Limited Options in Canada's Regulatory Tools for Addressing Underwater Noise

By

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ABSTRACT

Over the last two decades, underwater noise has been recognized as a significant threat to marine ecosystems. With an accelerating blue economy and industrial expansion, human-generated noise continues to increase, deepening this threat and its impacts. Such noise is produced by various human activities that span industries such as tourism, shipping, fishing, and energy. In Canada, these industries fall under a variety of jurisdictions and regulatory authorities, creating silos across noise-producing activities. Holistic management and planning approaches such as Marine Spatial Planning (MSP) could assist decision-makers in minimizing the negative impacts of underwater noise; however, an understanding of how noise might be addressed through existing regulatory tools remains limited. This study provides an assessment of Canada's ocean regulatory tools and their potential to address noise. A deductive document analysis was used to uncover current strengths, weaknesses, and gaps in the legislation. Results indicate minimal noise-related language in legislation and regulations, with explicit mentions being exceedingly rare. Most relevant terminology was found within the *Canada Shipping Act* and the annexed *Interim Order for the Protection of the Killer Whale (Orcinus orca) in the Waters of Southern British Columbia.* While this study highlights a finite capacity for Canada's regulatory tools to address noise directly, it also highlights how the interpretation of these tools, alongside developing programs, initiatives, and management plans, can help to bridge current gaps. As the ocean becomes increasingly busy and noisy, it will be important to embed this threat into marine species and ecosystems in planning and management by first capturing the full potential of existing legislations and regulations.

Keywords: Underwater noise, ocean noise, marine spatial planning, marine regulatory tools

LIST OF ABBREVIATIONS

AHD	Acoustic Harassment Devices
BC	British Columbia
CBD	Convention on Biological Diversity
COP	Conference of the Parties
CSA	Canada Shipping Act
dB	Decibel
DFO	Department of Fisheries and Oceans Canada
EBSA	Ecologically and Biologically Sensitive Area
EQA	Environment Quality Act
GC	Government of Canada
IMO	International Maritime Organization
IOC	Intergovernmental Oceanographic Commission
IOPKW	Interim Order for the Protection of Killer Whales in the Waters of Southern British Columbia
kHz	Kilohertz
LOMA	Large Ocean Management Area
MARPOL	International Convention for the Prevention of Pollution from Ships
MPA	Marine Protected Area
MSP	Marine Spatial Planning
NMCA	National Marine Conservation Area
OPP	Oceans Protection Plan
QVI	Quiet Vessel Initiative
SDG	Sustainable Development Goal
SARA	Species at Risk Act
SBSTTA	Scientific, Technical and Technological Advice
TTS	Temporary Threshold Shift
UN	United Nations
UNESCO	United Nations Educational Scientific and Cultural Organization
UNGA	United Nations General Assembly
US	United States

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Chapter 1 INTRODUCTION

1.1 Stress on the Ocean

The ocean is the connecting fabric between nations, but it is ubiquitously exposed to multiple human-induced stressors (Halpern et al., 2019). In this present Anthropocene, humans are driving changes in our ecosystems and climate, including ocean sustainability (Maruf & Gullett, 2022). The marine space is beset with a mosaic of activities, each with its own set of effects that contribute to cumulative impacts and stress on the ocean (Elliot et al., 2018). Despite these compounding threats to ocean health, the ocean remains a valuable resource, providing economic, cultural, recreational, educational, and ecological services (Barbier, 2017; Jouffray et al., 2021). It is now a global priority to strike a balance between preserving and consuming ocean space and resources according to the United Nations (UN) Sustainable Development Goal (SDG) 14 (United Nations, n.d.).

Marine spaces, especially those closer to the coast, often have multiple users who, undertake multiple and overlapping activities such as shipping, fishing, oil and gas exploration and production, tourism, marine construction, military construction, and more. Many of these ocean activities produce sound, which has high biological importance to marine species. Anthropogenic noise is commonly referred to as unintentional or purposeful sounds from human activity which adversely affect mammals and fish (Halliday et al., 2020). Anthropogenic noise, (herein referred to as noise) can impact marine life in various ways, such as altering hearing sensitivity, behavioural changes, displacement, or lack of communication (Gomez et al., 2016). Ocean noise can originate from various sources and can travel across the seas, coastal, and continental shelf waters (Hildebrand,

2009). Managing underwater noise, a transboundary issue, requires cumulative noise management to be implemented at various scales (Merchant et al., 2018).

1.2 Properties of Sound

Sound occurs when a compression wave causes particles of matter to vibrate; these vibrations produce small changes in pressure that can be detected or heard (Hatch & Wright, 2007). Sound waves can travel through solids, liquids, and gases, but the energy varies and is not measured the same for all substances. To compare how sound travels through the air and the ocean, we must understand that the propagation of sound can be affected by factors such as initial frequency, water depth, and the density within the water column, which varies with temperature and pressure (Nowacek et al., 2007). The physical differences between air and water cause sound to behave differently. For example, sound travels approximately five times faster through seawater than through air, and lower frequencies can travel hundreds of kilometres (km) with little energy loss (Urick, 1983, as cited in Nowacek et al., 2007; Wilhelmsson et al., 2013). These long distances are because the density of water is about eight hundred times greater than the density of air (University of Rhode Island and Inner Space Center, 2022). Furthermore, the way sound travels through the ocean depends on various conditions within the ocean. At the surface, sound travels faster than in deep water. When ocean temperature drops, as it does with increasing depth, the sound speed slows slightly. Sound intensity is often measured in decibels (dB), a relative measurement of waves' directional energy (Hatch & Wright, 2007). The decibel uses logarithms to base 10, meaning that an increase of 10 dB to 20 dB is not twice as loud but ten times louder (Robinson et al., 2014).

1.3 Sources of Underwater Noise

Noise can generally be considered as unwanted sound (World Wildlife Fund, 2013). The three primary sources of underwater ambient sounds are the motion of water itself, marine life, and human-made sources (Wenz, 1962). Natural sources include wind, earthquakes, lightning strikes, and rain (Southhall et al., 2017; Richardson et al., 1995). For example, heavy rain can create bubbles and spray, increasing noise levels (University of Rhode Island and Inner Space Center, 2020). Furthermore, many marine species, particularly mammals, produce sound for communication, navigation, and foraging (Erbe et al., 2015; Simmonds et al., 2014). Killer whales, for instance, use echolocation to navigate and to detect prey (Riesch & Deecke, 2011). In addition to natural sources, human activities are changing the underwater soundscape through the production of noise, including that resulting from military and commercial use of sonar, recreational boating and shipping traffic, and seismic surveys (Rolland et al., 2012). In particular, common noise sources include shipping, sonar, and air guns, though other sources include marine construction, seabed drilling, fisheries, and acoustic monitoring devices (Wilhelmsson et al., 2013).

1.3.1 Shipping

Research indicates that a primary source of noise in the marine environment is from commercial and recreational shipping activity (Harris et al., 2012; Rolland et al., 2012). Ship traffic, including commercial, research, recreation, and military boats, has rapidly increased over the last century (Tyack, 2008). The propellers, engines, and machinery of motorized vessels produce sound over a range of frequencies that interfere with those used by animals (Clear Seas, 2020). The vital life processes of many marine species are at risk

of impairment when natural noises are masked by sounds such as those from pleasure boats or large merchant vessels.

Monitoring trends of noise in the Northeast Pacific indicate that, since the 1960s, a spike in low-frequency ambient noise coincides with the doubling of the global shipping fleet (Rolland et al., 2012). The strongest noise source from a boat is typically from the propeller when it cavitates, otherwise known as the formation of rapid bubbles (Erbe et al., 2019; Hatch & Wright, 2007; Vagle et al., 2021). Other sources of vessel noise come from the engine, machinery on board, and the ship's hull through the water. However, the distance that sound travels vary on water temperature and pressure, thus sound can disperse multiple kilometres before losing considerable energy (NOAA, 2014). For example, a whale-watching zodiac with twin 150-horsepower engines at 50 km/hour would be audible at approximately 16 km (Nowacek et al., 2007). Moreover, an ice-breaker ship propeller and system are suggested to be audible to beluga whales at a maximum distance of 35-78 km depending on the conditions and location (Nowacek et al., 2007).

Generally, ship traffic is expected to increase by approximately four percent annually, with different rates predicted for varying ship types (Erbe et al., 2019). Further, low-frequency noise, especially that from a ship's engine and propeller, can travel further than high-frequency sounds (World Wildlife Fund, 2013). As expected, the amount of noise generated increases with vessel speed, size, and load. Given these properties, the noise spectrum emitted by a ship may have multiple sources at different frequencies, heading in different directions (Erbe et al., 2019).

1.3.2 Sonar

Active sonar is often used for tracking, surveillance, and identification of submarines, such as in military drills (Bjørnø, 2017). Sonar types include long-range detection sonar, short-range imaging sonar, and environmental sonar, most operating with sound source levels up to 245 decibels (dB) (Evans & Miller, 2004). Sound source level is the pressure level that is measured at a reference distance of one metre from an ideal point source, which radiates the same sound intensity as the source itself (Evans & Miller, 2004). Naval sonars could affect marine species over an area of about four million square kilometres (Wilhelmsson et al., 2013). Naval anti-submarine warfare sonars have already been associated with events of mass strandings of beaked whales (Kvadsheim et al., 2017; Wilhelmsson et al., 2013). A high-profile stranding event of these whales in the Bahamas in 2000 led to the United States (US) government acknowledging the likely contribution of sonar exposure in triggering the event (Balcomb and Claridge, 2001 as cited in Simmonds et al., 2014).

1.3.3 Air Guns

A seismic survey is a geophysical survey that is often used for oil and gas exploration (Štrbenac, 2017). Seismic surveys are also used to gather data for the government, such as mapping continental shelves (Gillespie, 2011). It uses an airgun, producing a high-intensity, low-frequency impulsive noise at regular intervals; each pulse's typical sound intensity level is 260-262 dB in water one metre deep (Štrbenac, 2017). Seismic airguns create an impulsive source of noise which differs from shipping noise which is a diffuse source (Southhall et al., 2017). When the airgun is fired, it releases a bubble of compressed air and sound is directed downwards (Gillespie, 2011). As

extractable resources are being depleted and demand for offshore fossil fuels continues to increase, seismic surveys will continue to spread into more sensitive marine habitats at greater depths (Wilhelmsson et al., 2013).

