refinement of timing windows was presented that can be used to identify periods of the year when risks to fish and fish habitat from WUA pressures are lower.
- The conceptual model includes (1) the timing of life processes of species of interest, (2) the relative vulnerability of each life process to WUA pressures, (3) seasonal variation in environmental conditions, and (4) an assessment of how magnitude and persistence of the effects of WUAs vary due to modulation by environmental conditions.
- The four components of the conceptual model can be used to inform an assessment of the variation in the risk to fish and fish habitat from WUA pressures throughout the year.
- Although the model was presented for a single fish species or groups of species with similar life histories, conceptually, it can be adapted for communities or guilds of species.
- Based on this conceptual model, timing windows can be established for periods when the risk to fish and fish habitat is assessed to be reduced. Uncertainty (due to lack of knowledge, or to spatial and temporal variation in biological and ecological processes) can be managed by varying the duration of timing windows in accordance with risk tolerances and management goals.
- Timing windows can be modified by including site-specific information on species biology and environmental conditions, and could also be modified as required in response to observed variation in biological or environmental events.
- Timing windows are one of a suite of mitigation measures commonly prescribed by FFHPP to reduce the risk of harmful impacts on fish and fish habitat. If a period of reduced risk cannot be identified and the impact of a WUA pressure cannot be mitigated by using this measure, timing windows may not be effective, and greater emphasis should be placed on the use of other measures.
- A three-tiered approach for evaluating the effectiveness of timing windows was adapted from previous advice. The first tier consists of monitoring to determine the extent of exposure of fish and fish habitat to WUA pressures during the timing window. The second tier is designed to establish if timing windows reduce fish mortality and/or impairment of the habitat's capacity to support life processes of fish. The third tier is an assessment of potential higher order consequences (e.g., above individual or site level) of the WUA pressure during the timing windows, and has a goal of increasing our understanding of their use.
- Challenges associated with the implementation of the proposed approach include estimating the risk to fish and fish habitat for complex and diverse fish communities in spatially and temporally variable environments, incorporating the effects of climate change, and difficulties evaluating the effectiveness of timing windows.

INTRODUCTION

Fisheries and Oceans Canada's (DFO) Fish and Fish Habitat Protection Program (FFHPP) has a regulatory regime in place to avoid, mitigate and offset the potentially harmful impacts of works, undertakings, or activities (WUAs) on fish and fish habitat (DFO 2021a). To manage these potentially harmful impacts, avoidance and mitigation measures are used to prevent or reduce the likelihood that a harmful impact will occur (DFO 2019a).

Timing windows are one such mitigation measure. In the context of this review, timing windows are defined as periods of the year when some or all of a proponent's activity is recommended or required to take place. Timing windows are established during times of the year when the pressure imposed by a WUA has a lesser effect on fish and fish habitat (Figure 3). They are a commonly used measure, and are almost always used in combination with other mitigation or avoidance measures in Letters of Advice, *Fisheries Act* Authorizations, or other Program instruments.

