Marine Mammal Mitigation Procedures in the Royal Canadian Navy (RCN)

By

Mark Joseph Chupick

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Abstract

Anthropogenic noise in the world's oceans has the potential to adversely impact marine mammals. Much research has gone into determining these impacts but the specifics are subject to some debate. Noise emitted by the oil and gas industry in the conduct of seismic surveys, and the noise generated from naval active sonar pulses, are two key sources. Many nations, including Canada, have passed legislation to protect marine mammals. More specifically, in order to mitigate the impacts from seismic surveys on the marine environment, a series of measures has been developed in Canada in the form of the *Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment.* The Royal Canadian Navy (RCN) has used this as the basis for developing its own mitigation procedures for active sonars. This project involved the refinement of mitigation procedures in the RCN, to validate and/or amend them based on a review of scientific studies, and re-promulgate them by means of an overarching policy document that was coincidentally under development. Further, to implement this policy more effectively, detailed procedural manuals required amendment, and the training of personnel involved in operating and managing the use of active sonars was reviewed.

Keywords: marine mammal mitigation; anthropogenic noise; naval sonar; seismic surveys; marine mammal observers; safety zone; passive acoustic monitoring; ramp-up procedures, marine protected areas; environmental management system.

List of Abbreviations and Acronyms

AOR	Area Of Responsibility. A geographically bounded area within which the Royal Canadian Navy has been assigned responsibility for military operations.
ATBA	Area To Be Avoided
AWR	Areas With Restrictions. Can include marine protected areas and ATBA as well as other sensitive areas for which restrictions are placed on navy operations and exercises.
CANLANT/JTF(A)	Refers to the Canadian Atlantic Area and all the military assets found in Atlantic Canada. For domestic operations, these assets fall under the command of the Joint Task Force (Atlantic) commander, who is also the Commander of the East coast navy.
CANTASS	Canadian Towed Array Sonar System. A passive sonar system trailed behind a warship at various depths to locate submarines.
CAS	Continuous Active Sonar
CBT Operator	Combat Operator. The working level sailor in a warship who operates the sensors systems on board including radar and sonar.
CCFL	Commander Canadian Fleet Atlantic. The officer in direct command of all sea-going assets in the Atlantic.
CCFP	Commander Canadian Fleet Pacific. The officer in direct command of all sea-going assets in the Pacific.
CO	Commanding Officer. In the naval context, this is the master of a warship.
Comd RCN	Commander of the Royal Canadian Navy. The highest ranking officer in the navy chain of command.
COSEWIC	Committee on the Status of Endangered Wildlife in Canada.
DComd RCN	Deputy Commander of the Royal Canadian Navy. Manages the daily workings of the RCN on behalf of the Commander RCN.
DFO	Department of Fisheries and Oceans
DRDC(A)	Defence Research and Development Canada (Atlantic)

EDB	Environmental Diligence Briefing
ER	Ecological Reserve
FSE	Formation Safety and Environmental office. This organization is responsible for local compliance with safety and environmental regulations and developing policies and procedures in these areas. There is an FSE office for each of the East and West coast navies.
HMS	Hull-Mounted Sonar. The primary active sonar system that is fixed to the hull of a major warship.
IAGC	International Association of Geophysical Contractors
IMO	International Maritime Organization
LFA	Low Frequency Active sonar system.
MARCOM	Maritime Command. Former name of the Royal Canadian Navy.
MARCORD	Maritime Command Order. The highest-level orders and directives promulgated by the Commander RCN and applicable throughout the entire navy. Replaced by NAVORD since 2010.
MARLANT	Maritime Forces Atlantic. The East coast navy including ships and shore establishments.
MARLANTORD	Maritime Forces Atlantic Order. The orders and directives promulgated by the Commander of MARLANT and applicable to all navy warships and shore establishments in the East coast navy.
MARPAC	Maritime Forces Pacific. The West coast navy including ships and shore establishments.
MARPACORD	Maritime Forces Pacific Order. The orders and directive promulgated by the Commander of MARPAC and applicable to all navy warships and shore establishments in the West coast navy.
MAZ	Mitigation Avoidance Zone. The term adopted by the RCN to refer to safety zone around a sound source.
MM	Marine Mammal.
MMO	Marine Mammal Observer
MMMP	Marine Mammal Mitigation Procedure

MOAMP	Maritime Forces Atlantic Operating Areas Management Plan. Provides details of environmental considerations in the designated navy operating areas in the Atlantic.
MPA	Marine Protected Area
MPA personnel	Maritime Patrol Aircraft personnel. In the navy and air force context, this refers to the aircrew on the large, fixed wing patrol aircraft operated by the air force, and employed by the navy.
NAVGEN	Naval General message. A formal means of communication used by the RCN to quickly reach virtually all personnel. Can be an informative message, or contain specific orders to be followed.
NAVO	Navigating Officer. The officer with primary responsibility for the planning and execution of a warship's movements.
NAVORD	Naval Order. Replaces the term MARCORD.
NMFS	National Marine Fisheries Service (USA)
NOAA	National Oceanographic and Atmospheric Organization (USA)
OOW	Officer of the Watch. The officer on the bridge of a warship who is temporarily in charge of the ship's movements, daily routine and safety on behalf of the Commanding Officer.
OPAREA	Operating Area.
ORO	Operations Room Officer. The on-watch officer in a warship who manages all weapons and sensors on behalf of the Commanding Officer.
PAM	Passive Acoustic Monitoring
RCAF	Royal Canadian Air Force
RCN	Royal Canadian Navy. Prior to 2010, known as Maritime Command.
QSP	Qualification Standardization Publication. A management tool used by the military training system as a source document to identify the details of specific military qualifications. The QSP is used to develop courses, training materials and lectures for each qualification.

SAND	Sea Animal Noise Database
SARA	*Species at Risk Act*
SEL	Sound Exposure Level
SEMS	Safety and Environmental Management System. The process used in the RCN to specify safety and environmental policies and detailed procedures. SEMS manuals are promulgated at each level of command with the RCN. For this paper, the most relevant SEMS manuals are the MARLANT and MARPAC Formation manuals and the warship class publications (each class of ship has slightly different equipment requiring a slightly different class manual).
SOCP	Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment
SOP	Standard Operating Procedure
SSO UWW	Senior Staff Officer Underwater Warfare
TE	Training Establishment. A generic term for a military training organization.
UWT	Underwater Telephone. A sonar system for voice communication through the water.
WUPS	Work Ups. An intense training and ship evaluation program designed to ensure a ship is fully prepared and capable of conducting the full range of navy operations and procedures. Normally done prior to operational deployments and after a long period of maintenance.

Acknowledgement

This project would not have been possible without the sponsorship and support of many people. Firstly, the overall sponsor, Captain (RCN) Catherine Corrigan, who recognized the potential value of the internship to both the RCN and me. Secondly, my special thanks for the support and facilities provided to me for the two internship periods by Mr. Jim Theriault at DRDC (Atlantic) and Mr. Kyle Penney of the Safety and Environmental Office in Halifax. Thirdly, the input and support shown by the other members of the Working Group to which I was seconded for this project was most appreciated. Specifically, in addition to those already mentioned, Ms. Danielle Smith of the West coast Safety and Environment Office, Lieutenant-Commander Appleton at Navy Staff Headquarters in Ottawa, and Lieutenant-Commander MacNeil from the East coast Navy Headquarters. Lastly, my thanks to the individuals, too numerous to mention, who responded quickly and professionally to my many requests for information.

Chapter 1: Introduction

This project paper is primarily focused on addressing the management issue of the design and implementation of Marine Mammal Mitigation Procedures (MMMP) for active sonar use for the Royal Canadian Navy (RCN). The project sponsor is the senior environmental compliance officer in the RCN assigned to the Naval Staff at National Defence Headquarters in Ottawa. Although her primary responsibility relates to her appointment as Comptroller for the RCN, she is supported in the management of environmental issues by a full-time Environmental Officer. The timing of this project was fortuitous as the RCN was in the process of re-writing the highest level directives regarding MMMP. A small working group had been formed to draft the new directive consisting of the Environmental Officer, a senior staff officer in Halifax, an environmental specialist from both the east and west coast navies, and a scientific advisor from Defence Research and Development Canada (Atlantic) (DRDC(A)). I became a member of that working group.

The project internship period required by the academic program was conducted in two periods of two weeks' duration. The first period was conducted at the Defence Research and Development Canada (Atlantic) (DRDC(A)) agency alongside the scientific advisor to the working group. During this period, a literature review of the scientific reports and studies into the impacts of anthropogenic noise on marine mammals was conducted. Also included in this section was a review of mitigation strategies and procedures to determine efficacy and best practices. The outcome of this phase was to gain a better sense of the scientific research available regarding impacts to marine mammals of man-made noise sources and identify which mitigation measures should be adopted by the RCN to ensure

due diligence in mitigating potential adverse impacts to marine mammals from active sonar use.

The second two week period was conducted at the Maritime Forces Atlantic Safety and Environmental Office (FSE) in Halifax alongside the working group representative from that office. The second portion of the project was a much more practical undertaking. It primarily involved the re-write of the high level navy guidance document to incorporate, insofar as possible, the mitigation procedures derived from the first internship period. Further, the revision of the high-level document impacted many other guidance documents. These impacts had to be identified and addressed to the extent possible within the internship period. Lastly, implementation of the policy and directives was viewed as a key issue by the working group. Consequently, training of those involved in actually utilizing mitigation measures was reviewed and recommendations made for improvement. The amount that could be accomplished in this regard was limited by the time available for the internship. Nevertheless, recommendations are provide in this area as well.

Chapter 2: Impact of Anthropogenic Sound on Marine Mammals

2.1. Background – Anthropogenic Sound

In general, the oceans of the world are not quiet places. The marine environment has a variety of natural sources of noise as shown in Figure 1 (Walmsley and Theriault, 2011. Page 7). Although this paper will not delve into the physics of underwater sound transmission, suffice it to say that sound can travel much farther in water than it does in the air. Because water is denser than air, sound in water travels faster and with less attenuation than sound in air. Sound speed in air is approximately 340 m/sec while sound speed in sea water averages 1530 m/sec, i.e. almost five times as fast, but will vary slightly depending on factors such as temperature, pressure (depth) and salinity levels. These variations can produce sounds channels or ducts within which sound can travel tremendous distances.

Thus, there is the potential for a single sound source to affect a large ocean area, sometimes covering millions of square kilometers, where the sound level can remain high enough to adversely impact marine mammals (Weilgart, 2007. Page 159). Human activity in the marine environment is an important component of the total oceanic acoustic background. These activities contribute to noise levels on a prevailing basis by generalized increases in the overall ambient noise over large ocean areas, as well as on an intermittent, or localized basis in the area where they are being used. Anthropogenic noise comes from many sources, of which the major ones include: propulsion noise from vessels at sea; airguns and other underwater seismic exploration devices; and offshore drilling and pile-driving, and naval sonar.

Many of these sources have been mapped in Figure 1 to give an indication of the frequency band in which they emit sound.