1.4 Impacts of Underwater Noise

1.4.1 Behavioural Impacts

Most marine species use sound for vital life processes like remote sensing, feeding or communication (Wilhelmsson et al., 2013), and are thus likely affected by changes to the soundscape. Marine mammals in particular are disproportionately affected by noise. All marine mammals produce sound, as it is associated with a variety of behaviours, including social interaction, mating, foraging for food, navigation, and hazard avoidance (Erbe et al., 2015; Gomez et al., 2016; Vagle et al., 2021; Duarte et al., 2021). Behavioural impacts refer to changes in these social functions which are used for daily survival. One way that behaviours are affected is through auditory masking, which occurs when the ability to recognize or detect a sound of interest is degraded by the presence of another sound, such as a ship (Erbe et al., 2015). Masking primarily impacts communication, echolocation, and the detection of environmental sounds. As a result, individuals may alter their normal behaviour, placing themselves in unfamiliar dangerous situations or unable to capitalize on opportunities which could result in a reduction of fitness. Such changes may alter social cohesion and the ability to spatially orient themselves in marine habitats (Duarte et al., 2021).

Similarly, if these animals are less capable of hearing the necessary signals, they may become confused and have difficulty avoiding hazards such as ships. Vessel strike mortality is difficult to quantify, but in British Columbia (BC), vessel strikes are now

considered to be a significant cause of mortality in orcas, and still pose a risk to other species (Cosandey-Godin et al., 2022). Speed restrictions can help improve the opportunity for vessel operators to detect animals and reduce the risk of strikes.

Daily behaviours such as foraging for food, feeding young, and mating can also be impacted by increased underwater noise. Fin whales, for instance, have songs that allow them to attract a mate (Erbe et al., 2015), which may be affected by noise. Furthermore, whale responses have been previously studied regarding the noise from whale-watching boats; responses included shortened surfacing, longer dives, interruption and termination of feeding and travelling behaviour (Blane & Jackson, 1994, as cited in Erbe, 2002). It remains unclear if such behavioural alterations among cetaceans will be long-lasting impacts or if they resume typical behaviour after minimal experiences of auditory masking.

1.4.2 Acoustic Impacts

Another response to auditory masking is acoustic behaviour change, which includes alterations in vocalization type or timing (Nowacek et al., 2007). Masking is particularly a concern when animals hear at the same frequency as the produced noise, which has already been recognized in some species of baleen whales (World Wildlife Fund, 2013; Erbe et al., 2019). In response to this masking, some animals may change their vocalizations by shifting their acoustic output in frequency and volume to avoid excessive noise (Morton & Symonds, 2002). Killer whales, for example, will raise the amplitude of their communication signals in the presence of ship noise (Erbe et al., 2015). Further, acoustic changes may affect reproduction rates of humpback whales as their vocalizations are associated with reproduction (Miller et al., 2000). If these vocal changes continued, reproduction rates would decrease in some populations, possibly leading to endangerment

(Tyack, 1981). However, the extent to which an acoustic behavioural response leads to consequences in fitness and survival requires further research.

1.4.3 Physiological Impacts

While most of the literature focuses on motor behaviour changes in marine species, noise can also impact individuals by reducing their ability to hear and increasing physiological stress, which may be both temporary and permanent (Cosandey-Godin et al., 2022). Due to the challenges involved in gathering empirical measurements, there is limited data available on assessing the physiological responses of marine life to noise. However, temporary threshold shifts (TTS), which refers to a shift in the auditory threshold, have been observed (Gregr et al., 2005). It is understood that repeated exposure to TTS could cause permanent damage. For instance, potential lasting effects could negatively impact species such as killer whales concerning reproduction, echolocation, and hearing the sound of the surf (Erbe, 2002). To reduce the risk of harm, data on noise-induced TTS is extensive in humans and small terrestrial mammals, and has been expanding to marine species (Finneran, 2015). TTS from exposure to sonar has now been conducted in countries such as the US, Netherlands, Russia, and Denmark (Finneran, 2015), but more research is still needed (Morton & Symonds, 2002).

Noise-induced stress has gained more academic attention concerning physiological responses to noise. Changes in hormone levels and stress reactions in marine organisms may cause stimulation of nervous activity, increased metabolism, and reduced immunity (Chahouri et al., 2021). The first evidence that low-frequency ship noise may be associated with chronic stress in whales was obtained through fecal samples of the North Atlantic right whale (Rolland et al., 2012). It is important to consider the possibility of similar

impacts on other species. While short-term stress responses may benefit the individual by mobilizing energy reserves and initiating a fast response to threats, repeated stressors may suppress growth, immune functions, or reproductions (Rolland et al., 2012). With the example of the North Atlantic right whale, reduced ship traffic in the Bay of Fundy, Canada, resulted in a six dB decrease in underwater noise, and some evidence suggests this reduced their stress (Duarte et al., 2021). However, stress is a complex concept to define, and different study results are difficult to compare due to the differences in interpretation (Nowacek et al., 2007).

1.5 Underwater Noise in the Canadian Context

Within Canada, many noise-generating activities occur along the coast that are populated with some of the busiest ports in North America; this sometimes results in overlaps between marine traffic and the habitat of various endangered marine species (Breeze et al., 2022). It has been suggested that low-frequency (10-500 Hz) ambient noise has increased by at least 20 dB from pre-industrial conditions in the Northern hemisphere (Vagle et al., 2021; Leaper & Renilson, 2012; Hildebrand, 2009). Multiple authorities and jurisdictions (Federal, Provincial, Territorial, and Indigenous) regulate and are affected by Canada's ocean. The Provincial and Territorial Governments have over 50 tools across 21 departments and agencies under which related marine management measures can be implemented in addition to Federal legislative tools (Schram et al., 2019). For example, the *Species at Risk Act* (SARA) is a federal tool that prohibits the destruction of critical habitat, which depending on interpretation could imply destruction due to noise (Williams et al., 2021). Currently, Canada has conserved nearly 14% of its oceans through the implementation of 14 *Oceans Act* Marine Protected Areas (MPAs) established by Fisheries

and Oceans Canada (DFO), three National Marine Conservation Areas (NMCAs) established by Parks Canada, one marine National Wildlife Area established by Environmental and Climate Change Canada as well as numerous marine refuges (IMPAC5, 2022; Schram et al., 2019). However, noise does not restrict itself to human-made management areas; therefore, it is essential to identify management tools that can be used in Canada across multiple authorities and jurisdictions. In 2009, the GC established 13 marine bioregions, spatial units defined by attributes and similarities, and five Large Ocean Management Areas (LOMAs) to advance integrated, collaborative marine planning (Figure 1.) (DFO, 2018).

Canada borders three oceans: the Pacific Ocean to the west, the Atlantic Ocean to the east, and the Arctic Ocean to the north. It also has the longest coastline in the world, spanning over 243,000 km, providing diverse ocean ecosystems that Canada relies on for economic, social, and cultural needs (Transport Canada, 2022; Schram et al., 2019). Canada's oceans are the home to a range of important species and habitats, such as deep-sea hydrothermal vents, cold-water corals, endangered whales and cetaceans, and fish stocks which support sustainable fisheries (DFO, 2021a). Protecting biodiversity and natural ecosystems helps support Canadian livelihoods and sustains its economy. The Government of Canada (GC) has already achieved its goal of conserving 10% of its ocean by 2020 and is now committed to conserving 25% by 2025 and 30% by 2030 (DFO, 2021a). These targets help Canada achieve global governance goals such as SDG 14 and continue efforts towards noise mitigation.

While Canada strives to simultaneously reach conservation targets and grow its blue economy, human activities are causing overfishing, habitat loss, pollution, and coastal

degradation (Schram et al., 2019). Additionally, many of these activities create an increase in underwater noise. Underwater noise has been a topic of research and mitigation efforts in Canada for more than 20 years. For example, Lesage et al. (1999) monitored the vocal behaviour of belugas in the St. Lawrence River Estuary. They found that belugas modify their vocal behaviour when exposed to temporary changes in background noise levels, primarily vessels producing noise well above frequencies of 1 kHz (Lesage et al., 1999). In Pacific waters, the endangered Southern Resident killer whale population depends on mitigating the cumulative effects of prey limitation, noise, and disturbance from toxic contaminants (Williams et al., 2021). Oil and gas activity has also been studied in Alaska and the Canadian Beaufort Sea, setting the stage for noise impact assessments aimed at bowhead whales (Halliday et al., 2020). Consistent with this theme, there has also been research that considered the effects of seismic and drillship noise exposure on bowhead whales and belugas in the Beaufort Sea (Richardson et al., 1995). The Canadian underwater soundscape requires integrated planning as noise-generating activities are widespread and likely to increase, but issues will vary by region, activity, and species.