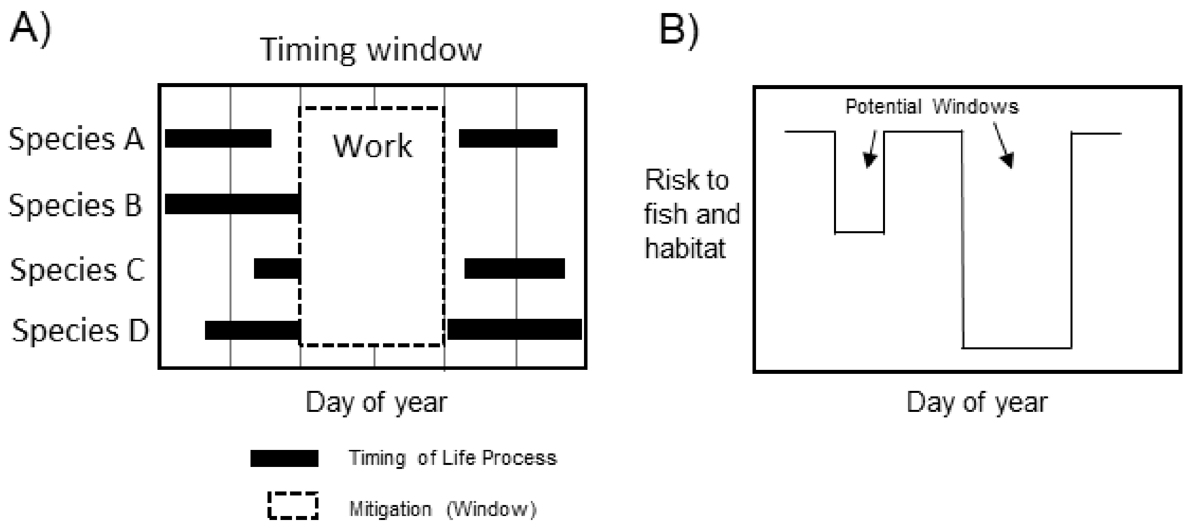

Figure 3. Schematics illustrating basic concepts associated with timing windows. (A) Synchrony in the timing of sensitive life processes results in a period of time when work can occur without exposing those stages to WUA pressures. (B) The risk to fish and fish habitat from WUA pressures can vary, creating potential periods when timing windows could be used to mitigate those pressures.

Timing windows currently in use are often developed by, or in collaboration with, provinces and territories, and can vary by jurisdiction, species, or watercourse. They are also called environmental windows or work windows, and are sometimes defined by their complement (e.g., restricted activity periods). DFOs *Projects Near Water* website provides links to the respective provincial and territorial websites where instructions on how to identify specific timing windows can be found (DFO 2019b). Their description varies as they are developed by each jurisdiction or DFO region, based on their own approaches or templates. For example, in some jurisdictions, restricted activity periods, when activity is to be curtailed are identified (AB, MB, NL, NT, NU, ON, SK) while others define timing windows, which are specified periods when a WUA can take place (BC, NB, NS, PE, QC, YT).

FFHPP has requested advice on the effectiveness of timing windows as a measure to mitigate pressures resulting from WUAs in freshwater, estuarine, and coastal environments. Advice generated by this process will assist FFHPP in the development of a science-based framework that could be used to guide the creation, modification, use, and assessment of timing windows. That framework may assist FFHPP to (a) rationalize the use of timing windows within FFHPP regulatory tools, (b) develop an approach for consistent and scientifically-defensible risk-based application of timing windows for FFHPP-regulated activities, (c) monitor and improve application of timing windows over time, (d) regularly update/amend timing windows to account for changes to the environment (e.g., climate change) or species status in collaboration with other jurisdictions as applicable, and (e) fill gaps and ensure a full nation-wide complement of timing windows.

It is expected that this process will also have synergies with other current Canadian Science Advisory Secretariat (CSAS) processes focused on habitat science advice, namely revisiting Pathways of Effects (PoE) diagrams in support of FFHPP risk assessment (DFO 2021b), estimating impacts and offsets for death of fish (DFO in press (a)) , and assessing cumulative effects in support of policy development and regulatory decision making (DFO in press (b)). Information may also be used for application of provisions of the *Species at Risk Act* for cases where listed species may be exposed to the WUA. The focus of this process was on freshwater habitat, and marine habitats were not explicitly considered. Some science advice on the use of temporal avoidance to mitigate impacts of noise in the marine environment can be found elsewhere (e.g., DFO 2020), and some of the principles described here may be applicable in any future processes for marine, estuarine and coastal environments.

There were three objectives for this advisory process: 1) review and synthesize examples of the use of timing windows to mitigate impacts to fish and fish habitat, 2) develop a standardized nationally-applicable set of criteria and/or scientific principles that should be considered in the development of a risk-based framework to guide the creation of effective timing windows, modification/refinement of existing timing windows, and their use, and 3) provide advice on the design of studies to evaluate the effectiveness of timing windows. A working paper was submitted (Tunney et al. In press) that provided information for the review. The paper informed the objectives by reviewing existing scientific literature, developing key considerations for the development of a conceptual model, and suggesting an approach for the evaluation of the effectiveness of timing windows.

ASSESSMENT

Objective 1: Review of Existing Information

Objective 1 focused on the review and synthesis of examples of the use of timing windows to mitigate impacts to fish and fish habitat.

To summarize current scientific knowledge, a search of available scientific literature on the design, use and effectiveness of timing windows was conducted. That search found 110 publications related to timing windows, most of which were technical reports or gray literature that spanned a range of habitat types and fish life history processes. The vast majority (> 90%) of publications concerned dredging. Only 19 peer reviewed journal articles were found.

The publications contained limited evidence on the effectiveness of timing windows. A few studies empirically evaluated the timing of critical life processes that were used to devise the windows, and some attempted to estimate the effects on fish found to be exposed to a stressor when an activity was taking place. Model-based approaches, that integrate the timing and intensity of stressors at different times of the year with lab or field-based studies on the biological outcomes of exposure to the stressor, offered a promising way to evaluate timing windows. A number of papers noted that the establishment and use of timing windows was not supported by evidence, but were more likely to have evolved from practitioner experience.