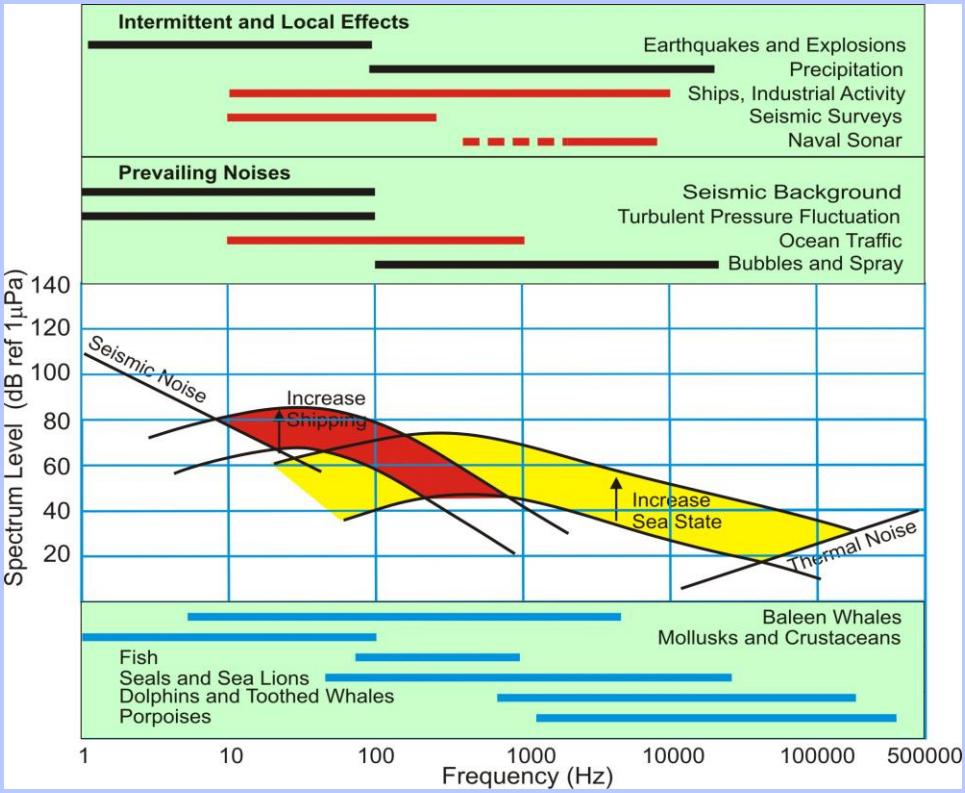


Figure 1: Typical ambient noise-frequency profiles for the marine environment (adapted from Wenz 1962 and the National Research Council 2003). Frequency bands associated with intermittent, prevailing and biological sources are indicated (red bars = anthropogenic; black bars = natural, and blue bars = biological).

Although seismic surveys and naval sonar are often characterized in figures similar to this one as intermittent and localized, sound from these noise sources can travel tremendous distances and should not be considered a "local effect". The main value of

this figure is in superimposing the frequency range of marine mammals with that of naval sonars. The figure clearly shows that the frequency ranges of these sonar systems overlap those of all marine mammal groups. Naval operations and exercises involve a number of activities that introduce noise into the oceans, including live-ammunition training, vessel noise and explosions. However, the activity that has been subject to the most scrutiny involves mid-frequency sonar. Mid-frequency naval sonar can produce sound at levels of up to 237 dB re 1uPa @ 1m mainly at frequencies between 2-10 kHz. Most Canadian and American naval sonars operate in this range, as do most of the allied navies (Hatch and Wright, 2007. Page 126).

2.2. Range of Impacts

Any investigation into the impacts of sound on marine mammals must begin with at least a basic understanding of the significance of noise to these animals. Marine mammals primarily rely on sound for virtually all biological and ecological facets of their lives. These include navigation and migration, communication, food-finding, reproduction, and hazard avoidance. (Weilgart, 2007 and Dolman et al., 2009). Consequently, man-made noise has the potential to interfere with these natural processes.

Around the world, mid frequency sonars have been correlated with fatal strandings of multiple Cuvier's and Blainville's beaked whales in the Bahamas and have been coincident in time and space with additional fatal stranding incidents (see Brownell, Yamada, Mead, & van Helden, 2004; Cox et al., 2006; ICES, 2005 in Weilgart, 2007). Other impacts include masking of marine mammal acoustic signals (potentially resulting in loss of opportunities for foraging or reproduction, anxiety or stress, and non-detection

of predators) and altered behaviour such as changes in vocalization rate/amplitude and spatial avoidance of the region of naval trials (Dolman et al, 2009, and DeRuiter et al, 2013). Claridge (2013) also found a reduced calving rate for Blainville's beaked whales in a naval range, signifying a population impact.

The precise mechanisms that cause physiological and behavioural modifications resulting from noise exposure are not always well understood. What is known is that marine mammals' hearing can be impacted by intense anthropogenic noise, although the consequences of long term exposure to even relatively low sound intensities is less well understood. Two key impacts are Auditory Threshold Shift and auditory masking. Animals exposed to sufficiently intense sound exhibit an increased hearing threshold (i.e., poorer sensitivity) for some period of time following exposure; this is called a *noise-induced threshold shift* (TS) (Southall et al, 2007). This can be further broken down into Temporary (TTS) and Permanent (PTS) threshold shifts depending on the severity of the noise exposure (NOAA, 2013). These terms will be discussed later as the levels at which they are believed to occur can affect the design of certain mitigation measures. For auditory masking, noise may partially or entirely reduce the audibility, including a degradation of the information content, of signals that a given species needs to hear to perform its biological functions. Southall et al. (2007) also go on to discuss physiological responses, including responses normally associated with stress, a subject that will also be more fully addressed later in the paper.

Compared to behavioural responses, determining at which levels threshold shifts occur is relatively straight-forward (NOAA, 2013) and can be accomplished with some

precision (specific auditory masking levels have also been determined for some species as mentioned in Finnerman and Branstetter, (2013)). Behavioural or physiological responses that may have resulted from noise exposure, and at what levels, is much more complex and problematic. To make matters even more complex, even though sound levels may elicit no overt, observable response, that does not prove an absence of adverse impacts, particularly in the most vulnerable individuals who may lack sufficient energy to move away or cannot afford to respond and interrupt feeding opportunities. (Weilgart, 2007, and Wright, 2014). Further, the accumulation of sound over time can have impacts which are largely unknown but have contributed to increased stress levels in marine mammals (Southall et al., 2007).

The next two sections of this paper will investigate the range of behavioural and physiological responses of marine mammals to anthropogenic noise in greater detail, although this is not intended as an exhaustive review of the available literature.

2.3. Behavioural Responses

There is a wide range of observed behavioural effects of noise on marine mammals including: changes in vocalizations, swim speed, diving, and foraging behavior, displacement, avoidance, and shifts in migration path. These effects can be extremely subtle and barely detectable, or quite obvious. Recent studies have been able to observe some of these behavioural changes, and they can occur at relatively low levels of noise exposure for at least some species (Tyack et al, 2011 and Goldbogen et al, 2013). The population significance of a large or small behavioural response is also extremely difficult to assess. Conversely, there are well-documented studies of apparent noise tolerance (Weilgart, 2007).

There are further complicating factors to drawing solid conclusions about what is being observed. Numerous factors (individual differences, differences between species, age, sex, prior experience with noise, behavioural state) affect the potential variation in marine mammal responses to stimuli such as noise. As well, even species with similar hearing capabilities across frequencies (audiograms) can respond differently to the same noise (NRC, 2003 and Weilgart, 2007).

Although there are many studies available on the effects of noise on marine mammals, and many such studies that are on-going, the precise extent to which anthropogenic noise impacts marine mammals is still heavily debated. Evidence has become clear, however, that man-made noise is damaging their health and biological processes (Wright, 2014). One of the serious challenges to gathering reliable data on marine mammal behavioural changes is that many of these animals are extremely difficult to observe or require sophisticated methods to document behavior (Dolman et al, 2009; Tyack et al. 2011; DeRuiter et al. 2013; Goldbogen et al. 2013).

There are still lots of unknowns. It was assumed that the ear and associated structures would be the most susceptible to damage from sound, given their necessary sensitivity, though this may not be true. Similarly, it was thought that behavioural responses, many of which are nearly impossible to observe, occurred at lower levels of sound than hearing impacts, which also may not be correct given TTS can occur at low levels over the long term in some species. Many changes in behaviour could well have important consequences over the long term (Wright, 2014). Hearing sensitivity has only been measured in a few of the many marine mammal species. No audiograms exist for adult

sperm whales or baleen whales (Erbe, 2013). Even where there has been substantial effort to determine thresholds for hearing loss and acoustic trauma in the United States (NOAA, 2013), data remain scarce. The reality is that the biological significance of individual acoustic impacts on the behaviour of marine mammals is often not known (Erbe, 2013), though can sometimes be surmised.

2.4. Physiological Responses

In addition to potential injury or even death, anthropogenic noise is placing added stress on marine mammals. In humans and other vertebrates, there are a range of well documented stress-related low-level physiological responses that include changes in cardiac rate and respiratory patterns, changes to pulmonary, cardiac, metabolic, neuro-endocrine, immune, and reproductive functions. Unfortunately, studies of noise-induced stress in marine mammals are very limited though the stress response is highly conserved among the various animal groups. Additionally, some data are available.

In one such study, it was determined that stress hormone levels and changes in cardiovascular function occurred in some toothed whales after exposure to high levels of sound (Romano et al., 2004). Further, in a study conducted by Rolland et al. (2012), they convincingly made the case that stress levels in Atlantic right whales were reduced when shipping activity was reduced. By inference, as noise levels increase, so do stress hormone levels. Tests were conducted of faecal samples to determine stress hormone levels following the terrorist attacks of 9/11 during a period of temporary and drastically reduced level of shipping activity in right whale habitat. They found that stress hormone levels were substantially reduced when compared to baseline levels providing evidence

of the physiological impacts of shipping noise to these animals (Rolland et al., 2012). Although the study was focused on shipping noise, it would not be unreasonable to presume that sonar signals that operate at a much higher intensity than shipping noise could also induce stress.

The extent to which noise from human activities impacts populations of marine mammals has been highly debated. However, there is increasing evidence that the myriad of sounds introduced into the oceans by humans is collectively damaging the health and reproductive capabilities of these animals in various ways. Furthermore, there are now a number of solid indications that what is currently known about the severity of the impact of human noise exposure on populations of marine mammals, as well as on individuals, could be only the "tip of the iceberg" (NRC, 2005). This is due to the multi-faceted, and often subtle, range of effects that noise can have on the lives of marine animals (Wright, 2014).

Especially in species as difficult to observe as cetaceans, we are limited in our ability to detect impacts. Long-term population impacts may occur without dramatic or even observable short-term indications. Long-term studies are needed to correlate disturbance reactions, and their significance, to marine mammal populations.

Chapter 3: Managing the Impacts

3.1. Legislation

Governments around the world have responded and accept that there is indeed a range of behavioural and physiological impacts caused by anthropogenic noise from which marine mammals need to be protected. There are a number of different ways that this has been addressed. For example, United States legislation protecting marine mammals from anthropogenic noise is primarily through the *Marine Mammal Protection Act*. With a view towards compliance, the National Marine Fisheries Service (NMFS) (a component of the National Oceanographic and Atmospheric Organization (NOAA)) has calculated sound pressure levels that would result in physical harm (known as a Level A "take" and assessed to occur at 180 dB) and behavioural disturbance (a Level B "take" assessed to occur at 160 dB) (NOAA, 2013). Although these figures are currently under review, it is intended that they be used to calculate a safety range outside of which marine mammals would receive less than these levels and "takes" would not occur or would be substantially reduced. Of note, little guidance is provided for any other type of impact and there are serious questions as to the utility of the figures that are provided for Level A and B takes (Dolman et al, 2009 and Weilgart, 2014). Nevertheless, that is a management tool that the United States has adopted. For a summary of international instruments and country-specific guidelines and legislation, see Erbe (2013).