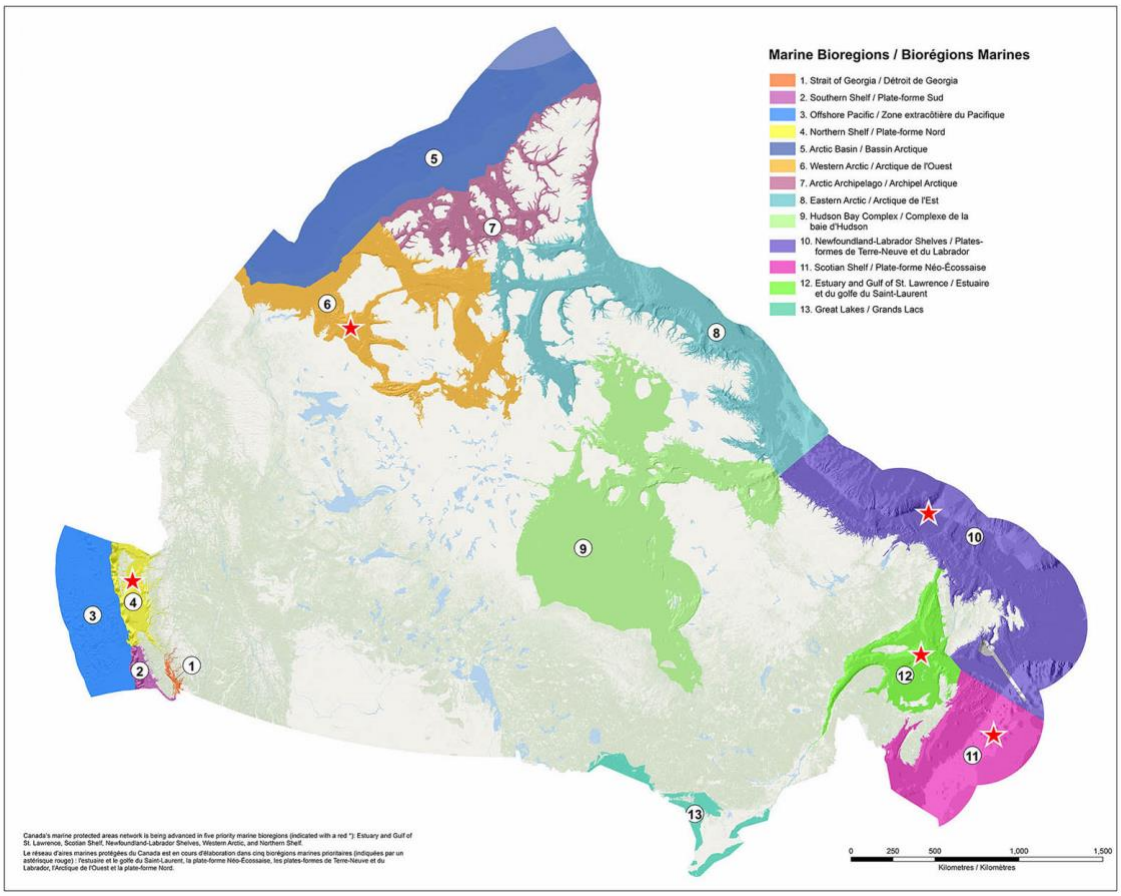

Figure 1. Large Ocean Management Areas (red stars) and Bioregions (coloured areas) in Canada (image retrieved from DFO, 2018).

1.6 Marine Spatial Planning

Marine Spatial Planning (MSP) is a process that can support informed decision-making in marine management concerning ocean activities. MSP is an internationally recognized, collaborative process that brings together relevant authorities to better coordinate how we use and manage marine spaces to achieve ecological, economic, social, and cultural objectives (Ehler & Douvere, 2009). Similar to how urban planning is used to help organize the development of cities, MSP focuses on a future-forward approach to ensure the effective use of ocean space across ocean users and regulators (DFO, 2021). MSP finds it roots back in the 1970s (Trouillet & Jay, 2021) where it was initiated as a

management approach for nature conservation in the Great Barrier Reef Marine Park over 30 years ago (Ehler & Douvere, 2009). By 2020, over 70 countries were undertaking some form of MSP process (Santos et al., 2020). The scientific literature on MSP increased markedly after the first international MSP workshop, organized by UNESCO's Intergovernmental Oceanographic Commission (IOC) in 2006 (Santos et al., 2019).

As an inclusive planning process, marine spatial planning will facilitate the use of other management approaches and tools. For example, MSP often proposes the "most appropriate use of space" among ocean activities such as shipping, fishing, and energy, which could lead to implementing tools such as a protected areas or marine refuges or the integration of other management measures that help mitigate underwater noise impacts (Hammar et al., 2020). Overall, MSP acknowledges that activities in the marine environment can co-exist, though the effects of activities on one another and the environment must be considered as a whole and managed consistently (Ehler & Douvere, 2009).

Although Canada does not have any existing marine spatial plans, oceans management – including the mitigation of potential noise impacts – has been occurring collaboratively through the development of conservation networks, the establishment of MPAs and development of other measures under various pieces of legislation (DFO, 2021). Considering MSP spans across sectors and regulations, the inclusion of noise data within MSP has been advocated as a method to mitigate increasing underwater noise (Erbe et al., 2012; Carlucci et al., 2021; Merchant et al., 2018; Maccarrone et al., 2015). There is precedence for this approach and international MSP initiatives can provide guidance toward the consideration of underwater noise data and mitigation into a Canadian MSP

model. For instance, Ireland's National Marine Planning Framework considers noise an environmental impact of human activity (Government of Ireland, 2018). Leveraging lessons learned from these other jurisdictions, Canada has the opportunity to build on existing initiatives and relationships through MSP, which requires transparency and collaboration between authorities.

Managing the impacts of noise on marine ecosystems exemplifies the many relevant regulations and the array of responsibilities across various departments (Breeze et al., 2022). To develop comprehensive plans, Canada must first understand the potential of their existing regulatory tools for addressing noise.

1.7 Management Problem

Although underwater noise is recognized as a threat through several international and regional conventions (Simmonds et al., 2014), it is unclear how Canada might best use existing mechanisms for noise management. This may be partly due to the transboundary nature of noise, making it difficult to monitor and manage. Under global blue acceleration, a new phase for humanity, our relationship with the ocean is drastically changing (Jouffray et al., 2021). With an advancing ocean economy and rapidly shifting climate, it can be challenging to predict and minimize noise impacts. In addition, industries such as commercial fishing and shipping are growing exponentially (Jouffray et al., 2021). For example, the 2013 trajectory of the marine transport industry in the North and Central Coast of BC was predicted to see a 100% increase in large vessel traffic by 2020 with continued future growth (World Wildlife Fund, 2013). In any case, Canada may benefit from the strategic use of existing legislation and regulatory tools to better mitigate the impacts of noise in the marine environment.

While it is clear noise detrimentally affects marine species, a lack of global syntheses of data has resulted in it typically being ignored in reviews and policy initiatives of cumulative impacts of anthropogenic stressors on marine life (Duarte et al., 2021). Supporting a multi-faceted blue economy. Canada has also already started to acknowledge the potential impacts of underwater noise and has taken steps to better understand and mitigate these impacts in recent years. For example, the GC has already been monitoring areas such as the Halifax Harbour to better understand anthropogenic ocean noise (Breeze et al., 2021). Further insight into how legislation and regulations can be applied to noise management is needed to identify limitations and possible areas of improvement for a sustainable future.

1.8 Research Scope and Objectives

Existing legislative and regulatory tools set the foundation for noise management. These tools likely hold potential to address underwater noise sources and impacts, but this is currently under explored. It is, therefore, essential to uncover if Canada has the necessary tools and resources to mitigate and regulate noise that would cause adverse short and long-term harm to marine life. By doing so, ocean managers can strategically employ existing tools to benefit ocean species, habitats, and ecosystems. This research aims to provide an overview of the potential for current Canadian legislation and regulations to address noise and explores options for better managing noise in Canada, including MSP. Once existing gaps are defined and acknowledged, the next steps can be taken to mitigate increasing underwater noise. The main research questions are:

1. How might Canada's legislative and regulatory tools potentially address ocean noise?

2. How might marine spatial planning support Canada in addressing ocean noise?

Chapter 2 METHODS

2.1 Data Collection

To inform the management problem and potential solutions, this research explored legislative and regulatory documents using a key term search and qualitative document analysis. See Figure 2. for a visual flow of the methods used.

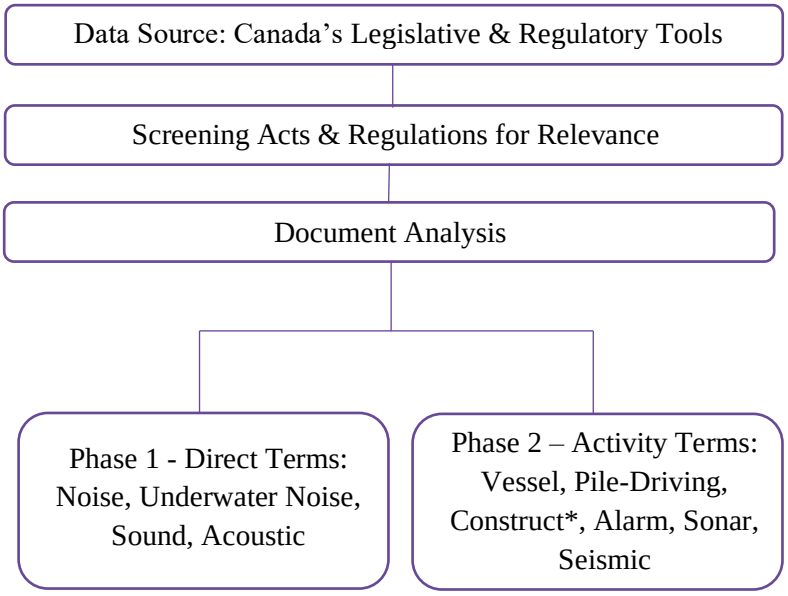

*Figure 2. Flow of methods starting with obtaining the data source, then screening acts and regulations for relevance, followed by a two-phase key term search. *Construct refers to variations of the term such as construction, constructing, or constructed.*

2.1.1 Data Source

In 2019 the Marine Planning and Conservation Directorate of DFO developed an inventory of legislation and regulatory tools related to Canada's marine environment (herein referred to as the inventory). The inventory, compiled in 2019, identifies principal authorities (Federal, Provincial, Territorial, Indigenous) that oversee how Canada's oceans

are regulated and prioritized across various activities and uses; all tools listed are publicly available. Only statutes that have a spatial element are included in this inventory, meaning they occupy a specific place and can be mapped in the marine environment. Tools were only included once in screening and document analysis. The inventory is separated by key activities that occupy space in the marine environment, including:

- Aquaculture
- Conservation
- Disposal-At-Sea
- Fisheries
- Harbours (small-craft harbours, public ports, port authorities)
- Energy (renewable energy, oil, and gas)
- Quarry Activities
- Telecommunications (undersea cables)
- Transportation

In this study, acts and regulations (herein referred to as acts) were screened from the existing inventory. The objective was to collect information relevant to noise regulation in Canada by analyzing legislative and regulatory tools that already exist. In this study, the *Canada Shipping Act* (CSA) and *Fisheries Act* were not counted twice but are mentioned in two instances due to specific regulations in those documents. Acts from the inventory were screened as a whole, and not screened by regulation apart from the CSA, and the *Fisheries Act.* In 2021, the Minister of Transport annexed the *Interim Order for the Protection of the Killer Whale (Orcinus orca) in the Waters of Southern British Columbia* (IOPKW). Similarly, after May of 1980 the *Fisheries Act* annexed the *Marine Mammal*

Regulations. Both regulations were screened and counted separately from their corresponding act.