There were some frameworks for creation or modification of timing windows, that include multi-step processes for developing, implementing, and in some cases monitoring a timing window. Few framework documents included details on the treatment of data and information, on the risk assessment process, or on the final decision-making process.

In summary, there is limited science on the development, use, and effectiveness, of timing windows available in the literature. There was consensus at the meeting that the results of the literature search match observations of participants in practice. Thus, there is a need for a scientific process for their development and modification to facilitate standardization and defensibility.

Existing timing windows that have been established for Provinces and Territories were compiled and reviewed. Most timing windows were established on the basis of the timing (phenology) of select life history processes for species of interest. In many cases, this was the spawning, egg, and early life history stages of sportfish or salmonids. The presence of spring and fall spawners in many regions resulted in timing windows being restricted to the summer months, as eggs or larvae may be present at other times of the year. Some timing windows were based on habitat considerations, such as restricting work to the growing season for riparian vegetation. The spatial scale for the application of individual timing windows varied from whole jurisdictions (i.e., Provincial scale), to those developed for specific waterbodies. The result was considerable variation in the nature and number of timing windows across the country (Figure 4).

The rationale and methods used to develop these timing windows were often not documented. Discussions with some practitioners suggested that some timing windows were developed based on regional knowledge and that they were intentionally conservative (i.e., of short duration) to minimize the risk to the life process of interest.

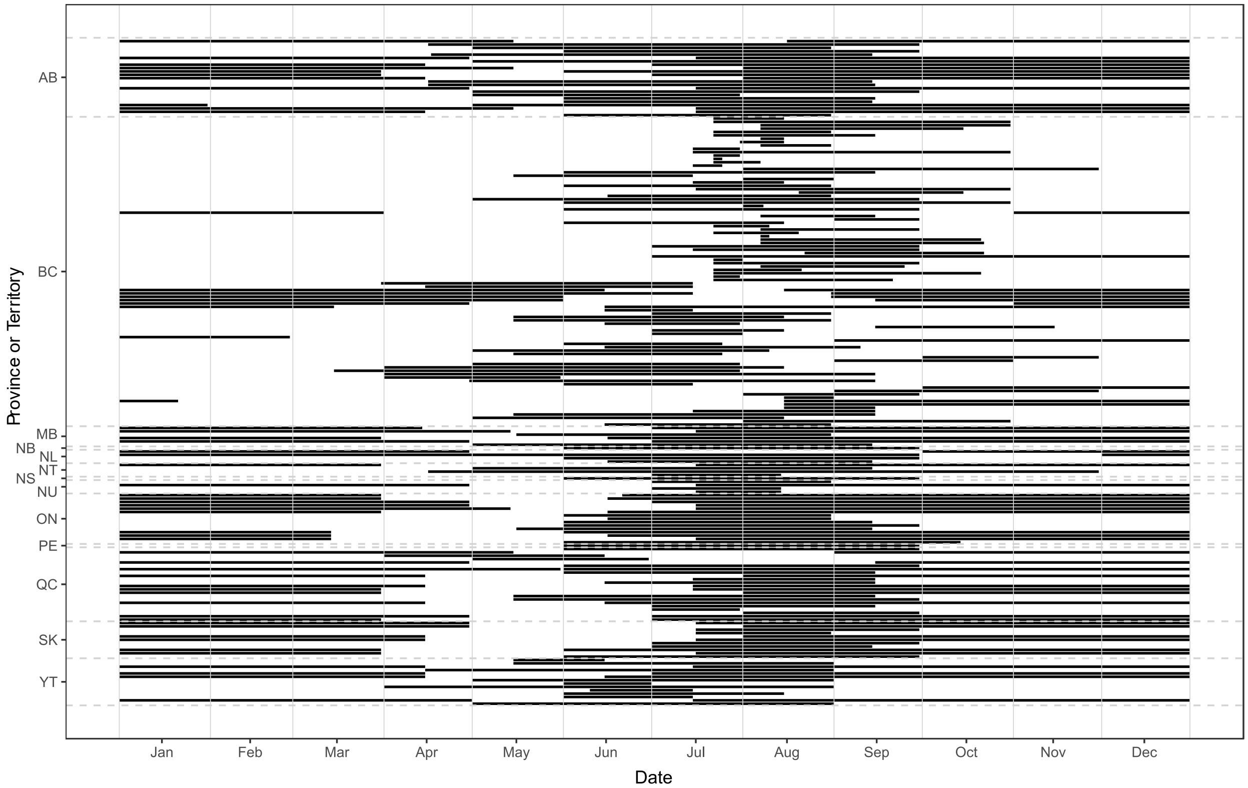

Figure 4. Plot showing the diversity of timing windows within and among Canadian provinces and territories. Horizontal lines indicate times when work is allowed.