In Canada, the most significant legislation that protects endangered or threatened marine mammals is the *Species at Risk Act* (SARA). There are other pieces of legislation that play a role in protecting marine mammals from anthropogenic noise including the *Oceans*

Act that provides for the establishment of Marine Protected Areas and under which the Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment (SOCP) is promulgated. Further, the *Fisheries Act* states that marine mammals are not to be "disturbed" but there is no definition of what this means. There are a number of other pieces of legislation (see Theriault et al, 2005), but for the purposes of this paper, it is the requirements of the SARA that are the most difficult to meet. Currently, the SOCP is the only guidance provided by the Government of Canada to help meet these requirements.

3.2. Species at Risk Act

In order to be afforded the protection of the SARA, a species (or population of a species) must be listed as "at risk". This determination is made by The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) which is an advisory body to the Government of Canada. Their recommendations are incorporated into the SARA (COSEWIC, 2013). The marine mammals relevant to this paper that are listed under the SARA as being Endangered or Threatened include the following whales: Blue, Right, Beluga, Killer, Sei, Fin (Pacific population only), Humpback and Bottlenose. Interestingly, there are no pinnipeds or other marine mammals listed in these categories.

Upon listing under SARA, prohibitions come into place to protect them and their habitat. Section 32 prohibits inflicting various forms of harm on an individual, as well as activities that involve any kind of transaction with respect to an individual. In part, the SARA states:

> *32. (1) No person shall kill, harm, harass, capture or take an individual of a wildlife species that is listed as an extirpated species, an endangered species or a threatened species.*

"Harm" is considered to be the adverse result of an activity where single or multiple events reduce the fitness (survival, reproduction, growth or movement) of an individual. "Harass" is considered to be the disruption, alarming or molestation of an individual caused by an act or series of acts, which by means of frequency and magnitude could change the normal behavior of individuals and impact life history function(s), possibly reducing the likelihood of survival or recovery of a population. These definitions come from the SARA Regulatory Framework Workshop that was held February 25-28th 2014 (Theriault and Moors-Murphy, 2014a). The SARA does not currently provide specific guidance on sound exposure criteria or thresholds for harm or harassment of individuals, or for destruction of critical habitat.

3.3. Statement of Canadian Practice

As shown in the earlier section, anthropogenic noise has a series of adverse impacts. With a focus on seismic profiling, the Canadian Science Advisory Secretariat (Theriault and Moors-Murphy, 2014b) in Figures 3 and 4 tabulated direct and indirect impacts that contravene the SARA. Although this was assessed for seismic surveys, it is relevant to the use of naval sonars (Moors-Murphy and Theriault, 2014, Page 4). In fact, current navy guidance on mitigation measures was directly adapted from the SOCP. As seen in these figures, whales are either directly or indirectly affected by the entire range of physiological and behavioural effects and responses.

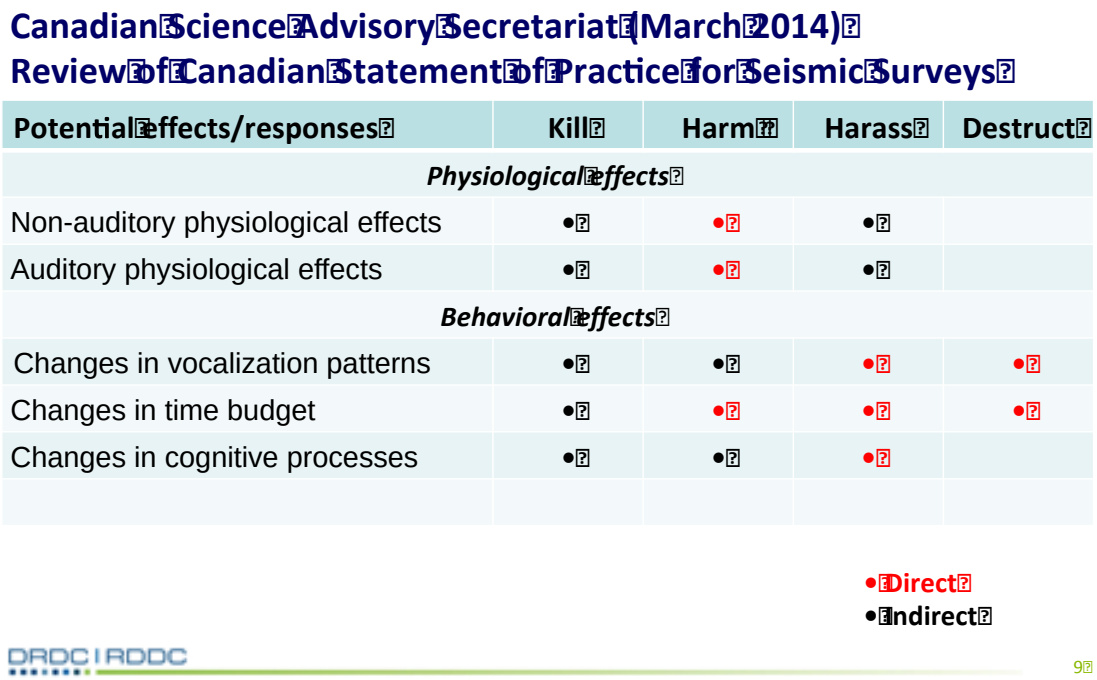


Figure 2 (Theriault and Moors-Murphy, 2014b)

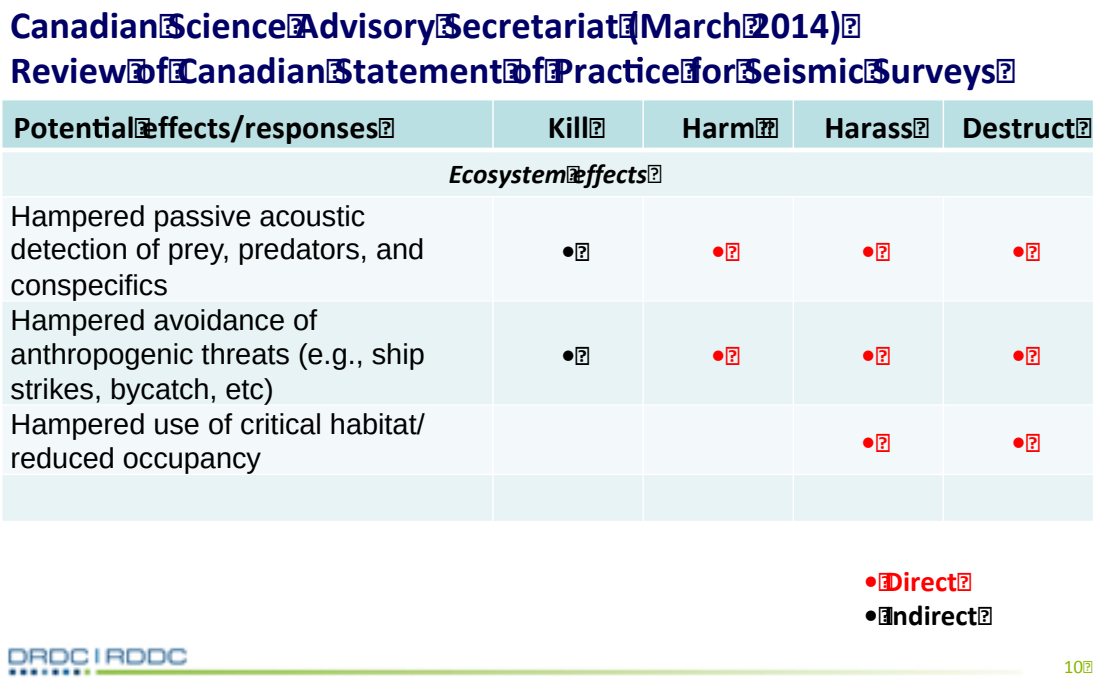


Figure 3 (Theriault and Moors-Murphy, 2014b)

Since it is not feasible to eliminate all oil and gas exploration, nor to prohibit the use of navy sonars, an attempt has been made to mitigate the impacts. In Canada, as previously introduced, that mitigation strategy is outlined in the SOCP. The SOCP attempts to combine established mitigation measures into one document and provide them to industry as "guidelines" rather than regulations. This suite of guidelines contains specific measures of greater and lesser efficacy in actually accomplishing the goal of mitigation.

Currently, the policy on marine mammal mitigation in the RCN is contained in a Maritime Command Order entitled Marine Mammal Mitigation Procedures for Active Sonar Use (short title - MARCORD 46-13). As mentioned, the provisions in the directive are adapted from the SOCP. The MARCORD is undergoing revision as a Naval Order (NAVORD 4003-6). This project, in part, is intended to contribute to that revision process to ensure that appropriate mitigation measures are developed and implemented. In order to do so, mitigation measures from the SOCP will be discussed in greater detail.

Chapter 4: Mitigation Measures

This section will discuss all the mitigation measures currently required under the SOCP, and their effectiveness will also be examined. The measures include:

a. Planning considerations to avoid critical habitat

b. Lowest power setting to achieve operational results

c. Safety Zone

d. Marine Mammal Observers

e. Start up (Ramp-up) and shut down requirements

f. Passive Acoustic Monitoring

With the exception of avoidance of habitat and reducing sound levels, all mitigation measures have issues that make their effectiveness questionable. Nevertheless, they all have some utility and the intent of this section is to review these measures with a view towards developing what could be the best practices for the Royal Canadian Navy (RCN).

4.1. Temporal/Spatial Closures of Specific Areas

One of the simplest ways to mitigate adverse noise effects on marine mammals is to avoid their habitats in the first place. While marine mammals can be found virtually anywhere in the world's oceans, there are critical areas that have been identified where interactions are most likely to occur and there are areas that are the equivalent of ocean deserts, low in marine life. Critical areas could simply be closed (temporarily or permanently) to ensure protection. Brazil was the first country to clearly define areas for closure in such a manner in order to protect breeding humpback whales (Weir and Dolman, 2007, Page 17). Since that time, many other nations have made similar efforts,

including Canada. Figures 5, 6, 7 and 8 below show a sampling of such key habitat areas for four species listed in the SARA. Some of these areas enjoy special protection.