2.1.2 Screening Acts and Regulations for Relevance

In response to the research questions, we assessed only tools that regulate ocean activities directly or indirectly producing underwater noise. We first determined the relevance of each legislative or regulatory tool to this study based on the title, purpose of the act or regulation, and where necessary, objectives. Texts that were considered for this study were screened using the following inclusion criteria (within the inventory):

- Legislation or regulation pertaining to Canada's ocean.
- Legislation or regulation relevant to Marine Spatial Planning.
- Legislation or regulation relevant to underwater noise.
- Legislation or regulation with potential to discuss and/or include restrictions or limitations to underwater noise.

Passages of text that contained search terms relevant to other potentially harmful activities, but were not related to noise, were excluded (e.g., discharge of a pollutant such as oil from a vessel). Regulations regarding physical pollution substances, including deposits of waste, oil, or hazardous substances, were not reviewed. Tools considered to be relevant to this study based on the above criteria underwent a two-phased document analysis using key term searches.

2.2 Document Analysis

A deductive document analysis was conducted in two-phases using a key term search on the relevant acts and regulations, followed by analysis of the extracted text passages. The first phase aimed to determine the use and frequency of terminology

explicitly relevant to underwater noise. The second phase aimed to capture activities that generate noise and are therefore relevant for potential regulation. These terms were selected based on their relevance to activities with the potential to produce, manage or mitigate noise, as used in a previous systematic literature review (Gomez et al., 2016). The rationale behind determining the relevancy of term hits was derived from the context within the passage and supported by desktop research. In both phases, all relevant documents were analyzed for key terms directly or indirectly related to noise (See phase boxes in Figure 2.). Where there was any uncertainty regarding the relevance of a passage of text containing phase two key terms, the passage was included to ensure that all potentially useful information was captured in this study.

Phase 1 search terms included "NOISE," "SOUND," "ACOUSTIC," and "UNDERWATER NOISE." Terms found as "NOISE," or "UNDERWATER NOISE" were considered separate instances of the word "NOISE." This phase explored explicit connections to underwater noise. Phase 2 included "VESSEL," "PILE-DRIVING," "CONSTRUCT*," "ALARM," "SONAR," and "SEISMIC." This phase explored how else noise may be captured within existing legislative and regulatory tools, if not explicitly.

In both phases, we recorded the total occurrence, only including those in English and the body of the document (i.e., not in tables of contents, headers, or footers). Passages of text containing key terms were then screened for relevance to the research objectives (e.g., a "sound ecosystem" is not relevant in the context of this research). Only relevant passages of text containing key terms were retained for qualitative analysis.

Relevant passages of text containing key search terms were qualitatively analyzed for information to assess potential for addressing underwater noise, aided by comparative analysis of key term frequency across legislative and regulatory tools. Excerpts of text from tool documents were extracted to demonstrate how key terms are used in Canadian tools and to inform their potential for regulating noise.

Chapter 3 RESULTS

3.1 Data Collection

We identified 129 legislative and regulatory tools as potentially relevant. These tools represented all activity areas identified by the Inventory based on their potential to incorporate noise, apart from quarry activities and telecommunications. Of these tools, 75 of these were unique items (54 duplicates removed, Figure 3.) that were then compared to the inclusion criteria. A total of 28 tools (26 acts and two regulations) were identified based on the established inclusion criteria (See Table A1 in Appendix). Of the 28 remaining tools, 12 pertained to conservation, five to transportation, five to energy, one to disposal-at-sea, two to aquaculture, one to fisheries, one to harbours, and one labeled for designated major projects.

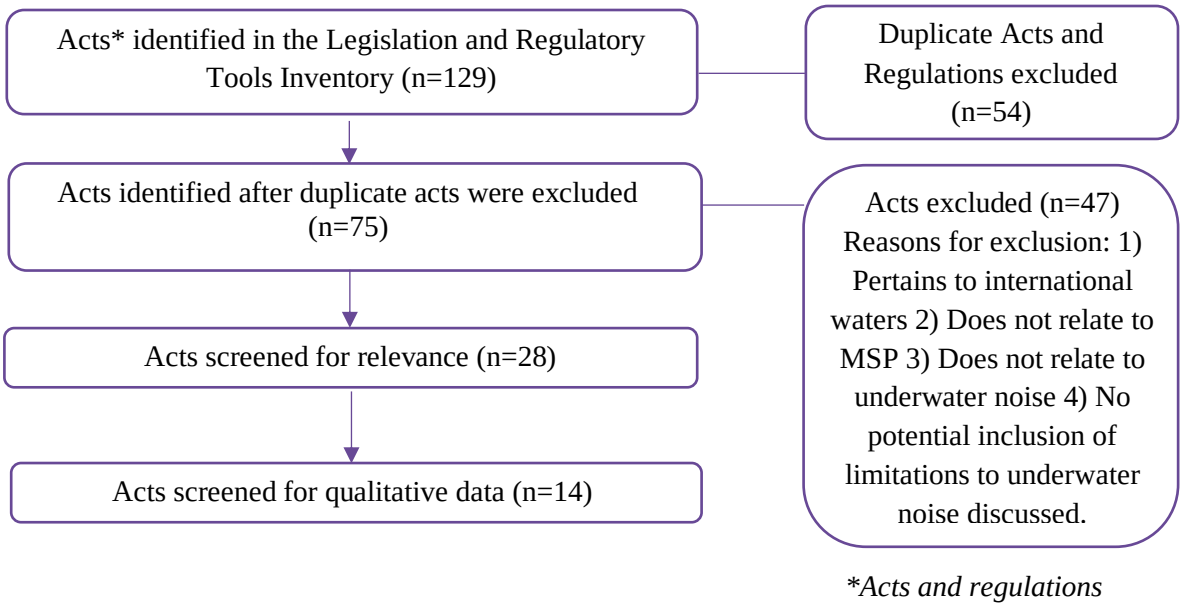

Figure 3. Screening acts and regulations for relevance. The inventory had 129 items with 54 duplicate titles. Out of the 75 acts and regulations listed, 28 were deemed relevant for document analysis, only 14 contained key search terms.

3.1.2 Screening Acts and Regulations for Relevance

Of the 28 tools included for document analysis, only half contained the key search terms from both phases (See Table A2 in Appendix). Within these 14 tools, we found a total of 1616 occurrences of key search terms. Of these occurrences, only 81 were considered relevant to the research questions (Table 1.). Of these, 11.1% were for direct search terms, apart from "underwater noise." The remaining 88.9% were activity terms, though occurrences only included "vessel" and "construct*" (Figure 4.). No other activity terms were found in the analyzed texts. There were 44 occurrences of the term "vessel" and 28 findings of any variation of the word "construct*" (i.e., construction, constructed,

constructing). Table 1. displays this count demonstrating the lack of presence of terminology within Canada's legislative and regulatory tools.

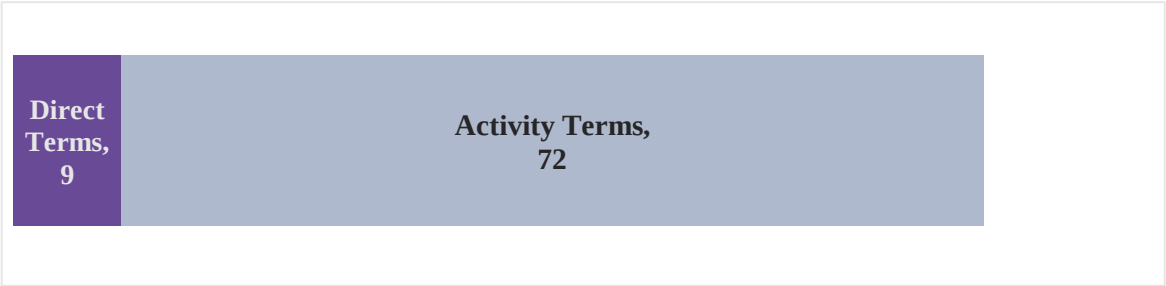

Figure 4. Total direct terms, 9 and activity terms, 72.

Table 1. Term occurrence results.

	Search Term	Count
Phase 1 – Direct Terms	Noise	5
	Acoustic	3
	Sound	1
	Underwater Noise	-
Phase 2 – Activity Terms	Vessel	44
	Construct*	28
	Alarm	-
	Pile-Driving	-
	Seismic	-
	Sonar	-

3.2 Document Analysis

We found very minimal language in the legislation and regulations directly related to noise and limited presence of indirectly relevant activity terms in the analyzed documents (Figure 5.). Occurrences of terms pertaining to vessels and their restrictions or

prohibitions were the most prevalent, followed by occurrences of construction-related activities, such as developing infrastructure, aquaculture facilities, and offshore renewable energy projects. There were no occurrences of other activity terms, including "alarm," "pile-driving," "seismic," or "sonar" (Figure 5.).

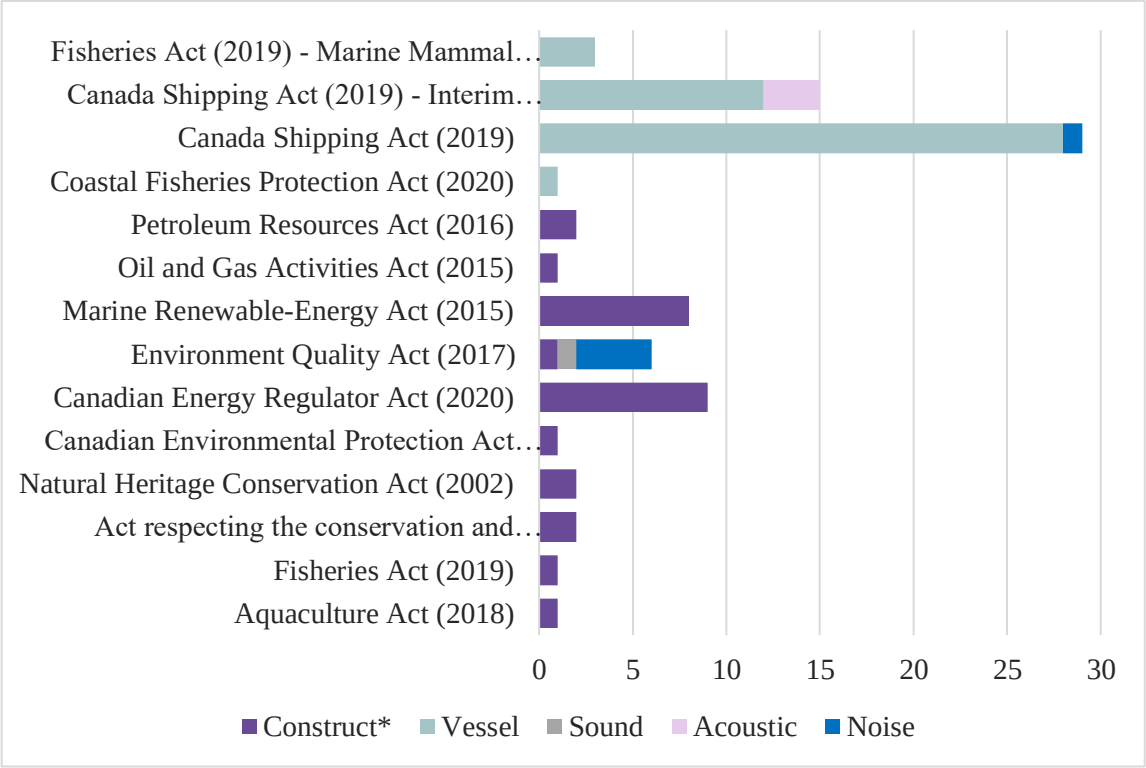

Figure 5. Relevant term occurrence by acts and regulations (n=81).