Objective 2: Considerations for Developing Timing Windows

Objective 2 focused on the development of a standardized nationally-applicable set of criteria and/or scientific principles that should be considered in the development of a risk-based framework to guide the creation of effective timing windows, modification/refinement of existing timing windows, and their use.

A conceptual model (Figure 5) for key considerations to guide the development, application, and modification of timing windows can characterize how the risk to fish and fish habitat from the effects of a WUA may vary through the year. Periods of lower risk could be used for timing windows.

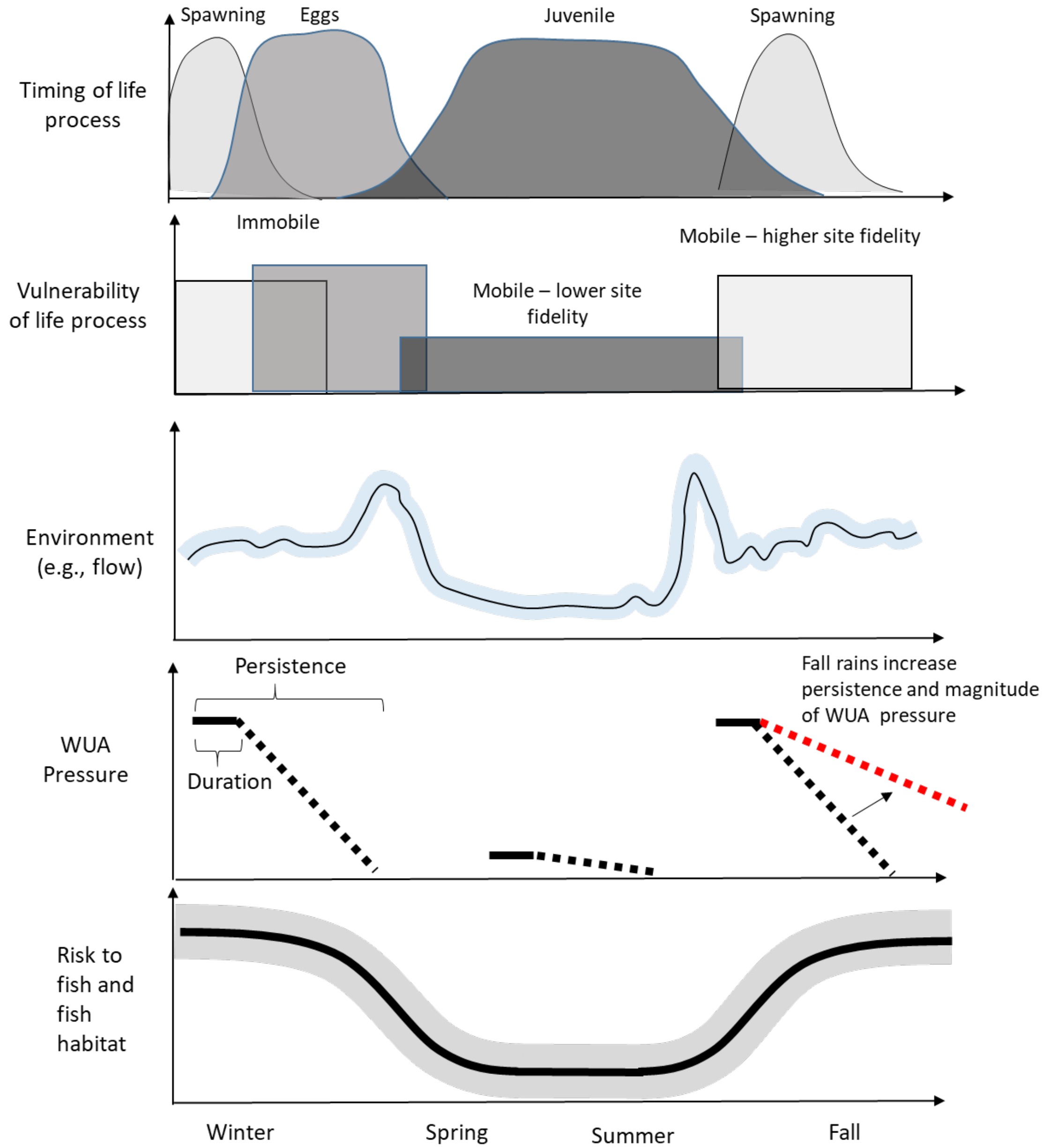

Figure 5. Conceptual model of the key components to guide the development, modification, and application of timing windows, adapted from Tunney et al. (in press). First, fish complete different life processes (e.g., spawning, rearing, migration) at different times of the year (top panel). Each of these stages will differ in its vulnerability to pressures (second panel); for instance, eggs are immobile and may be more strongly impacted by work relative to mobile juveniles or adults. The realized pressure experienced from a WUA can also be strongly modified by environmental factors and physical habitat conditions such as precipitation and flow, which vary over different time scales (third panel). As a result, the pressure during and after a WUA may differ considerably depending on timing. In this example, magnitude and temporal persistence of a WUA increases during higher flows in the fall, relative to lower flow periods in the summer (fourth panel). Collectively, these elements define the temporal trajectory of risk (bottom panel), which can inform the development or modification of timing windows.

The model has four components: (1) the timing of life processes of species of interest, (2) the relative vulnerability of each life process to WUA pressures, (3) seasonal variation in environmental conditions, and, (4) an assessment of how magnitude and persistence of the effects of WUA vary due to modulation by environmental conditions. These components are then used to inform an assessment of the variation in the risk to fish and fish habitat from WUA pressures throughout the year. The model and its applicability was discussed during the meeting. A summary of the outcome of the discussions and the resulting advice on how such a model could be used in the consideration of criteria for the development and/or modification of timing windows is presented below.

1. Timing of Life Processes

In temperate or northern ecosystems, key life processes occur at certain times of the year, likely as a result of natural selection imposed by seasonal environmental conditions. Processes such as migration, spawning, and the development of early life stages (eggs, larvae) often take place during defined time periods that are relatively consistent from year to year. Some of these processes result in a significant proportion of a local population being concentrated in space and time. Thus, identifying the timing of life processes is the first step in determining whether there is temporal variation in risk to WUA pressures.