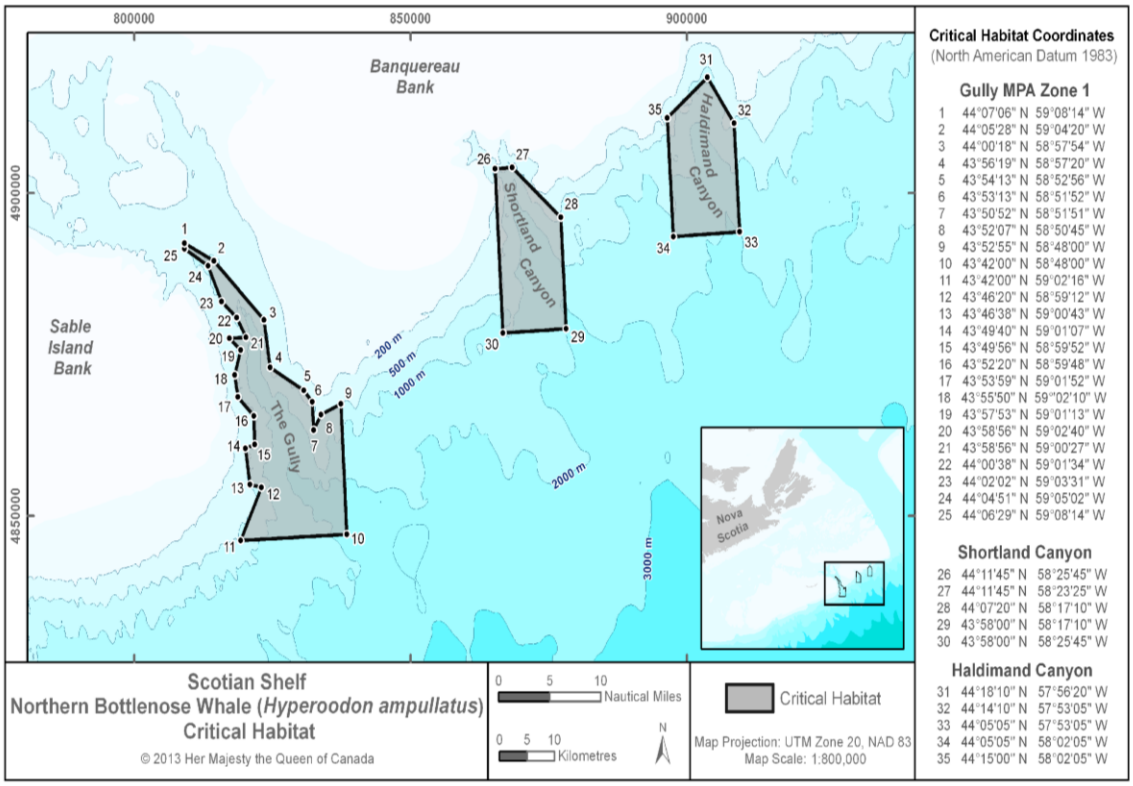


Figure 4. Boundaries of the Critical Habitat of Northern Bottlenose Whale on the Scotian Shelf. (DFO, 2014).

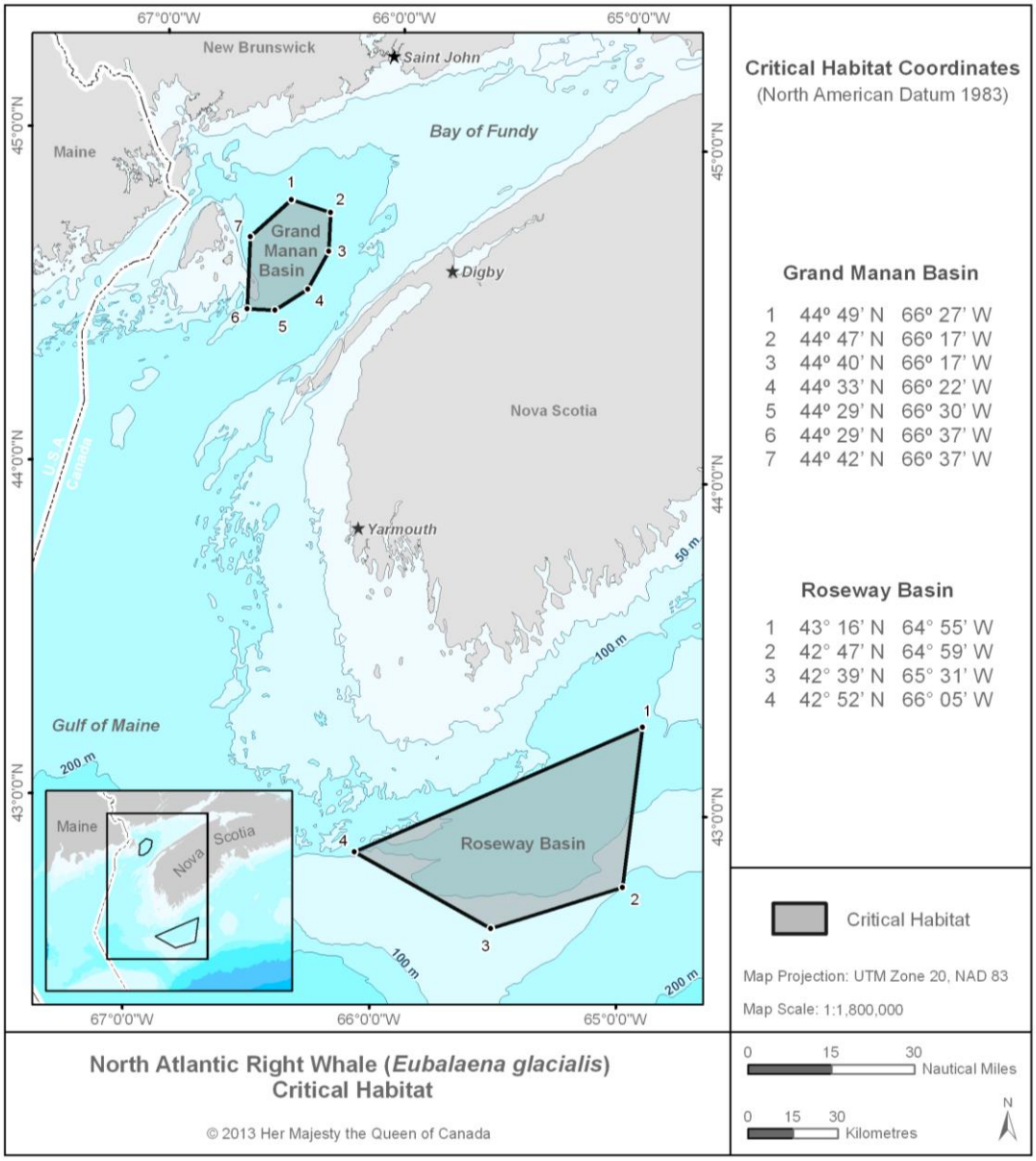


Figure 5. Boundary of North Atlantic right whale SARA critical habitat in Grand Manan Basin and Roseway Basin (DFO, 2014).

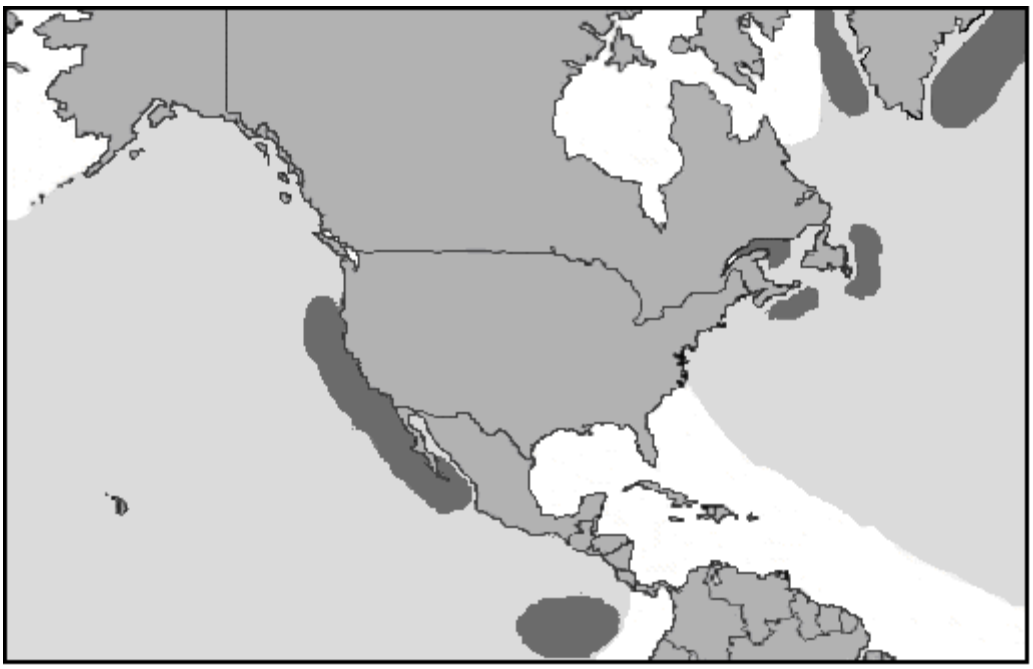
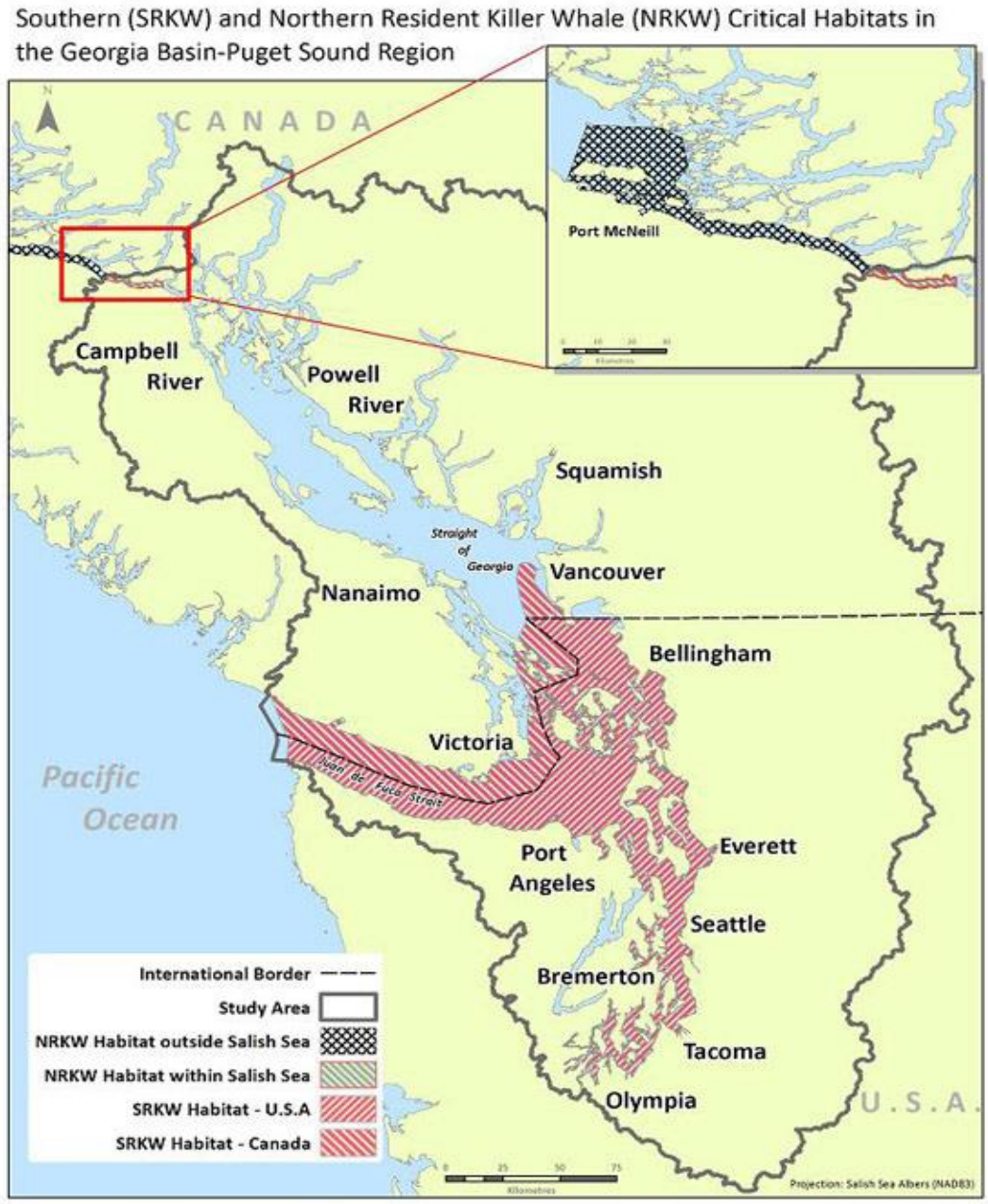


Figure 6. Geographical range of the blue whale, along the coast of North and Central America. Adapted from Sears and Calambokidis (2002) in Beauchamp et. al 2009 (darker areas showing greater concentrations).