3.2.1 Search Term Analysis

Noise

We found five occurrences of the term "noise" within the analyzed legislative and regulatory tools. These arose among two acts, the CSA (1 occurrence) and the *Environment Quality Act* (EQA) (4 occurrences, Figure 4.). The CSA's primary objective is to protect the marine environment from damage due to navigation and shipping activities (CSA, 2001). This Act applies to all Canadian and foreign vessels operating in Canadian waters

and is considered to be the principal legislation governing marine transportation (Breeze et al., 2022). This Act incorporates some measures from the International Maritime Organization's (IMO) International Convention for the Prevention of Pollution from Ships (MARPOL). Although MARPOL does not explicitly define noise as a pollutant. However, the CSA mentions the term noise under the pollution regulations within the CSA.

Canada Shipping Act, Section 207 (2)

> *Regulations - Pollution*
>
> *2) The Governor in Council may, on the recommendation of the Minister, make regulations*
>
> *(a) regulating or prohibiting the discharge of pollutants from pleasure craft; and*
>
> *(b) regulating **noise** emissions from pleasure craft engines.*

The types of pleasure craft engines and the noise levels they emit is not specified further in the CSA. From the above excerpt, noise emissions are under pollution regulations, and the CSA defines a pollutant as:

Canada Shipping Act, Section 165

> *(a) a substance that, if added to any waters, would degrade or alter or form part of a process of degradation or alteration of the quality of the waters to an extent that is detrimental to their use by humans or by an animal or a plant that is useful to humans; or by an animal or a plant that is useful to humans.*

Generally, the CSA does not list noise as a part of the definition for pollution. Most occurrences of “noise” were found in the EQA, which aims to protect, improve, restore,

develop, and manage the environment for long-term sustainability. Within this act, noise is mentioned, though it primarily refers to noise on land such as inside or outside buildings, as well as determining terms and conditions of use for any vehicle, machinery, instrument, or equipment that generates noise.

Environment Quality Act, Section 95

> *The government may make regulations to:*
>
> *(a) prohibit or limit abusive or useless **noise** inside or outside a building;*
>
> *(b)determine the terms and conditions of use of any vehicle, engine, piece of machinery, instrument, or equipment generating **noise**;*
>
> *(c) prescribe standards for **noise** intensity.*

Acoustic

The term "acoustic" was found within the IOPKW, annexed in the CSA with three occurrences. This interim order, established by the Minister of Transport, is required to deal with direct or indirect risks to marine safety or to the marine environment (Transport Canada, 2022). It established approach distances as well as Interim Sanctuary Zones for Southern Resident killer whales, a critically endangered species, in prescribed areas of BC from June 1st of 2020 to November 30th of 2020.

Interim Order for the Protection of the Killer Whale (Orcinus orca) in the Waters of Southern British Columbia, Section 8 (1)

> *The Minister may, in writing, issue an authorization to a vessel and to persons operating that vessel to approach a killer whale, other than a Southern Resident killer whale, for the purpose of commercial whale-watching at a distance of between 200 m and 400 m in the waters*

indicated in Schedule 1 if the vessel is owned or operated by a person or organization that has entered into an agreement with the Minister that is intended to reduce the risk of physical and ***acoustic*** *disturbances to Southern Resident killer whales*

The remaining occurrences were similar to the above excerpt, though these were under the authorization of promotion of protection of killer whales and the conditions of authorization instead of the authorization of whale watching.

Sound

We found one relevant occurrence of the term "sound," within the EQA that applies broadly to the environment, under the definition "contaminant." Sound is considered a "contaminant" under the EQA, and a pollutant is considered to be a single contaminant or a mixture of several contaminants.

Environment Quality Act, Section 1

contaminant: a solid, liquid or gaseous matter, a microorganism, a ***sound****, a vibration, rays, heat, an odour, a radiation or a combination of any of them likely to alter the quality of the environment in any way.*

There were many findings of the term "sound" in the initial screening, though the vast majority were not relevant to this study. For example, the SARA highlighted the endangered beluga whale population from Southeast Baffin Island, Cumberland Sound (SARA, 2002). In other occurrences, "sound" was used as an adjective, for example retaining a sound ecosystem, which was also not relevant to this study.

Vessel

The activity term "vessel" occurred 44 times within the legislative and regulatory tools. These findings were split between four tools: the CSA (28), the IOPKW (12), the *Marine Mammal Regulations* (3), and the *Coastal Fisheries Protection Act* (1). Pursuant to section 43 of the *Fisheries Act,* legislation directed specifically towards marine mammals was developed in the *Marine Mammal Regulations*. These regulations are largely aimed at hunting and harvesting activities but also include prohibitions against disturbing or harassing marine mammals by any means other than fishing. However, the regulations do not provide a definition of the term harassment. The regulations also describe acceptable approach distances when interacting with and avoiding marine mammals. Within the *Coastal Fisheries Protection Act*, the following excerpt containing the term "vessel" relates to conservation and management:

Coastal Fisheries Protection Act, Section 6

> *Any measure for the conservation and management of any straddling stock…to ensure that the foreign fishing* ***vessel*** *does not engage in any activity that undermines the effectiveness of conservation and management measures for any straddling stock that are taken under the Convention on Future Multilateral Cooperation in the Northwest Atlantic Fisheries, done at Ottawa on October 24, 1978, Canada Treaty Series 1979 No. 11*

Within the CSA, important occurrences discussed testing vessels, their machinery, equipment, and supplies. This also included regulating or prohibiting the operation, navigation, anchoring, mooring, or berthing of vessels (CSA, 2001).

Construct

The search term "construct,*" capturing "construct," "constructed," "construction" and so on, resulted in 28 occurrences across 10 different acts (Figure 4.). This term had 9 findings in the *Canadian Energy Regulator Act,* 8 in the *Marine Renewable-Energy Act,* and one or two findings in the other acts. Most of the occurrences were regulations setting standards for construction projects, for example in the *Aquaculture Act*:

Aquaculture Act, Section 11.2

> *Regulations: The minister may make regulations p) prescribing standards relating to the* ***construction****, layout, equipping and operation of an aquaculture facility.*

The majority of occurrences were within the *Canadian Energy Regulator Act*, affecting pipeline operations, powerlines, offshore renewable energy projects, and more. Many of these operations can create noise disruptions on a varied scale (Prior & McMath, 2008). The purpose of this Act is to ensure that exploration for oil and gas operations is carried out in a manner that is safe, secure and protects people, property, and the environment. Within the *Marine Renewable-Energy Act*, another significant text for this term, direct protection against noise impacts is not described. Instead, this Act affects construction for marine renewable energy areas and the consultation process for developing these energy sources.

Chapter 4 DISCUSSION

This study provides insight into the existing legislative and regulatory tools in Canada for addressing noise. This document analysis has revealed minimal language in place to directly regulate noise and existing gaps in tools, highlighting the infancy of this

area of management in Canada. Results demonstrate the vague language used in legislative texts, uncovering how noise may get lost in regulatory considerations for underwater activity. While there was limited capacity to address noise, some tools contain language that indirectly consider noise impacts, and their interpretations have the potential to support new programs and initiatives. The complexity of underwater noise requires an effective solution that simultaneously addresses multiple sound sources, regulatory authorities, and diverse ecosystems.

4.1 Limited Direct Potential for Addressing Noise

Explicit mentions of noise were found to be exceedingly rare in this study, occurring only in the EQA and CSA, and notably absent from legislation that reasonably ought to include relevant terms (e.g., *Oceans Act* or *Species at Risk Act*). For instance, the *Species at Risk Act* (SARA), legislation that is very relevant for marine mammals and their protection (Breeze et al., 2022), does not explicitly mention noise, nor any of the indirect activity terms assessed in this research. Instead, the SARA more broadly includes prohibitions to kill, harm, or harass Species At Risk (*Species at Risk Act*, 2002). Minimal occurrences of direct terms outline in this study indicate limited capabilities in the legislative and regulatory tools to directly address underwater noise impacts on their own adequately.

The EQA (see section 3.2.1) includes generalized references to the noise, particularly from machinery, developments, and construction and inside or outside buildings, but does not necessarily extend to noise in the terrestrial and marine environments. This study may have revealed limited findings because underwater noise is a relatively recent concern. Most of the Canadian tools analyzed in this study were adopted

before noise was a well-known environmental issue; over the last two decades, marine noise has become recognized as an issue of major significance (Simmonds et al., 2014).

Limited direct potential for addressing noise in legislation, however, has not precluded the advancement of solutions to mitigate noise impacts. An example of this is the development of technology, machinery and equipment that can help mitigate noise from vessels. In 2019, Transport Canada launched the Quiet Vessel Initiative (QVI) to promote the adoption of safe and environmentally responsible quiet vessel technologies, including new vessel designs and operational practices to mitigate noise (Breeze et al., 2022). Such research and potential solutions are not yet captured in legislation and/or regulations in Canada. Further, the CSA discusses the testing of vessels and their machinery; the law gives the government powers to "protect the marine environment from damage due to navigation and shipping activities" (CSA, 2001). However, quiet-ship technology, such as the QVI is not accounted for in this study, reflecting how technology advances faster than legislation. Canadian vessels may eventually be required to use low noise-producing propellers and engines, which would help the CSA reach their objective of protecting the marine environment from damage due to shipping activity (World Wildlife Fund, 2013). Regulators and decision-makers must incorporate tools that reflect the dynamic and developing nature of the underwater noise issue.