Although life processes may be seasonal, it is also recognized that interannual variation in the timing of a process can occur, often as a result of environmental conditions (e.g., flow or water level, temperature). As well, variation among water bodies is likely, as populations respond to local conditions.

The general timing of life history events for individual species may be available from published literature, and may be refined from direct observation or sampling programs. In some cases, local or interannual variation may be predicted from environmental conditions, which may be appropriate may be useful for assessing the suitability of modifications or adjustments to regional timing windows.

2. Vulnerability of Life Processes

Fish life stages will vary in their vulnerability to stressors resulting from WUAs. Vulnerability will depend on which stressors occur as a result of the work, their intensity and duration, and the intrinsic vulnerability of the life stage. Some stages may be vulnerable due to lack of mobility or physiological sensitivity. Some pressures may render habitat unsuitable for the life stage (e.g., suspended sediment causing impairment of foraging). Life processes that result in the concentration of individuals will increase vulnerability (e.g., spawning).

For many stressors, vulnerability can be predicted from laboratory experiments, field observations, and expert judgment. However, uncertainty about the intensity and duration of each stressor, and the cumulative effects of interactions among stressors across different life stages that may result from a WUA will complicate the assessment.

3. Seasonal Variation in Habitat Environmental Factors and Habitat Conditions

Predictable seasonal variation in environmental factors and habitat conditions may interact with the WUA pressure, resulting in times of the year when the WUA has a greater or lesser impact on fish and fish habitat. Examples include changes in flow or water levels, temperature, or the establishment and growth of riparian vegetation.

To implement this component, the seasonal predictability of environmental factors and habitat conditions should be considered along with their potential to interact with potential pressures (or stressors). Those interactions may result in variation in the risk to fish and fish habitat over the year.

4. Modulation of WUA Pressures by Environmental Factors and Habitat Conditions

In this component, the WUA pressure is characterized. The magnitude of the pressure will depend on the intensity, spatial scale and duration of the WUA. Two components of the WUA pressure are considered: those that occur when the activity is taking place, and the continuing, but likely declining, pressure that remains after the work is completed. Timing windows are only appropriate for activities that result in transient effects (such as during and immediately after construction); activities that result in long-term or permanent effects will require other management measures.

The effect of the WUA pressure on fish life processes and fish habitat may vary with seasonal variation in environmental factors and habitat conditions. For example, water withdrawals during low flow periods are likely to present greater risk than during times of high flow. Conversely, disturbance of shoreline and riparian habitats during periods of high flow or rain events are likely to have a greater impact on habitat than in drier periods.