The Southern and North Resident Killer Whale Critical Habitats are displayed in three separate "areas" within the Georgia Basin-Puget Sound region. A small, southern extent of the Northern Resident Killer Whale critical habitat can be found within the Northwest corner of the Salish Sea and for greater detail can be seen within the inset map. The Southern Resident Killer Whale critical habitat is one habitat but is displayed as two separate areas to help illustrate what portion of the habitat is on each side of the Canadian and U.S. border.

Figure 7. Southern and Northern Resident Killer Whale Critical Habitats (EPA, (No date)).

There are regulatory instruments available to designate certain areas of the oceans as particularly sensitive to specific species and, consequently, these areas could enjoy a special level of attention. Two such frameworks include the national designation of critical habitat as a marine protected area (MPA), and designating a specific geographic area as an Area To Be Avoided (ATBA) under International Maritime Organization (IMO) provisions. Within the Canadian context for example, the area surrounding the Gully in Figure 5 has been designated as a Marine Protected Area whereas the Roseway Basin in Figure 6 has an official designation by the IMO as an Area To Be Avoided. This has been shown to be very effective in reducing vessel traffic in the area (Vanderlaan and Taggart, 2009). These restricted areas are promulgated in Notices to Mariners to ensure widespread notification (CCG, 2014).

Obviously, in order for this mitigation measure to be effective, knowledge is required of where and when all species at risk may be found. Much of this information is simply not available. It has frequently been identified that there needs to be a worldwide effort to identify and define key marine mammal habitats (see NOAA, 2012, page 26, for example).

4.2. Safety Zone Radius

Many jurisdictions have developed a safety zone radius around the noise source within which marine mammals would be subject to injury. The SOCP requires that the production of sound cease if a marine mammal enters this zone. There are two main methods of establishing the size of this safety zone. Firstly, the distance can be a somewhat arbitrary figure as in the case of the SOCP in Canada. It sets the radius at 500

meters around the noise source as a minimum. This radius is one of the smallest in the world (Weir and Dolman, 2007). The second method is to determine the sound pressure level for various species where injury might occur. With this approach, it is necessary to calculate how far from the noise source that the sound would propagate before the intensity level dropped below these thresholds. In the United States, the NMFS has calculated these levels at 180 dB for injury, and 160 dB for behavioural changes (NOAA, 2013). Borrowing from this approach, the Canadian Navy has promulgated a figure of 160 dB for calculation of a safety zone radius for sonar operations (MARCORD 46-13).

Although it might appear that the second method provides a better means to calculate safety zone radius, there are many inaccuracies that make these calculations highly suspect. Firstly, the sound pressure levels used are somewhat arbitrary in themselves as we have previously seen in this paper; the levels at which injury or changes in behavior occur are not adequately known for most species, although in some species changes in behavior are known to occur at levels far below 160 dB (DeRuiter et al. 2013; Goldbogen et al. 2013). Secondly, there is tremendous variation in the distances sound travels in water. Depending on variations in the water mass caused by numerous environmental factors, propagation distances could be in the hundreds of miles before the levels dropped below established thresholds making it unmanageable as a mitigation measure (Moors-Murphy and Theriault, 2014), since most whale species can generally only be reliably sighted to 1 km or so.

This is further complicated by the numerous ways sound can propagate in water. For example, the distance it will take for the sound pressure level to drop to a specified level

will vary tremendously if the sound is travelling via a direct path, bouncing off the bottom, or trapped in layers and ducts (or a combination of any or all of these). Detecting marine mammals within the safety zone, no matter its size, is problematic, especially for long-diving species such as bottlenose whales. This can result in safety zones becoming ineffective and unusable in the real world (Wright, 2014, p. 22).

4.3. Marine Mammal Observers

Regardless of how the safety zone is calculated, the requirement exists to detect marine mammals within it. The most common method is visual detection by marine mammal observers (MMO). The SOCP requires that a qualified MMO continually visually observe the safety zone for the presence of marine mammals for at least 30 minutes prior to, and during, airgun operations. There is no definition of what training is required to become certified as a MMO and a standardized qualification process in Canada has yet to be put in place. Baker et al. (2013) provides recommendations for a standardized training program and MMO qualifications in the United States that could serve as a guide for development of a similar approach in Canada.

Numerous organizations have identified serious issues regarding the use of MMOs as a mitigation measure. For example, the Scientific Committee of the International Whaling Commission has raised issues including: increasing distances of monitoring from sound sources, complex multispecies requirements, the authority and independence of MMOs, their training and assessment, numbers of observers required to be effective, and data availability (IWC, 2014).

Additionally, observer estimates of distance to a sighting may be inconsistent. Further issues arise when the required distances are beyond the visual range of the observers, or when weather, darkness or sea conditions compromise their ability to spot marine mammals (Wright, 2014. P. 22). Sea conditions can have a particularly large impact on observer effectiveness. Studies have shown that increasing sea state clearly impacts the ability to detect cetaceans of all species. Sighting rates, even for easily detectable species, decreased more than 10-fold when wind speed changes from a Beaufort 0-1 to a Beaufort 5 (Nichol 2009).

A number of other human factors can affect an observer's ability to detect marine mammals. For example, it is known that observer fatigue negatively impacts detection rates; consequently, a maximum shift length of four hours has been recommended (Weir and Dolman 2007). DFO (2010) also recommends setting a maximum total duty time per day in addition to a maximum shift length. It is very difficult for a single observer to cover 360^{O} around a vessel reliably; therefore maximizing the number of observers on watch simultaneously is also recommended (DFO 2010). Development of standardized MMO protocols that take these human-related factors, as well as the platform and equipment used, into account would provide guidance on how MMOs should perform their duties to maximize the effectiveness of the visual detection methods employed (Moors-Murphy and Theriault, 2014).

Naturally, to be visually observed, the marine mammal would have to be on the surface. Visual observation is, therefore, completely ineffective for submerged animals. In such cases, passive acoustic monitoring (PAM) is also included as a mitigation measure.

4.4. Passive Acoustic Monitoring

Passive acoustic monitoring (PAM) is used when visual observation is compromised due to darkness, fog, rain, or sea state and also as a compliment to visual observations when marine mammals are below the surface or out of visual range. PAM involves listening for marine mammal vocalizations through the water. While PAM helps address the detection shortcomings of visual observation, it also suffers from a number of drawbacks and challenges. As noted regarding MMOs, human factors such as training, experience and fatigue play a major role in the effectiveness of the PAM operator to perform this function. In addition, the type of equipment and analysis software that are used, and orientation of the monitoring device to the ship noise and marine mammal, also impact effectiveness. If ship noise is too loud, PAM may be rendered ineffective as well. Environmental factors such as sea state, background noise levels and underwater sound propagation also play a role. And, of course, biological factors such as marine mammal vocalization rate, source level, and frequency range will be key factors in the detectability of marine mammals (DFO, 2010).

Here again we see that there are no existing standardized PAM operator training and qualification in Canada, nor is there an existing standardized approach to PAM protocols (DFO 2010). Some efforts to address this have been made elsewhere. The International Association of Geophysical Contractors (IAGC) recently developed guidance on the use of PAM during oil and gas operations that include minimum performance, and technical and operational requirements (IAGC 2014). Standardized programs and protocols could enhance the effectiveness of PAM and increase the probability of detecting marine mammals (Moors-Murphy and Theriault, 2014. Page 14).

4.5. Ramp-up Procedures

In a twist of irony, the SOCP calls for a ramp-up procedure in an effort to warn away marine mammals from the safety zone – a behavioural change that is technically proscribed by the SARA for listed species. Ramp-up procedures are also known as soft starts. During this procedure the sound source level is gradually increased before it is used at normal operating power. As mentioned, the expectation is that nearby animals will respond to the increasing sound level by swimming away. Soft starts are used in an effort to prevent worse harm, although no clear evidence exists for their effectiveness as a mitigation measure (Ainslie and von Benda-Beckmann, 2012, Page 2). In theory, some species may approach the sound source out of curiosity during ramp-up, only to be exposed to the full sound level when they are close.

Limited research has gone into examining the effectiveness of this technique. In a recent review of some of the available research (von Benda-Beckmann et al, 2013), it was found that the effectiveness of the ramp-up procedure depends on the assumed responsiveness of the marine mammals that it is intended to keep outside of the safety zone. We have already seen that marine mammal behavior after exposure to anthropogenic sound is extremely hard to predict making it difficult to assess the effectiveness of the ramp-up procedure. Moreover, if a prey patch only occurs near the noise source, ramp-up may not be enough to encourage animals to leave.

4.6. Mitigation Measures Summary

All of the mitigation measures outlined in the SOCP have serious drawbacks that make them of questionable effectiveness. Consequently, implementing any or all of them should not be construed as providing assurance that marine mammals will not be harmed.

Some measures, however, are more effective than others. Avoiding marine mammal habitat (assuming this is well documented) is clearly an effective measure. Similarly, although not specifically addressed above, the SOCP requires the use of the lowest possible power setting for seismic airguns. It is self-evident that if the anthropogenic noise source is sufficiently low, it would be an effective mitigation measure. Unfortunately, however, doing so may make it impossible to gain any useful survey data (or active sonar detections in the case of the RCN) at the levels likely required to avoid any impact on marine mammals.

The remaining measures are more problematic. Nevertheless, they are better than doing nothing. As mentioned, some of them can likely be improved by establishing formalized training, qualification standards and protocols (as in the case of MMOs and PAM operators) and standardized technical specifications for PAM equipment. All of the mitigation measures identified are implemented by many jurisdictions around the world and are contained in many reviews of best practices (see Weir and Dolman, 2007, page 27, for example). Virtually all of the literature and studies of the impacts of anthropogenic sound on marine mammals and techniques to mitigate harm call for additional research and study as there is simply too much that is not known about these issues.

Lastly, although not mentioned in the SOCP, the potential exists to use high-frequency active sonars for the detection of marine mammals. These systems generate numerous false contacts and much work remains in order to identify individual species using this technique. Additionally, there is a great deal of concern about the impact on marine mammals of putting additional sound energy into the water (see Weir and Dolman, 2007,

page 18 and Wright, 2014, page 24).

Chapter 5: Second Internship Approach

The basic management issue being addressed in this project is to ensure the Royal Canadian Navy (RCN) is being a conscientious steward of the environment as it relates to its impact on marine mammals from active sonar use. This broad issue includes a number of dimensions:

a. Where (i.e. in what documents and authorities) does the direction and guidance on marine mammal mitigation procedures (MMMP) reside and who is responsible? Is this appropriate?
b. Are the MMMP for active sonar transmissions used in the RCN appropriate? If not, what amendments should be made?
c. How is this policy implemented at the user level? What improvements are necessary to enhance implementation?
d. Is there an adequate system in place to ensure continuous improvement (adaptive management) in the management of this issue? If not, what improvements should be made?
e. What areas will continue to require attention beyond this project in the management of the issue?