4.2 Lack of Clarity in Regulatory Tools

While relevant terminology was rarely found in the analyzed tools, where terms were identified, the language surrounding the use of key terms was often vague. Such vagueness is inevitable, and sometimes even desirable, in legal texts; it helps to maintain flexibility, exercise power, and mitigate potential problems (Li, 2017). Still, it can be

difficult for legislation to capture complex issues to their fullest extent. Within the CSA, noise emission from pleasure crafts is mentioned, but it does not specify and define the types of noise limitations enforced by this tool, though it does include the regulation of noise from the engine. The engine is the loudest part above the surface of the water, but this does not capture noise from other parts of a vessel. Noise can be emitted from propeller cavitation, machinery on board, or the hull through the water (Erbe et al., 2019). Based on the findings of this study, the CSA may not offer real protection from the impacts of vessel noise on marine life.

In the case of renewable and non-renewable energy projects, the *Canadian Energy Regulator Act* exemplifies how legislative texts often have a broad purpose, leaving room for interpretation. The purpose of this Act is to ensure that oil and gas exploration operations protect "people, property and the environment" (*Canadian Energy Regulator Act*, 2019). It can likely be assumed that the ocean is considered under the umbrella of "the environment," and it would be reasonable to expect that the Act could enforce measures regulating ocean noise. However, as indicated in the results, this is not the case. This Act generally contains standards relating to activities such as offshore renewable energy projects or pipeline operations and reinforces the "polluter pays" principle; however, noise is not considered a pollutant in this context. Although marine renewable energy devices may produce lower noise levels compared to other anthropogenic sources, they have the potential to cause long-term exposure to marine organisms (Gill, 2005). Lack of clarity within legal documents leaves room for multiple interpretations that may favourably (or unfavourably) affect noise mitigation and management strategies.

Vague terminology is also used in the *Coastal Fisheries Protection Act*. The Act mentions that a vessel should not engage in any activity that "undermines the effectiveness of conservation and management measures of any straddling stock" (*Coastal Fisheries Protection Act*, 1985), though it remains unclear whether loud noise production is considered an undermining activity. This is an important issue, as deteriorating conditions can reduce fish viability, which may have consequences for not only ecosystems, but also sustainable fisheries (Štrbenac, 2017). It is known that fish can detect sound, but sensitivity to different frequencies varies by species (Štrbenac, 2017). Fish such as herring, sardines, anchovies, and American shad possess a gas-filled channel that connects the swimbladder to an ear structure, allowing them to sense sound over wider frequencies (Olesiuk et al., 2012). These species are all important to the Canadian fisheries, some of which the total allowable catch has already been reduced to minimize the pressure on such stock (DFO, 2022b). However, the thresholds and recovery from impact in most fish is still requiring much research (Caroll et al., 2017). These studies highlight that fish both experience sound and can be negatively affected by noise in the environment. While the *Coastal Fisheries Protection Act* has the potential to address the impacts of noise, under the Act noise must demonstrably undermine the effectiveness of conservation and management measures, for which providing evidence may prove challenging in complex ocean ecosystems.

The relationship between received sound levels and behavioural responses of marine mammals to noise persists when including important context, particularly for acoustic responses for species-specific and sound-source specific studies (Gomez et al., 2016). Detailed research can support the development of regulations based on species-specific, context-specific thresholds, particularly for acoustic responses. The challenge is

that detailed research to clearly support the threshold is not available for all potential species of concern.

4.3 Potential of Emerging Programs

The broad statements of legislation and regulation leave space for emerging, sustainable programs and initiatives to fill gaps and bolster potential for addressing underwater noise in Canada. The QVI has enabled Transport Canada, Canada's authority for regulating shipping and the impacts from it, to support projects that work towards quieting vessels. In addition to the QVI, other advancements in noise research and management have continued to develop. The GC is now developing its first Ocean Noise Strategy as a part of the Oceans Protection Plan (OPP), expected to launch in 2023 as a first step towards a whole-of-government approach to address underwater noise (DFO, 2022). In 2017, the Canadian federal government launched the OPP with over 50 initiatives including investigating cumulative effects of marine shipping (Gill, 2018). Implementation of the OPP was stated to emphasize working collaboratively with marine stakeholders and forming partnerships with Indigenous communities (Gill, 2018). It is also noted that the Government is funding research to study the impacts of underwater noise and the reduced availability of prey for marine mammals (Transport Canada, 2020). Additionally, in 2018, the Government introduced a five-year program to support the recovery of significant and endangered marine mammals, such as the Southern Resident killer whale, North Atlantic right whales, and St. Lawrence Estuary belugas (DFO, 2022a). This *Whales Initiative* includes the updated *Marine Mammal Regulations* analyzed in this study. Although marine transport is a global activity that is managed by an array of international conventions and policies, domestic efforts are crucial to effectively mitigate marine noise in Canada.

Programs such as the OPP, QVI, and *Whales Initiative* recognize the need for partnerships and collaboration when addressing non-point, dispersive, and cumulative issues such as noise.

4.4 The Dispersive Nature of Noise

Noise is a widespread and ubiquitous issue resulting from multiple ocean activities (Williams et al., 2015). While much of the current literature focuses on noise from commercial shipping, it is important to consider other activities too. Based on this study, transportation is the most prominent activity with legislation or regulations containing relevant terminology; however, results also revealed five other categories to consider: energy, conservation, aquaculture, disposal at sea, and fisheries. Energy and aquaculture are further expanded on as examples in this section.

Energy activities were the second most common activity with tools containing relevant terms after transportation. For example, this might include the potential effect of noise from offshore wind farms. Noise is produced throughout the development, construction, operational and decommissioning phases of a wind farm (Evans, 2008). In particular, pile driving, drilling, rock laying, cable trenching, vessel and machinery for the wind farm, and the wind turbines themselves, likely produce noise (Nedwell & Howell, 2004). Behavioural reactions have been observed in harbour porpoises in response to wind turbine noise (Nedwell & Howell, 2004). Furthermore, many current wind farms are located in shallow water, within five kilometers of the coast, but plans are now being explored for deeper-sea developments with larger turbines (Evans, 2008). Marine renewable energy sources are a significant opportunity for humanity in addressing the

climate crisis, but advancements in renewable energy should not be at the expense of disregarding the scientific understanding of the impacts from noise.

For aquaculture activities, the Minister may prescribe standards relating to the construction and operation of an aquaculture facility (see Results section 3.2.1). Like many ocean activities, aquaculture generates ongoing operational sounds associated with construction, maintenance, and decommissioning. Small boats and vessels are used to service the facility, but additional noise comes from the routine use of generators, tools, pressure washers, pumps, aerators, and fish feeders (Olesiuk et al., 2012). Noise-emitting Acoustic Harassment Devices (AHDs) are also sometimes used to deter seal and sea lion attacks at salmon farms. These devices can also have far-ranging effects on non-target species such as harbour porpoises and killer whales (Olesiuk et al., 2012). In 2012, DFO recommended that AHDs at fish farms be prohibited, and that the aquaculture industry adopt practices to minimize noise propagation, particularly when near Ecologically and Biologically Sensitive Areas (EBSAs) (Olesiuk et al., 2012). Although many of the routine operations at an aquaculture facility individually are not likely to be severe enough to cause injury, they could invoke behavioural responses with potentially significant implications for marine ecosystems.

4.5 Noise and Marine Spatial Planning

The impacts of noise have become a primary focus for marine animal researchers but are now also a concern to the public and policy makers (Simmonds et al., 2014). Strategies for addressing overlapping and multiplicative ocean issues have emerged, such as implementing MPAs, ocean zoning, and MSP (Simmonds et al., 2014). For example, MSP is the process that can help us identify where quiet spaces are important and how

conservation efforts like the establishment of MPAs can be a part of marine plans. More specifically, marine areas that require protection for conservation can form a data layer within a marine spatial plan (Vaughan & Agardy, 2020). Reducing noise in marine spaces has already shown a remarkable increase of the Sowerby's beaked whale in the Canadian MPA known as The Gully, as well as the nearby Shortland and Haldimand canyons of the Northwest Atlantic (Whitehead, 2013).

Since MSP aims to be ongoing, adaptive, and flexible through time, new research, technology developments, and species changes should all factor into shifting plans. As noise is a non-point issue - that is, from diffuse sources - it is not a single-sector's responsibility to regulate, nor mitigate impacts, in entirety. Instead, noise mitigation and regulation require multi-sector coordination, a requirement of successful MSP (Williams et al., 2015; World Wildlife Fund, 2013; Maccarrone et al., 2015). Noise is a complex stressor, demonstrating a place where precautionary planning makes good sense. Decision-makers will have the chance to plan and select management actions that are expected to reach a desired vision instead of reacting to events after they occur (Santos et al., 2019). Emerging marine issues, including noise, require multiple federal departments, and in some cases international cooperation, to comply with and enforce plans to minimize negative impacts on the marine environment.

Incorporating noise into management plans is challenging due to the transboundary nature of noise (Merchant et al., 2018). Nevertheless, in 2008, the International Maritime Organization (IMO) added, "noise from commercial shipping and its adverse impacts on marine life" to the work of its Marine Environment Protection Committee (Simmonds et al., 2014). In 2014, an Italian proposal for underwater noise was defined to develop a

widespread monitoring plan for sub-regions in European Union waters with two sub-programs for impulsive and continuous low-frequency sounds (Maccarrone et al., 2015). Within the US, an Underwater Sound Field Working Group has been created to map noise through the US Exclusive Economic Zone (EEZ); this group represents a step forward in terms of integrating noise into the US commitment to MSP (Erbe, 2012). To integrate noise into ocean management plans, noise must be quantified as well as budgeted for (Merchant et al., 2018). Using both place-based and ecosystem-based approaches have helped noise management become used in MSP in areas such as the Northeast Atlantic, Baltic Sea, and Mediterranean Sea (Merchant et al., 2018). National and international recognition of noise as an issue has led to the desire to investigate and manage noise impacts through tools such as MSP.