Continuing pressures are expected to decline over time as a consequence of natural recovery processes or application of other mitigation measures. That trajectory may vary if environmental conditions exacerbate the effects of the stressor (e.g., if high flow events prolong sediment release from disturbed areas), or if those conditions impact mitigation or remediation efforts once the WUA is completed (e.g., soil temperature or precipitation negatively effect success of riparian planting).

This component will most likely be evaluated qualitatively, based on interactions between a few key environmental variables and the expected effect of typical (or classes of) WUAs. The level of detail to be evaluated will depend on how fine-scale the timing windows are with respect to the type of WUA. Many activities, such as the construction of physical works in or near water are likely to have similar suites of WUA pressures that could be considered as a generic group. However, there may be other activities (e.g., water diversions) that have quite different interactions with environmental effects, potentially warranting case- or context-specific timing windows.

5. Risk Trajectory

The four components of the conceptual model can be used to inform an assessment of the variation in the risk to fish and fish habitat from WUA pressures throughout the year. At present, this will be a qualitative assessment, based on the compilation of available information and judgements about the changes in the component processes over the year, and the implications for the risk to fish and fish habitat. In some cases, quantitative information may be available to permit a more formal analysis, possibly using an integrated modelling approach that incorporates the effects of stressors, modulated by environmental factors, on fish life processes.

The conceptual model for developing timing windows shown in Figure 5 illustrates a case for a single species (or guild of similar species) with temporally defined life processes, and a simplistic consideration of the effects of the environment and the WUA on the risk to fish and fish habitat. This is roughly similar to situations where the management focus is on a single type of fish, such as salmonids, where spawning often occurs in discrete locations and times of the year. However, in many regions, fish communities will be diverse, and there may not be a single species or life history type of management focus. Some complexity can be reduced by clustering species into life history-based guilds.

Uncertainty and the Development of Timing Windows

The goal of timing windows is to reduce the risk associated with a WUA by restricting work to times of the year when the effects of a WUA are lowest, thus offering increased protection for fish and fish habitat. The conceptual model can be used to establish if there is a period of the year when the effects are lower, but uncertainty about when, and for how long, that period occurs will create risks when establishing timing windows. Protection may be maximized, and risk minimized, by reducing the duration of the timing window to the interval of lowest effects, however, that may not be feasible given the need for sufficient time to complete work in or near water. Short timing windows may also result in work occurring over multiple years, which may increase overall risk. They may also result in multiple projects occurring simultaneously, leading to intensified cumulative pressures.

To illustrate the consideration of risk, the risk trajectory of the conceptual model is broken into segments (Figure 6). First, there is the period of high risk, when for most of the time, and at most locations, the vulnerable life stage is present and environmental conditions increase risk. The low risk period is defined as the interval when vulnerable life stages are not present (or their occurrence is uncommon) or the environmental conditions are likely to abate risk.

Between the high and low risk intervals, there is a period of intermediate risk. Risk to fish and fish habitat may be lower because fewer fish of the sensitive life stages are present than during the high risk period. Risk during this interval may also be more variable, due to interannual variation in environmental conditions, or as a result of variation among waterbodies in the region.

Using this scheme, the most precautionary timing window would include only the low risk interval, and would be designed to be protective of most individuals and habitats in most years at the majority locations where it is to be applied. Conversely, a less precautionary approach would allow work to occur during the low risk period, and some or all of the intermediate interval, acknowledging that in some years and locations, WUAs taking place within this window may result in greater impacts to fish and fish habitat.

Timing windows are often established for application at broad spatial scales. However, risk can also be managed by having more localized information that would allow for a precise determination of the temporal risk profile, so that a timing window can be tailored to local conditions. This approach could also be extended to accommodate interannual variation in fish life processes, environmental factors and habitat conditions, permitting in-season adjustment of timing windows based on observations of fish or habitat.

The ultimate decision about whether to implement timing windows and the duration of those windows is a management process that will consider the spatial scale for application, the risks to fish and fish habitat, additional environmental management measures (avoidance, other mitigation, or offsetting) or other considerations.