Each of these elements will be addressed in this portion of the project paper. Naturally, the RCN has numerous environmental responsibilities and countless ways in which to implement them. MMMP is but one of these. In an organization like the RCN, there are numerous levels of oversight, and each of these levels has a role in outlining RCN policy and procedures. Ultimately, however, regardless of what MMMP are adopted, if the user

level does not have adequate training and awareness of this issue as they plan for and operate active sonar in the world's oceans, unnecessary harm to marine mammals could result. The RCN recognized that implementation is a major issue to ensure success, and thus has become a focus area of this internship project on behalf of the sponsor.

The RCN has been very active in the area of environmental management and MMMP in particular. Much work has been done that directly relates to MMMP and this project also served to capture where in the various systems of the RCN, and in what series of documents, this is addressed. Not only is this project concerned with the RCN MMMP themselves, but reviewing how they are implemented and rationalizing the guidance documentation has also become a part of this project.

As the project internship unfolded, revisions to documents and training were proposed, many of which were adopted during the course of the project internship. Where appropriate, this will be identified. Given the magnitude of the undertaking, and the short time available, consensus of all stakeholders on all proposals was not possible. This will also be documented. Consequently, the outcome of this project will be actual changes in procedures and documentation, as well as a list of areas that will require on-going attention that will be passed to the project sponsor for consideration.

5.1. Organization

The organizational construct within the Royal Canadian Navy (RCN) to manage overall environmental issues is outlined in Naval Order (NAVORD) 1002-0 *RCN Safety and*

Environmental Program Management. An organization chart is provided below as Figure 8.

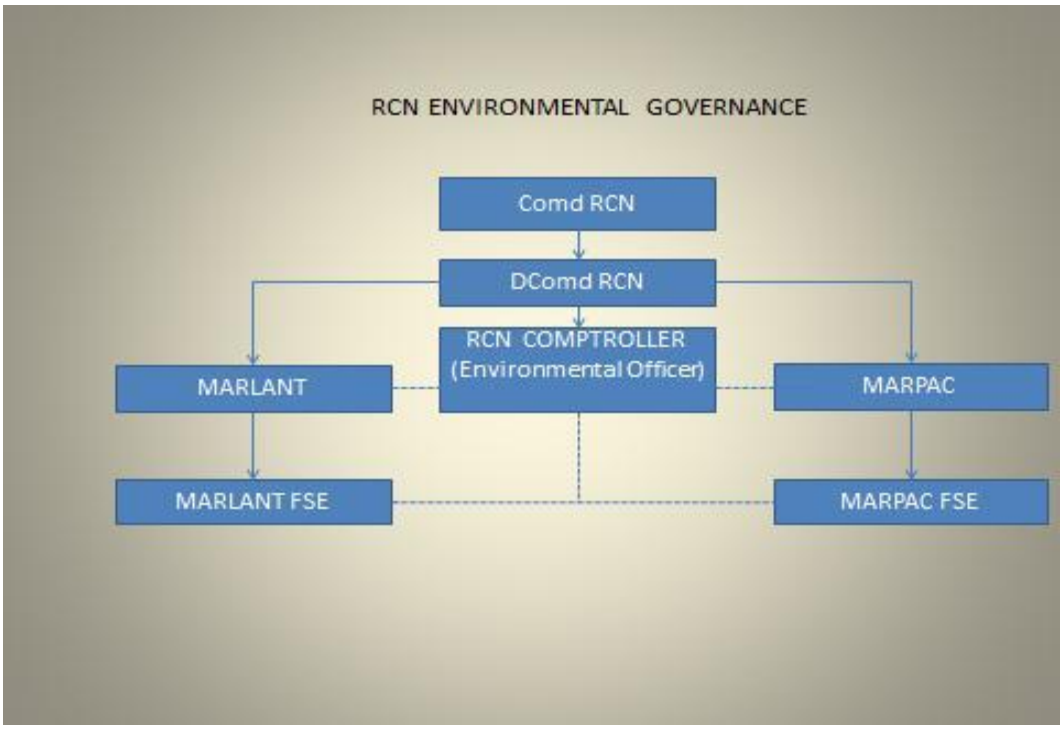


Figure 8: A simplified organization chart showing the Commander RCN (Comd RCN), the Deputy Commander RCN (DComd RCN), the Environmental Officer and the two main formations of Maritime Forces Atlantic (MARLANT) and Maritime Forces Pacific (MARPAC) and their associated Formation Safety and Environment officers (FSE).

Within that document, the Commander of the RCN (Comd RCN) has overall responsibility to ensure MMMP policy is established. This responsibility is executed on his/her behalf by the Deputy Commander (DComd RCN). The office that manages this responsibility on behalf of the DComd is the Navy Comptroller's office – who is also the

chief environmental compliance officer for the RCN. This person (who is also the sponsor for this project) ensures environmental compliance across a broad range of environmental issues of which marine mammal mitigation is but one part. Within that organization, an RCN Environmental Officer has been established to manage the staff work required to ensure the RCN is being a responsible steward of the environment.

Also beneath the Comd RCN in the hierarchy are three formations. Naval Reserve headquarters located in Quebec City (this organization is not relevant to the issue of MMMP as the ships operated by the Naval Reserves fall under the responsibility of the other two formations.) The remaining two formations are Maritime Forces Atlantic (MARLANT) and Maritime Forces Pacific (MARPAC). These formations have the responsibility to implement MMMP policy, provide direction, support and oversight. Each formation has a fleet commander - Commander Canadian Fleet Atlantic and Pacific (CCFL and CCFP) responsible for the employment of ships and aircraft that are assigned to each coast. NAVORD 1002-0 specifically assigns the responsibility for MMMP implementation to them.

Although CCFL and CCFP are responsible for implementation, they do not have the environmental expertise internal to their organizations. That expertise is found within each formation identified as Formation Safety and Environmental offices (FSE) located on each coast. These are the key organizations for environmental issues as they have the responsibility to develop, manage MMMP direction and training, and to provide expertise

and guidance to both the fleet and formation commanders, and provide direct guidance and support right down to the ship and individual levels.

To further set the stage for the key players in the management of MMMP, due to a re-organization within the RCN, some responsibilities regarding navy-wide issues have been delegated to the formations. Related to MMMP, the MARLANT planning staff; specifically, the senior staff officer for Under Water Warfare (SSO UWW N52-4), is leading the effort to re-write the existing policy. The policy vehicle chosen for this is a Naval Order (NAVORD) which provides the highest-level direction from the Commander of the RCN on MMMP and it applies across the entire navy.

To assist N52-4 in developing the new NAVORD, an ad hoc team was put in place consisting of the Atlantic and Pacific Formation Safety and Environmental staffs, and the RCN Environmental Officer at Naval Staff Headquarters in Ottawa. Scientific advice and expertise in the development and assessment of specific mitigation measures is provided by a scientist in the Defence Research and Development (Atlantic) (DRDC(A)) agency who can be considered more of a consultant as he has no decision-making authority for the RCN. This project was undertaken by the author as a member of that ad hoc working group.

The working group functions by consensus. Although authority resides within some members of the working group to amend and promulgate certain lower-level guidance documents that will be addressed in this project, a draft NAVORD requires legal and

other reviews before it is approved for release to the RCN by the Commander RCN. Once the working group achieves consensus on the content of the NAVORD, it is forwarded back up the chain of command for additional review, approval and promulgation.

Drafting of, and achieving consensus on the NAVORD within the working group is, consequently, the key output of this project. Other outputs of this project include revision of lower-level documents that would be impacted by the content of the new NAVORD, and identification of other areas that remain to be addressed as it is not possible to deal with all of these within the scope and timelines of this project.

5.2. Documents

The approach taken to accomplish this ambitious undertaking included a literature review to better understand the scientific knowledge of the impacts of active sonar on marine mammals, identify common mitigation measures in place, and get a sense of their effectiveness. This was conducted at DRDC(A) in Dartmouth, NS, over a two-week period. The outcome of this review was to identify mitigation measures to incorporate into navy policy. The second internship period was used to draft the new NAVORD and review education, training and guidance documents currently provided in the RCN to identify what additional documentation needs to be amended as a result. It was also conducted over a two-week period embedded within the MARLANT Formation Safety and Environmental staff organization in Halifax as a member of the ad hoc working group to re-write the NAVORD.

The review of existing documentation in the Navy proved to be a massive undertaking in the short time period available for the internship. Nevertheless, a great deal of information was collected and reviewed. Among the key documents related to MMMP (in addition to the over-arching NAVORD early drafts) include:

a. The Maritime Forces Atlantic and Pacific Formation Safety and Environmental Management System (SEMS) manuals;
b. SEMS manuals for each class of ship (frigates, destroyers, coastal defence vessels, submarines, and replenishment vessels)
c. Maritime Forces Atlantic Operating Areas Management Plan (MOAMP)
d. Mitigation Sheets and navigation chart overlays of marine mammal habitat areas for Maritime Forces Pacific activities;
e. Environmental assessments for both the Atlantic and Pacific operating areas;
f. Related Maritime Forces Atlantic and Pacific Orders (MARLANTORDs and MARPACORDs – subordinate documents to NAVORDs); and
g. Lesson plans on MMMP delivered to students at the Naval Operations Schools

These documents contain far more information than merely the issue of MMMP related to active sonar use. Nevertheless, it is clear that the RCN has an extensive and comprehensive series of regulations, guidance, education and training related to marine mammal mitigation issues. As previously indicated, it is more in the area of implementation that some additional direction is necessary. The drafting and

promulgation of a new NAVORD on this issue will also serve as an opportunity to re-energize the implementation of MMMP within the RCN.

There is one additional document that is the current, principal source of MMMP in the RCN. That document is a Maritime Command Order (MARCORD) 46-13*: Marine Mammal Mitigation Procedures*. That order is not being revised; it is being cancelled and replaced. When the Government of Canada re-named Canada's navy from the old title of Maritime Command to the resurrected name of the Royal Canadian Navy, all Maritime Command Orders needed to be replaced by Naval Orders. The new NAVORD 4003-6: *Marine Mammal Mitigation Measures for Active Sonar Use* provided the opportunity to review the current system related to this issue and to make revisions deemed appropriate by the working group.

The key documents that will be revised as a result of this project will be discussed in greater detail later. The next section will discuss the marine mammal mitigation measures that are to be, and in many cases have already been, adopted as they will be key content items in the documents to be revised.

Chapter 6: Mitigation Procedures for Active Sonar Use

The previous MARCORD contained a specific series of mitigation procedures that units were to follow involving far more than just the use of active sonar. It contained a great deal of detailed information that was considered inappropriate for a high-level policy directive. Further, the policy guidance in the new NAVORD would relate specifically to active sonar use. It was decided during the MARDCORD re-write into a NAVORD, that detailed, operator level mitigation procedures were to be removed from this document, and inserted into the SEMS manuals applicable to each class of ship.

What precisely these mitigation procedures would be was the subject of much discussion. The literature review in the first part of this paper allowed for an assessment of extant RCN mitigation procedures that follows below. Generally speaking, however, few changes were made to the specifics of the mitigation measures to be employed as they were quite comprehensive and reflected due diligence, in my view, in the use of active sonar systems. Changes were primarily in organization and emphasis of these procedures.