DFO is a regulator and authority on various marine matters, including fishing, marine navigation, scientific research, and protecting Species At Risk. However, the abundant sources of ocean noise create a complex regulatory environment where the activities of more than one authority are implicated. Managing the impacts of noise on marine mammals exemplifies the many relevant regulations and the array of responsibilities across various departments (Breeze et al., 2022). The results of this research indicate that Transport Canada, provincial Energy and Mines Ministries, Canada Energy Regulator and DFO are the top authorities with regulatory tools that hold the potential to address this issue. If MSP were to consider this impact, it would be critical that practitioners foster strong partnerships with these regulators in addition to relevant science programs. MSP is continuous, and the process should be regularly funded and adapted after each planning cycle. The iterative process requires the engagement of multiple actors and

stakeholders at various governmental and societal levels (Olsen et al., 2014, as cited in Santos et al., 2019). In summary, MSP can help support the GC's initiatives (such as the OPP); prioritizing partnerships with all relevant authorities will also improve efficiency and synergy between programs. Although the existing legislative and regulatory tools have the potential to be used as a foundation, other tools, such as MSP, will aid a whole-of-government approach.

4.6 Limitations and Future Directions

While this study reveals valuable insight into the gaps in Canada's existing tools, it is important to acknowledge the limitations of this research and to provide future research directions. First, this study only considers existing domestic legislation and regulations in the marine environment, though it is understood that underwater noise, mainly via marine transportation, can be managed through international conventions and policies (Breeze et al., 2022; Simmonds et al., 2014; Williams et al., 2015). Future research could expand by considering Canada's legislations and regulations alongside international policy and law that informs noise management. Further, select key terms were considered when screening legislative and regulatory tools. These terms were deemed most relevant to finding answers to the research questions, but other terms may have collected a different array of text passages. Finally, this study focuses on existing legislation and regulations and non-regulatory approaches, as opposed to emerging programs and initiatives. Future research may consider an in-depth qualitative review of Canada's legislative and regulatory tools, in addition to current policies, programs and initiatives, to bolster the understanding of the potential found in this study.

Chapter 5 RECOMMENDATIONS AND CONCLUSIONS

As demands for ocean space increase and noise levels rise underwater, effective management solutions are needed to regulate noise and its impacts on marine ecosystems. While the existing legislative and regulatory tools in Canada may be limited in their potential to address noise directly, new programs and initiatives alongside integrated management tools such as MSP can help to bridge the legislative and regulatory gaps identified in this study. Since noise is a dispersive issue, both in physical nature and in how it is regulated, it is imperative to include noise within marine spatial plans, adapt ocean policies to account for the cumulative impacts of noise, and increase the awareness of noise as an environmental issue. Without adaptive ocean management that incorporates noise, marine life, such as cetacean and fish populations, will be exposed and put at risk, which will have greater consequences for Canada's reputation as a leader in marine conservation and for ocean ecosystems at large.

Noise exemplifies the need for collaborative, coordinated planning, demonstrating the potential value of MSP for addressing this issue. It is recommended to include specific noise targets in developing marine spatial plans. Targets could be set by using previous noise levels as a baseline or noise limits for species in a specific habitat (World Wildlife Fund, 2013). Successful integration of noise within ocean management plans should use both place-based and ecosystem-based approaches. Overlaying noise maps with wildlife maps is one way to integrate noise into MSP (Erbe, 2012). However, it is expected that marine spatial plans will be routinely adapted, changing alongside the evolving ecosystems it strives to manage.

Complementing MSP, ocean policies should consider the cumulative impacts of noise, including behavioural, acoustic, and physiological impacts. Revisions to existing regulations or implementing new regulations are acceptable solutions to improve noise management. Some legislation already implies prohibitions on destroying critical habitat, but the connections to noise are open to interpretation. For example, it remains unclear if the critical habitat for SARA cetaceans could be temporarily destroyed due to noise (Williams et al., 2021). In addition, the revised *Marine Mammal Regulations* under the *Fisheries Act* set approach distances for whale-watching boats; this revision has a more apparent purpose concerning noise (*Marine Mammal Regulations*, 2018). New regulations and programs will differ across regions in Canada. The policies surrounding ocean activities should be used with regionally specific regulations to prevent significant species from becoming at risk. New initiatives alongside existing policies at different scales will help to improve overall noise management.

Finally, persistent gaps between science and policy related to ocean noise have led to a regulatory system that may easily let noise slip through the cracks. Science requires an improved response that applies directly to policy and management needs; therefore, science should be tailored to decision-makers' needs (Cvitanovic et al., 2016). Increasing an understanding of the issues is one way to help bridge this science-policy gap. The issue of noise has been included in many important discussions and international frameworks such as the Regional Seas Conventions, the Convention on Biological Diversity (CBD), the IMO, and the United Nations General Assembly (UNGA) (Maruf & Gullet, 2022; United Nations Environment Program). The Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA), a scientific body under the CBD, has provided

recommendations to the Conference of the Parties (COP) to promote research and awareness on the impacts of anthropogenic underwater noise (Maruf & Gullet, 2022). Increased awareness of noise will help promote future mitigation measures and encourage public advocacy. Workshops like those hosted by the World Wildlife Fund have attempted to promote an ongoing dialogue and cross-sectoral relationships between managers, planners, industry, scientists, researchers, and conservation groups (World Wildlife Fund, 2013). Continuing the conversations on noise and protecting marine life will help decision-makers create shared objectives with support from the public, non-governmental organizations, and local communities.

A global shift towards sustainable ocean development must integrate environmental, social, and economic objectives. This study highlights the significance of underwater noise as an ocean management challenge in Canada, particularly given gaps in the current legislative and regulatory environment as described in this study. This analysis provides insight for those in positions of authority to take the necessary steps toward protecting vulnerable marine communities, habitats, and species. Results of this study indicate that non-point issues such as noise can and should be incorporated into ocean management plans, with the support of emerging programs and initiatives that can help to maintain the species and many ocean resources on which humans rely. Next steps include cultivating strong partnerships between regulators and promoting noise research. Canada has the opportunity to be a leader in maintaining sustainable ocean noise through the strategic use of management tools, cross-sectoral engagement, and support from industry and ocean users.

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APPENDIX

Table A1

Acts & Regulations Screened for Terms
Fisheries Act (2019)
Aquaculture Act (2018)
Fish Protection Act (1997)
Species at Risk Act (2002)
Oceans Act (2019)
Canada Wildlife Act (2017)
Canada National Marine Conservation Areas Act (2019)
Canada National Parks Act (2019)
Saguenay-St. Lawrence Marine Park Act (1997)
Marshland Infrastructure Maintenance Act (2013)
Wildlife Conservation Act (2019)
Act respecting the conservation and development of wildlife (2002)
Natural Heritage Conservation Act (2002)
Act respecting threatened or vulnerable species (1989)
Impact Assessment Act (2019)
Canadian Environmental Protection Act (2019)
Oil and Gas Activities Act (2015)
Canadian Energy Regulator Act (2020)
Marine Renewable-Energy Act (2015)
Environment Quality Act (2017)
Petroleum Resources Act (2016)
Coastal Fisheries Protection Act (2020)
Fishing and Recreational Harbours Act (1992)
Arctic Waters Pollution Prevention Act (2019)
Canadian Navigable Waters Act (2019)
Canada Shipping Act (2019)
Fisheries Act (2019) - Marine Mammal Regulations
Canada Shipping Act (2019) - Interim Order for the Protection of the Killer Whale (Orcinus orca) in the Waters of Southern British Columbia

Table A2

Act or Regulation	Text Passage
Canada Shipping Act (2019)	Regulations - Pollution 2) The Governor in Council may, on the recommendation of the Minister, make regulations (a) regulating or prohibiting the discharge of pollutants from pleasure craft; and (b) regulating noise emissions from pleasure craft engines. 35.1 (1) The Governor in Council may, on the recommendation of the Minister of Transport, make regulations respecting the protection of the marine environment from the impacts of navigation and shipping activities, including regulations (a) respecting the design, construction, manufacture and maintenance of vessels or classes of vessels; (b) specifying the machinery, equipment and supplies that are required or prohibited on board vessels or classes of vessels; (c) respecting the design, construction, manufacture, maintenance, storage, testing, approval, arrangement and use of the machinery, equipment and supplies of vessels or classes of vessels; (d) respecting the requirements that vessels, or classes of vessels, and their machinery and equipment are to meet; (e) requiring the obtaining of certificates certifying that any of the requirements referred to in paragraph (d) are met; (f) specifying the terms and conditions of certificates referred to in paragraph (e); (g) respecting the inspections and testing of vessels, or classes of vessels, and their machinery, equipment and supplies; (h) respecting procedures and practices that are to be followed; i) respecting the development, maintenance and implementation of a management system that sets out the manner in which marine environment protection measures are to be integrated into day-to-day navigation and shipping operations and the criteria to which that management system is to conform as well as the components that are to be included in the system; (j) respecting compulsory routes and recommended routes; (k) regulating or prohibiting the operation, navigation, anchoring, mooring or berthing of vessels or classes of vessels; and (l) regulating or prohibiting the loading or unloading of a vessel or a class of vessels. 190. (1) The Governor in Council may, on the recommendation of the Minister, make regulations respecting the protection of the marine environment, including regulations (a) prescribing pollutants for the purpose of sections 187 and 189 and respecting the circumstances in which such pollutants may be discharged; (b) respecting the circumstances in which persons on board vessels shall report discharges or anticipated discharges, the manner of making the reports and the persons to whom the reports shall be made; (c) respecting the carrying of pollutants on board a vessel, whether as cargo or fuel; (d) respecting the control and prevention of pollution of the air by vessels; (e) respecting reception facilities for oily residues, chemical residues, garbage and sewage; (f) respecting the control and management of ballast water; (g) for preventing or reducing the release by vessels into waters of aquatic organisms or pathogens that, if released into those waters, could create hazards to human health, harm organisms, damage amenities, impair biological diversity or interfere with legitimate uses of the waters; (h) respecting the design, construction, manufacture and maintenance of vessels or classes of vessels; (i) specifying the machinery, equipment and supplies that must be on board vessels or classes of vessels; (j) respecting the design, construction, manufacture, maintenance, storage, testing, arrangement and use of vessels' or classes of vessels' machinery, equipment and supplies; (k) respecting the requirements that vessels, or classes of vessels, and their machinery and equipment must meet; (l) requiring the obtaining of certificates certifying that any of the requirements referred to in paragraph (k) are met; and (m) respecting the inspection and testing of vessels, or classes of vessels, and their machinery, equipment and supplies.
Fisheries Act (2019) - Marine Mammal Regulations	(2) For the purposes of subsection (1), disturb includes to approach the marine mammal to, or to attempt to, (a) feed it; (b) swim with it or interact with it; (c) move it or entice or cause it to move from the immediate vicinity in which it is found; (d) separate it from members of its group or go between it and a calf; (e) trap it or its group between a vessel and the shore or between a vessel and one or more other vessels; or (f) tag or mark it.
Marine Renewable-Energy Act (2015)	12. (1) Prohibition without licence or permit: (1) Except in accordance with a licence or permit, no person shall construct, install or operate within an area of marine renewable-energy priority. Notwithstanding subsection (1), a contractor or subcontractor of the holder of a licence or permit may, in accordance with the licence or permit, construct, install or operate within an area of marine renewable-energy priority. Where a contractor or subcontractor of the holder of a licence or permit constructs, installs or operates within an area of marine renewable-energy priority. The holder of the licence or permit shall ensure that the contractor or subcontractor is advised of and adheres to any terms or conditions in the licence or permit that relate to the work of the contractor or subcontractor. Subject to subsection (4), the aggregate nameplate capacity of the licensed generators that may be constructed, installed or operated within the FORCE Marine Renewable-electricity Area is 64 megawatts.