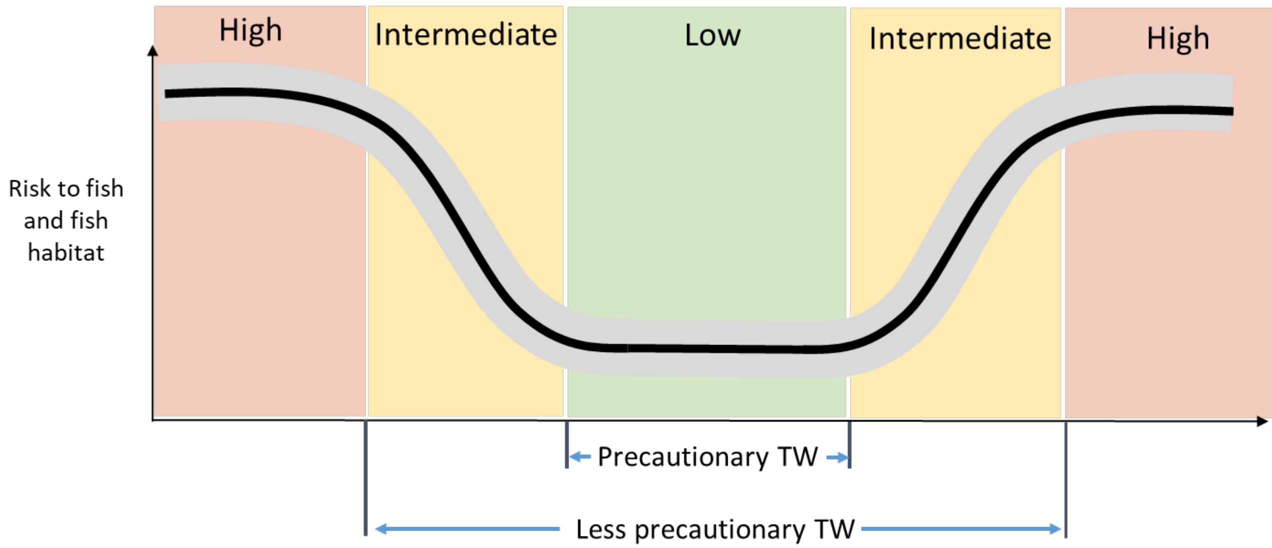

Figure 6. The temporal risk trajectory from the conceptual model can be used to inform the development of timing windows. For simplicity the risk profile is divided into three categories. The most precautionary timing window is narrow and only allows work when risk is lowest. A less precautionary timing window would permit work when there is the potential for an elevated level of risk.

Objective 3: Evaluating Timing Window Effectiveness

Objective 3 of the advisory process focused on providing advice on the design of studies to evaluate the effectiveness of timing windows. Evaluations of the effectiveness of timing windows are required to improve the use of this mitigation measure, however, there is little guidance in the literature on monitoring and evaluation of timing windows.

A tiered approach based on previous guidance on monitoring (DFO 2012) was developed where each tier differs in objective, and in the required levels of effort to be successful. The proposed tiers are:

Tier 1 (*probability of exposure*) – Determine if there is overlap between the timing window and a life process, environmental factor, habitat condition, or WUA pressure.

Tier 2 (*consequence of exposure on a process*) – Determine if exposure to a WUA pressure during the timing window results in fish mortality and/or impairment of the habitat's capacity to support life processes of fish.

Tier 3 (*consequence of exposure to the population*) – Determine if exposure of a life process or habitat function to a WUA pressure during the timing window has higher order consequences above the individual or site level.

Tier 1

The objective of this tier is to determine if the timing window overlaps with the fish life processes that it was intended to protect or changes in environmental conditions (e.g., temperature) that could affect life processes. Studies or other sources of information may confirm the presence or absence of key species and may define the timing of a life process. Similarly, a study may determine whether pressures from a WUA overlap with a high-risk period for fish and fish habitat. Tier 1 evaluations could be conducted with relatively straightforward surveys or observations of fish presence/absence and environmental conditions, and monitoring of indicators of pressures resulting from the WUA that were intended to be reduced by using the timing window (e.g., sedimentation sediment).

Tier 2

The objective of Tier 2 is to determine if exposure to a WUA pressure during the timing window results in fish mortality and/or impairment of the habitat's capacity to support life processes of fish. For this tier, the observed or inferred effect of a WUA on fish and fish habitat is evaluated. A key feature of this tier is the quantification of risk associated with the exposure of a life process or habitat function to the pressure. Such a quantification is critical for contrasting risk for different life processes occurring through the year, which is needed for developing or evaluating timing window options. Field studies that track the response of a life process or habitat function to a specific WUA pressure *in situ* would fit into this tier, but lab-based studies may also provide a more controlled assessment. Models that predict the extent or duration of a WUA pressure are also suitable for deriving estimates of risk.