6.1. Time and Space Considerations (Planning to Avoid)

As previously mentioned, the most effective way to mitigate adverse impacts on marine mammals from sonar operations (short of not using sonar at all) is to avoid their habitat as much as possible through appropriate planning of exercises and ship transits. General guidance and responsibilities for planning will be introduced in the NAVORD with more specific guidance provided elsewhere as will be highlighted later in the review of key documents.

Responsibility in the navy for planning exercises involving sonar use is held at two levels. Firstly, the Planning Staff at Atlantic and Pacific Fleet Headquarters, and secondly, by individual unit commanding officers (COs). Currently, the Fleet Planning staffs engage with the coastal Environmental offices (FSE) when planning exercises to assess the environmental impact of their exercises across a broad range of environmental issues, including marine mammal impacts. To do this, procedures are in place to inform FSEs where the units will be operating sonar, what the expected impacts are, and what mitigation measures are applicable. The FSEs in turn provide Fleet Planners with guidance on where sensitive areas are located, and where and when known congregations of marine mammals might be more likely to be encountered in order to avoid these areas, if possible. The Formation Environmental staffs receive these data from DFO Canada and have a regular liaison with them for this purpose. Consequently, when exercises are planned by the Fleet Staff, the considerations for selecting appropriate times and locations to minimize marine mammal encounters are addressed. The policy that requires them to engage in this process was outlined in both the old MARCORD and will migrate to the new NAVORD.

Each coastal formation has normal operating areas that are identified on navigation charts available for military and civilian use. A number of environmental assessments of these operating areas have been conducted over the years to help planners in selecting the most appropriate areas for their exercises to take place. These assessments have resulted in the creation of various planning tools. These planning tools are different for each coast.

The Atlantic Fleet has developed the Maritime Forces Atlantic Operating Areas Management Plan (MOAMP). This plan provides detailed guidance and planning considerations for the staff. It also requires them to report to the FSE regarding where they are operating with active sonar, and what mitigation measures will be in place. Standard mitigation measures (known as a Mitigation Sheet contained in the MOAMP), largely drawn from the previous MARCORD although additional information is also included, are reported to the FSE to show due diligence while operating sonars in these areas. It is unclear if the participating ships also received a copy of the Mitigation Sheet, but the requirement to do so has been highlighted as an outcome of the NAVORD re-write.

The Pacific Fleet does not have an equivalent plan to the MOAMP. They do, however, provide Mitigation Sheets for various operating areas to west coast planners when they undertake exercise planning. Ideally, both coasts should adopt the same process for exercise planning in the normal operating areas. This would allow for better familiarity with "the system" of exercise planning as senior personnel frequently transfer between coasts during their careers. The selection and design of a single system is outside the scope of this project but will be included as a recommendation for further study.

The situation is different for single ship operations, exercises and training. Commanding Officers (CO) of individual ships don't normally engage FSE to determine where and when they should operate to minimize marine mammal encounters. Rather, they merely employ the mitigation measures that were outlined in the previous MARCORD. This can

be problematic depending on the familiarity and expertise of the crew members involved in sonar use.

There is also specific guidance to ships if operating in an area with restrictions. Foremost is to avoid doing so in the first place. This guidance is contained in the class SEMS manual and is comprehensive in nature as it relates to far more than just active sonar use. Specific identification of areas where sonar operations have been prohibited by the Formation Commander (either MARLANT or MARPAC) can be promulgated in orders that apply within the Formation. These directives are known as MARLANT or MARPAC Orders (MARLANTORDS AND MARPACORDS). MARLANT has chosen to promulgate such an order that states in part:

> Accordingly, Underwater Sound Generating Systems shall be prohibited, for exercise purposes, in known MM (Marine Mammal) habitat areas identified in the CANLANT/JTFA(A) AOR (Canadian Atlantic Area of Responsibility). These known habitats include the Bay of Fundy, Roseway Right Whale Conservation Zone and the Gully Marine Protected Area; further details on these MM habitat areas and other known dolphin and whale concentration areas are provided in the MOAMP and GIS package available from N48 (FSE). Marine Mammal encounters and mitigation actions shall be included in post exercise/serial reports." (MARLANTORD 44-4: Requests for Service Support).

In MARPAC, similar direction is promulgated in MARPACORD 46-501but it only applies to proposed Federal Marine Protected Area (MPA) in the existing Provincial Ecological Reserve (ER) of Race Rocks. This order indicates that ships shall not normally enter this area with exceptions for emergencies and diving operations. MARPAC is, however, developing electronic chart overlays, that include numerous types of areas with restrictions, along with attached files that indicate specific restrictions within them. These overlays and files are being upgraded in order to provide more user friendly data that can be easily used by ships on a real time basis.

As part of the drafting process for the NAVORD, consensus was reached that "areas with restrictions" (AWR) mentioned in existing guidance documents requires a much fuller description. Consequently, a specific definition of what constitutes an AWR has been incorporated into the NAVORD and will be included in other documentation as well. Generally speaking, however, planning considerations as a mitigation measure is extensively implemented in the RCN. With the inclusion of a broader definition of AWRs into the guidance documents as well as specific direction not to operate active sonar (or even enter the AWR if it can be avoided), this crucial mitigation measure has been strengthened.

6.2. Mitigation Avoidance Zone (MAZ)

The RCN uses the term MAZ to refer to a safety zone mentioned in the SOCP. In spite of the confusing wording that implies a zone to avoid mitigation, it should be considered to mean "Mitigation AND Avoidance Zone". There are issues with the effectiveness of a MAZ, regardless of its size or how it is calculated. As was previously shown, it is

difficult to detect marine mammals, and a lack of detection does not mean that marine mammals are not present. Nevertheless, it is common practice in navies of the world to use a MAZ when operating active sonar and the consensus was reached in the working group that the RCN would continue to employ this mitigation measure.

If it is determined that a marine mammal is within the MAZ, sonar operations are to cease. Given the difficulties in determining the range of marine mammal even if it is detected, normal practice is that sonar operations cease whenever a marine mammal is sighted or detected by passive means unless it can be proven to be outside of the MAZ.

Within the working group, two schools of thought emerged for determining the size of the MAZ. One view was that the MAZ should be based on Sound Exposure Level (SEL) calculations that would identify the maximum amount of noise exposure over a given period of time to which a marine mammal can be safely exposed. This would be a highly suspect calculation as we have previously seen that not enough is known about the impacts of even low intensity sounds over the long term. Furthermore, this would require a calculation for each sonar system to compute the range at which the sound exposure level would be less than whatever rather arbitrary amount was used. It would also need to be re-computed to account for sound propagation changes in the water mass as ships moved through their operating areas. This was deemed to be too complex an undertaking for individual ships and may also result in a MAZ that was so large that it would make sonar operations, and detection of marine mammals within it, impossible. Consequently,

a hybrid solution was proposed combining the concepts of calculating MAZ radii for each water mass, and establishing fixed MAZ size.

MAZ radii for each RCN active sonar system were previously developed and included in the MARCORD. The process used to calculate the radii took into account a combination of best practices and generic sound propagation models for common RCN operating areas. It is these ranges that are now being transferred to the class SEMS manual for each class of ship and each sonar system. These ranges vary from 500 to 4000 yards, depending upon the sonar system. These fixed ranges will be subject to change as the proposal includes the requirement to refine the MAZ distances based on systematic measurements from field studies in the normal Canadian operating areas.

Although there remain concerns with how MAZ ranges are calculated, and whether or not marine mammals can be reliably detected within these zones, the RCN has made considerable effort in establishing these ranges. Their re-promulgation in the ship class SEMS manual will also allow for ease of amendment should further studies into sound propagation loss in Canadian operating areas reveal that they need refinement.

6.3. Marine Mammal Observers

RCN ships maintain a visual watch on a 24/7 basis whenever they are at sea although there are no specifically assigned marine mammal observers. There is always an Officer of the Watch (OOW) on the Bridge (there may be a second and third as well depending on the number of officer trainees on board), and lookouts for the port and starboard side of the ship as well as a lifebuoy sentry maintaining a visual watch astern. Detecting and

reporting marine mammals is also a part of their function at all times. The MARCORD, however, specifically requires the OOW, lookouts and lifebuoy sentry to maintain a visual and infrared watch for marine mammals when operating active sonar. None, however, are solely dedicated to observing or monitoring marine mammals although that is a part of their duties. The related direction in the class SEMS manual merely requires sightings to be recorded, but this is a requirement no matter where or when the ship sights marine mammals. All references to the requirement to maintain a proper visual lookout for marine mammals, as well as recording and reporting requirements, will migrate to the class SEMS manual.

Maintaining a visual watch at sea to report marine mammals is not the same thing as being trained as a marine mammal observer. It has been shown in the section dealing with the review of scientific literature (and is recognized by the RCN in the current MARCORD) that marine mammal detection by visual means is, generally speaking, the most likely way that their presence will be known. Improvements in the skills of those maintaining a visual watch will enhance the RCN's ability to be aware of the presence of marine mammals and take earlier action to mitigate any adverse impacts. Even though the MARCORD requires them to be trained and assessed in their responsibilities to recognize marine mammals, it is unclear how effectively this requirement has been implemented. This issue will be addressed later in the section on training and will be incorporated in the re-write of the NAVORD while specific duties will be addressed in the class SEMS manuals.

6.4. Passive Acoustic Monitoring (PAM)

As previously mentioned, the use of PAM as a mitigation measure is not entirely effective in locating marine mammals. Its effectiveness is limited by the reliance on marine mammal vocalizations, capabilities of the PAM system in use, and training of the PAM operators, among other factors (ship noise, ambient noise, etc.). Nevertheless, it has been adopted by the RCN as one of its MMMP.

Ships have many types of underwater listening devices, some of which are more effective than others in detecting various species. It is arguable that, given the critical requirement for naval ships to be able to detect and classify underwater noise sources as part of the anti-submarine mission, the PAM equipment in the RCN is already among the very best available even though these systems may not be optimized for marine mammal detections. Recommendations for improvements to PAM equipment capabilities that may eventually make their way onboard ships is an undertaking outside the scope of this paper. Nevertheless, this is an area that could be addressed by DRDC(A) on behalf of the navy should the priority become high enough to fund an R & D effort focused on MM detection by passive means.

The extant MARCORD provides some direction on the use of passive acoustic monitoring. Specifically in the MARCORD, it states that a minimum of 30 minutes prior to energizing active sonar systems, passive systems including underwater telephone (UWT), Passive Sonobuoys, towed array sonars (CANTASS) (if deployed), and hull-mounted sonars (HMS) are to be manned and tuned to maximize the chances of hearing the marine mammals in the area. It also requires them to maintain PAM throughout the

exercise period when active sonar is being used. It has been agreed in the working group that this requirement for PAM will migrate to the class SEMS manuals.

PAM operator training is something the navy conducts on a regular basis. The training of sonar operators in PAM will be discussed in the section dealing with all aspects of training on MMMP within the RCN. Generally speaking, however, the equipment used for passive detection of marine mammals, and the training of sonar operators in detecting and recognizing marine mammal vocalizations, is comprehensive.