	Digby Gut Marine Renewable-electricity Area Subject to subsection (4), the aggregate nameplate capacity of the licensed generators that may be constructed, installed or operated within the Digby Gut Marine Renewable-electricity Area is 1,999 kilowatts. Grand Passage Marine Renewable-electricity Area Subject to subsection (4), the aggregate nameplate capacity of the licensed generators that may be constructed, installed or operated within the Grand Passage Marine Renewable-electricity Area is 1,999 kilowatts. Petit Passage Marine Renewable-electricity Area Subject to subsection (4), the aggregate nameplate capacity of the licensed generators that may be constructed, installed or operated within the Petit Passage Marine Renewable-electricity Area is 1,999 kilowatts. (4) After consulting with the public, the Minister shall prepare and release to the public a report summarizing the information obtained when consulting with the public and including the following information: d) any significant impacts that the proposed establishment of a marine renewable-electricity area or amendment of the regulations establishing a marine renewable-electricity area, and the installation, construction, and operation of generators within the marine renewable-electricity area, are reasonably expected to have on activities being undertaken or that may be undertaken in the marine renewable-electricity area;
Petroleum Resources Act (2016)	126. A pipeline construction or use authorization holder must, as soon as their construction work has been completed, restore the land affected by the work to its former condition.
Fisheries Act (2019)	2) The standards and codes of practice may specify procedures, practices or standards in relation to works, undertakings and activities during any phase of their construction, operation, modification, decommissioning or abandonment.
Canadian Environmental Protection Act (2019)	54. (1) For the purpose of carrying out the Minister's mandate related to preserving the quality of the environment, the Minister shall issue: a) environmental quality objectives specifying goals or purposes for pollution prevention or environmental control, including goals or purposes stated in quantitative or qualitative terms; (b) environmental quality guidelines specifying recommendations in quantitative or qualitative terms to support and maintain particular uses of the environment; (c) release guidelines recommending limits, including limits expressed as concentrations or quantities, for the release of substances into the environment from works, undertakings or activities; and (d) codes of practice respecting pollution prevention or specifying procedures, practices or release limits for environmental control relating to works, undertakings and activities during any phase of their development and operation, including the location, design, construction, start-up, closure, dismantling and clean-up phases and any subsequent monitoring activities.
Natural Heritage Conservation Act (2002)	55. The following activities are prohibited in a marine reserve: (1) activities carried on for the purposes of exploration for or the mining of mineral substances and the construction of infrastructure to be used to transport such substances; (2) activities carried on for the purposes of petroleum or underground reservoir exploration, petroleum production or storage, or brine production; (3) oil and gas pipeline construction; and (4) activities carried on for the purposes of the commercial production, processing, distribution and transmission of electricity.
Act respecting the conservation and development of wildlife (2002)	73. The Government may, by regulation: determine territories where the operation of fishing ponds, breeding ponds, fish-tanks for baitfish or aquaculture sites may be prohibited or restricted for wildlife conservation purposes and, for such purposes, fix special norms relating to the construction, layout and equipment thereof; establish norms relating to the construction, layout and equipment of a breeding pond or a fish-tank for baitfish;
Environment Quality Act (2017)	94. It shall be the duty of the Minister to supervise and control noise. For such purpose he may construct, erect, install and operate any system or equipment necessary in the territory of any municipality. He may also acquire by agreement or expropriation any immovable required and make any agreement with any person or municipality. 95. The government may make regulations to: (a) prohibit or limit abusive or useless noise inside or outside a building; (b)determine the terms and conditions of use of any vehicle, engine, piece of machinery, instrument, or equipment generating noise; (c) prescribe standards for noise intensity.
Coastal Fisheries Protection Act (2020)	Any measure for the conservation and management of any straddling stock to be complied with by persons aboard a foreign fishing vessel of a prescribed class in order to ensure that the foreign fishing vessel does not engage in any activity that undermines the effectiveness of conservation and management measures for any straddling stock that are taken under the Convention on Future Multilateral Cooperation in the Northwest Atlantic Fisheries, done at Ottawa on October 24, 1978, Canada Treaty Series 1979 No. 11
Canada Shipping Act (2019) - Interim order for the protection	Approach Distance Prohibition Prohibition - vessels

of the killer whale in the waters of Southern British Columbia	2 (1) Beginning on June 1, 2022, a vessel must not approach within 400 m of a killer whale in the waters indicated in Schedule 1 Prohibition — other vessels. Prohibition - persons 3 (1) Beginning on June 1, 2022, a person operating a vessel must not approach within 400 m of a killer whale in the waters indicated in Schedule 1 Interim Sanctuary Zones Prohibition - vessels 4 (1) During the period beginning on June 1, 2022, and ending on November 30, 2022, a vessel must not navigate in the waters indicated in Schedule 2 Prohibitions - persons 5 (1) During the period beginning on June 1, 2022, and ending on November 30, 2022, a person must not operate a vessel in the waters indicated in Schedule 2. Speed Limits 6 (1) During the period beginning on June 1, 2022, and ending on November 30, 2022, a vessel must not proceed at a speed in excess of 10 knots over ground in the waters indicated in Schedule 3. Speed Limits - person 7 (1) During the period beginning on June 1, 2022, and ending on November 30, 2022, a person must not operate a vessel at a speed in excess of 10 knots over ground in the waters indicated in Schedule 3. Authorization - whale watching 8 (1) The Minister may, in writing, issue an authorization to a vessel and to persons operating that vessel to approach a killer whale, other than a Southern Resident killer whale, for the purpose of commercial whale-watching at a distance of between 200 m and 400 m in the waters indicated in Schedule 1 if the vessel is owned or operated by a person or organization that has entered into an agreement with the Minister that is intended to reduce the risk of physical and acoustic disturbances to Southern Resident killer whales. Authorization – promotion of protection of killer whales (2) The Minister may, in writing, issue one of the following authorizations to a vessel and to persons operating that vessel for the purpose of a non-commercial activity that promotes compliance with and monitoring of measures taken to protect killer whales if the vessel is owned or operated by a person or organization that has entered into an agreement with the Minister that is intended to reduce the risk of physical and acoustic disturbances to Southern Resident killer whales: Condition of Authorization (4) An authorization is subject to the condition that the authorization holder complies with measures respecting the protection of killer whales, including those respecting the reduction of the risk of physical and acoustic disturbances to Southern Resident killer whales, set out in the agreement entered into with the Minister.
Canadian Energy Regulator Act (2020)	Mandate: The Regulator’s mandate includes: overseeing the construction, operation and abandonment of pipelines, interprovincial power lines and international power lines and overseeing work and activities authorized under Part 5 as well as abandoned facilities; Polluter Pay Principles 136. The purpose of sections 137 to 142 is to reinforce the “polluter pays” principle by, among other things, imposing financial requirements on any company that is authorized under this Act to construct or operate a pipeline Absolute Liability 4) If an unintended or uncontrolled release of oil, gas or any other commodity from a pipeline occurs, the company that is authorized under this Act to construct or operate that pipeline is liable, without proof of fault or negligence, up to the applicable limit of liability that is set out in subsection (5) for the actual loss or damage, the costs and expenses and the loss of non-use value, described in paragraphs (1)(a) to © Matters to be taken into account 203. (1) Subject to subsections (2) and 202(6), the Commission must not approve a plan, profile and book of reference unless it has taken into account, in order to determine the best possible detailed route of the pipeline and the most appropriate methods and timing of its construction Laws of a province: 252. For the purposes of sections 253 to 255, a law of a province is in relation to lines for the transmission of electricity from a place in the province to another place in that province if the law is in relation to any of the following matters:

	(a) the determination of their location or detailed route; (b) the acquisition, including by expropriation, or lease of land required for the purposes of those lines, the power to so acquire or lease land and the procedure for so acquiring or leasing it; (c) assessments of their impact on the environment; (d) the protection of the environment against the consequences of the construction, operation and abandonment of those lines, and the mitigation of their effects on the environment; (e) their construction and operation and the procedure to be followed in abandoning their operation. Criteria 2) In determining whether to make a recommendation, the Commission must seek to avoid the duplication of measures taken in respect of the international power line by the applicant and the government of any province through which the line is to pass, and must have regard to all considerations that appear to it to be relevant, including (a) the effect of the power line on provinces other than those through which the line is to pass; (b) the impact of the construction or operation of the power line on the environment; and (c) any other considerations that may be specified in the regulations. Damage Prevention: Prohibition - construction or ground disturbance 5 (1) It is prohibited for any person to construct a facility across, on, along or under a pipeline or engage in an activity that causes a ground disturbance within the prescribed area unless the construction or activity is authorized or required by the orders made under subsection (3) or (4) or regulations made under subsections (5) or (6) and done in accordance with them.
Oil and Gas Activities Act (2015)	Prohibitions prohibiting the carrying out of any oil and gas activity or related activity at any point within a specified distance of any boundary, roadway, road allowance, right of way, building of any prescribed type or any specified works; (b) despite anything in the Local Government Act and the Community Charter, prohibiting the construction of a building or structure within a specified distance of a well, pipeline or facility, if the Lieutenant Governor in Council is satisfied that the prohibition is necessary to protect the public.
Aquaculture Act (2018)	Regulations: The minister may make regulations p) prescribing standards relating to the construction, layout, equipping and operation of an aquaculture facility.