Tier 3

The objective of Tier 3 is to assess whether a timing window is reducing the effect of WUA pressures at greater scales of management interest (e.g., exposed fish or the local population, fish community). This tier may investigate how a population or community respond to a specific WUA taking place during a life process or habitat process that is targeted for protection. A large-scale field study may be the preferred method to evaluate effectiveness at this tier. This may take the form of an experiment where the WUA pressure is manipulated, and the response is compared to a reference population. Applying this manipulation at times within the yearly cycle may provide insights into how the risks of a population or community level effect from a WUA pressure varies with different timing windows. However, this will be a challenging and specialized study to implement. Such studies may not be feasible in many cases, due to the confounding effects of seasonal change. Simulation models may prove to be valuable to provide information on population or community effects but they will require sufficient information for parameterization.

The evaluation of the effectiveness of timing windows is not a simple one-time test. For example, if, during Tier 1 surveys, a consistent overlap of life processes and the WUA is observed, more detailed Tier 2 or Tier 3 studies to evaluate or quantify the risk may be warranted. The tiered approach provides guidance for standardization of the approach but recognizes the need for some flexibility in study specifics. This flexibility also aligns with the diversity of fish community assemblages and habitat conditions, and the variety of WUA pressures that need to be considered. The proposed tiered approach to evaluating timing window effectiveness draws on multiple sources of information that carry different weights of evidence, but collectively provide powerful insights into our understanding of a system. The acquired information provides the opportunity to adjust timing windows to manage risk, thus making them more effective, and is consistent with an adaptive management approach.

Sources of Uncertainty

Uncertainty in the development, use, and adjustment of timing windows can be categorized based on the conceptual model (Figure 5). Some major sources of uncertainty are:

- Lack of information on spatial and temporal variation in the timing of key life processes of fish populations;
- Lack of information on the vulnerability of different life stages to WUA pressures;

- Lack of understanding of the interaction of environmental factors and WUA pressures;
- Absence of a structured method to arrive at the temporal variation in risk to fish and fish habitat resulting from WUA pressures that may occur at different times of year.

Most of these uncertainties can be reduced through the application of the tiered monitoring program described above. It is the paucity of monitoring information that ultimately limits our understanding of the effectiveness of timing windows.

CONCLUSIONS AND ADVICE

The application of timing windows results in work in or near water being conducted at a time when the risks of those activities to fish and fish habitat are thought to be lower than other times of the year. Although timing windows are intuitive in nature, have been developed for most regions of Canada, and are widely used, their effectiveness as a mitigation measure is largely unknown.

The conceptual model for timing windows provides the basis for a structured process for developing and refining ,timing windows. For the model to be useful, key decisions regarding the species to be considered, and how the WUA pressures will be characterized are needed. Further consideration on how to incorporate uncertainty into timing window duration is required.

Timing windows are one of many measures that can be used to mitigate the effects of WUAs in or near water. Given the lack of knowledge about the effectiveness of timing windows currently in place, and the challenges with evaluating timing windows in complex situations that were revealed during the consideration of the conceptual model, uncertainty in their effectiveness should be considered in their application relative to other mitigation measures that are better understood.

OTHER CONSIDERATIONS

The conceptual model to support the use of timing windows as a mitigation measure was initially based on a simple case with one fish life history pattern, a single axis of environmental factors, and a single WUA pressure. However, most timing windows are designed for application at broad spatial scales and broad classes of WUAs

In many regions, the objective of a timing window is to protect a single fish population or a fish community. Timing windows that are based on many species with similar timing of vulnerable life processes (e.g., fall spawners) may be effective for community level mitigation of WUA pressures, however, there will be some communities where the diversity of life histories and life stage sensitivities may prevent the identification of a time of year when the overall risk to the fish population and community and their habitats is lower. In these cases, other mitigation measures may be more effective in reducing WUA pressures. Similarly, when projects result in multiple WUA pressures, the effectiveness of timing windows may depend on how each pressure interacts with environmental conditions and how risk resulting from the combined effects of pressures may vary seasonally.

Although timing windows have not been used for flow or water level management, it was identified that the conceptual model may have value for the evaluation of the effects of flow manipulation on fish and fish habitat.

Climate change is likely to affect the timing of fish life history events, as well as the environmental factors that can affect how those life events interact with WUA pressures. Timing windows developed for contemporary conditions may therefore have diminishing effectiveness with ongoing and future climate change. There is also significant uncertainty in how climate change impacts will be manifest. Timing windows could be designed to buffer against climate change and its associated uncertainty. In addition, it was identified that climate change could be considered within the tiered approach to evaluate timing window effectiveness, so that changes in fish phenology and environmental factors resulting from climate change can inform updates to timing windows.

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Watkinson, Doug	DFO Science, O&P

SOURCES OF INFORMATION

This Science Advisory Report is from the CSAS national science advisory meeting of February 14-17, 2022, entitled “Science advice on the use of Timing Windows as a mitigation measure.” Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

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