6.5. Ramp-Up Procedures

A very detailed ramp-up procedure is specified in the current MARCORD. As mentioned in the scientific literature review, there are concerns about the effectiveness and potential adverse impacts of this mitigation measure on marine mammals. There was discussion within the working group if this measure should be retained. Since ramp-up procedures are still an industry standard (for the oil and gas industry in the conduct of seismic profiling at sea), and mentioned in the Canadian Statement of Practice, it was decided to retain it as a mitigation measure. It will, however, be moved to the class SEMS manual. Of note, ramp-up procedures are only applicable to the AN/SQS 510 sonar – the primary mid-frequency, active sonar system in the RCN inventory. Given the questionable utility of ramp-up procedures as a mitigation measure, it was agreed that there is no need to produce ramp-up procedures for any of the far less powerful active systems.

Ramp-up procedures require additional study to determine effectiveness, and the issue will need to be re-visited as new active sonar systems are provided to the Navy –

specifically low frequency active sonar (LFA) and Continuous Active Sonar (CAS), although this is another issue outside the scope of this project. Nevertheless, this is a mitigation measure that has been adopted by the RCN, and the details of this procedure will be outlined in the class SEMS manuals as an outcome of this project.

Chapter 7: Key Document Review

7.1. NAVORD 4003-6: Marine Mammal Mitigation Measures for Active Sonar Use

Prior to the commencement of this project, the working group had already done a significant amount of work to determine what should go into the new NAVORD and a preliminary draft was produced. Part of the rationale for the re-write of this high-level directive was that too much detail on specific mitigation measures was provided in the former MARCORD. It was determined that the information would be better placed elsewhere in more practical documents. The re-write of the MARCORD into a NAVORD provided the opportunity to gather all the existing direction and guidance on MMMP and place the policy and responsibilities into the NAVORD and place specific measures and planning guidance (as amended by this review process) into more appropriate documents.

As a member of the working group, I was able to dedicate much of the second internship period into revising the early draft NAVORD. Each successive revision that was made to the NAVORD was then passed to members of the working group for comment and to reach consensus on a final product. That work was able to be completed and the resultant draft NAVORD has been forwarded to RCN headquarters staff for final review, approval and promulgation.

The changes that were made to the early document as a result of the project internship included:

a. A more comprehensive definition of Areas with Restrictions (AWR) was developed;
b. A definition of the Operating Authority to include commanding officers when individual ships are operating independently to ensure mitigation considerations are addressed that are normally undertaken by planners of multi-ship activities;
c. Changes to the scope to indicate that it applies to Canadian ships anywhere in the world;
d. Changes to education and awareness training responsibilities and specific identification of the Naval Training System role in the Responsibilities Table; and
e. Direction on how MAZ is to be calculated and applied.

A large number of smaller changes were also made; a copy of the revised NAVORD is provided at Appendix A. It should be noted that this draft is still undergoing review within the RCN, and some additional changes may result.

7.2. SEMS Manuals

As with any hierarchical organization, high level policy guidance progressively becomes more detailed and more refined in scope as it gets reflected at each successive level in the organization. There is an overarching Safety and Environmental Management System outlined in the MARCOM SEMS manual. This manual contains a description of the management system and directs the creation of subordinate SEMS documents (Formation and Class SEMS) and assigns responsibilities. Also included in that document is a

reference to the federal legislation that concerns the RCN with regard to wildlife and habitat disturbance issues. Furthermore, since the management system requires environmental management to be continually reviewed and improved, the project provides an example that fulfills that requirement.

Beneath the MARCOM SEMS manual are the Formation SEMS manuals. These differ substantially between the two coastal formations. The MARPAC SEMS contains very specific guidance on marine mammal mitigation measures whereas the MARLANT SEMS is silent on the issue, although it identifies the FSE as being responsible for such matters. Responsibility for maintain and amending the Formation SEMS documents rests with each coastal FSE office. The MARPAC SEMS specifies this by including the marine mammal mitigation measures (Directive E7) that are provided in the ship class SEMS manuals. The MARLANT SEMS manual has a section dealing with Range and Training Area Management (Directive E12) that addresses mitigation and refers to the comprehensive MOAMP that provides additional detail. There was consensus among the working group that the Formation SEMS manuals should contain higher level guidance to planners of fleet exercises and be more consistent with each other, although specific amendments to these manuals was outside the scope of this project as well.

The class SEMS manual (separate manuals exist for each class of ship and the submarines) contains, among other issues, all environmental management procedures and directives that cover every activity that may have an environmental impact. These are detailed procedures to be followed by every ship for a variety of specific safety and

environmental issues. Within this manual, a “Standard Operating Procedure” (SOP) exists that covers Marine Mammals and Reptiles (SOP E5).

Currently, that SOP E5 refers users to the MARCORD that contains mitigation measures for active sonar use. It was determined by the Navy environmental staff, in consultation with both Atlantic and Pacific naval formations, that this document needed to be amended to include specific mitigation measures that are currently identified in the MARCORD. In the hierarchy of RCN documents, the MARCORD should provide policy and responsibilities, and the class SEMS SOPs should contain procedures and specific measures, rather than the other way around. This was a major part of the project. In addressing content of the class SEMS manual, the Halifax Class manual was selected to be the first to undergo amendment. It applies to the largest number of large ships operating the most powerful sonars in the inventory. Amendment of other class SEMS manuals was not possible within the scope of this project.

Specifically within the Halifax Class SEMS manual, Standard Operating Procedure (SOP) E5: *Marine Mammals and Reptiles* was substantially amended to include marine mammal mitigation measures in general, and to include a detailed description of procedures to mitigate marine mammal disturbance when operating active sonars. A proposed re-write of the entire SOP – going far beyond just those measures related to active sonar use - was undertaken as part of this project.

The principal changes to this document as a result of this project include:

a. Additional responsibilities of commanding officers;

b. Making mitigation requirements mandatory for relevant areas with restrictions as well as Marine Protected Areas and avoiding those areas entirely, if possible;

c. Inclusion of specific measures for active sonar operations;

d. Mandatory reporting requirement of marine mammal sightings;

e. Enhancing the requirement for training and awareness briefings; and

f. Additional guidance and direction to Officers of the Watch and Lookouts who function as marine mammal observers.

Of note, the MARLANT FSE office is responsible for the content of both the MARLANT SEMS manual and the class SEMS manuals for each class of ship across the entire navy. This arrangement of responsibilities is important to achieving the outcomes of this project. Changes to the class SEMS manuals, and implementing those changes, can be staffed expeditiously once consensus with principal stakeholders has been reached. The resultant document has been distributed for final approval by key stakeholders and is attached as Appendix B.

Chapter 8: Education and Training Review

As with any policy or plan, effectiveness depends on how well it is implemented. That in turn depends in large part on how well the organizations and individuals charged with responsibility for marine mammal mitigation procedures are trained and educated. Implementation of MMMP within the RCN was a key area to be reviewed as part of this project and has led to specific recommendations to enhance it. Before those recommendations could be made, it was necessary to review the extant direction in the MARCORD for education and training and investigate how that was implemented within the formal course structure of the RCN and other less formal training. This proved to be a daunting task in the time available.

The current MARCORD is very directive in assigning responsibilities for effective training in MMMP. It states the following:

> These measures to mitigate potential active sonar impacts on MM are the result of MARCOMs commitment to protect and sustain the environment where it operates and trains. To achieve and sustain this objective will require positive and proactive education of Operational planners, Ships, Helos [helicopters], and MPA [Maritime Patrol Aircraft] personnel, on the need for and content of these procedures. TEs tasked with training lookouts, Lifebuoy sentrys and OOWs are to contact Formation Environment offices to arrange for lectures and exercises. Training staffs are to amend QSPs [Qualification Standards Publications], lesson plans and procedures IAW with these instructions. Sea Training staffs are to

ensure that an Environmental Diligence Briefings (EDB) to Lookouts, Lifebuoy sentries, OOWs [Officers of the Watch], CBT [Combat] operators, including ships personnel is included as a WUPs [Work Ups] lecture requirement. Formation Environment Offices will produce standard Ship Briefing Packages to be available upon request. Formation Environment Offices are also to work closely with formation Operational Planners to provide MM databases and OPAREA [Operating Areas] planning tools along with any applicable local training. (MARCORD 46-13 Paragraph 17).

After an investigation of formal training on this issue, the following was revealed:

a. Sonar operator supervisors are trained in the use of AN/SQS-510 sonar ramp-up procedures, Mitigation Avoidance Zone radii for all active sonars, shut-down protocols when marine mammals are detected within MAZ, and recording of detections of marine mammals in sonar logs. Students are led through an in depth review of the MARCORD and practice the ramp-up procedure in both the classroom and in sonar simulators. Practical assessment of the ramp-up procedure is conducted at sea in a training environment;
b. Underwater Warfare Directors (managers of the operators of sonar systems and other underwater sensors, and anti-submarine weapons) receive similar training plus additional instruction on reporting of detections of marine mammals to other key members in the ship. During their training, students are led through a review of the MARCORD and receive a lecture on the specific MMMP procedures as

they relate to active sonar, including reactions upon detection and associated risks to marine mammals;

c. Operations Room Officers (managers of the combat capability of the entire ship) receive a lecture on planning considerations to avoid marine mammals and external reporting requirements of marine mammal detections;

d. Navigating Officers are instructed on the requirement and procedures to report marine mammal detections on a routine basis, specific reporting requirements when a marine mammal in obvious distress, or trapped in fishing gear, has been detected, and provided guidance on transit planning to minimize marine mammal encounters; and

e. Sonar operators also receive extensive training in aural recognition of biological sound sources. This occurs at two levels in their careers with an introductory course early on, and more in-depth training later in their careers. Various data files compiled from open source sites are used although primarily this information comes from the Royal Navy's (United Kingdom) Acoustic Data Analysis Centre's web program SAND (Sea Animal Noise Database). This database includes a regularly updated collection of hundreds of common species found throughout the world's oceans and contains specific images, sounds, lifestyle information and detailed data on appearance, size, feeding areas and migration patterns. Of note, this training is also provided to sensor operators in the Royal Canadian Air Force who fly in shipboard helicopters and Maritime Patrol Aircraft (MPA) that have an anti-submarine warfare mission.

Of interest was that no formal training exists for Officers of the Watch (OOW) (responsible for ship movements, safety and internal daily routine while on watch, on behalf of the commanding officer) or for on-watch lookouts charged with reporting visual detections of other ships, fishing vessels/gear, navigation aids or any other sightings of interest to the OOW – this includes marine mammals. It should be noted, however, that both coastal FSE offices provide ships with marine mammal recognition posters, for animals specific to each coast, to assist in identifying any marine mammals that are observed. The training of OOWs and Lookouts is a key issue. As has been shown, the effectiveness of marine mammal observers is a critical factor in the number of sightings made and in the accuracy of those sightings.

There is no specific training for current or prospective commanding officers, although periodically, the MARPAC FSE office provides a briefing on environmental issues to the Command Development Course (a course intended for mid-level officers pursuing the qualification for command at sea) held on the west coast.

MMMP procedures and training for submarine crews and commanding officers were not reviewed or assessed as part of this project. Often, however, submariners are best positioned in the water column, and have excellent passive listening equipment and operator skillsets, that they could make a significant contribution with regard to reporting of marine mammal detections.

8.1. Training Recommendations

As a result of this review, I assess that sonar operators receive adequate training in marine mammal aural recognition that would support effective Passive Acoustic Monitoring. Further, their training in current active sonar mitigation measures is appropriate. Underwater Warfare Directors also receive adequate training related to their responsibilities for marine mammal mitigation. Nevertheless, operator and director training programs will have to be reviewed and amended based on changes in key documentation resulting from this project.

Once the specific mitigation measures from the MARCORD migrate to the NAVORD (and SEMS manuals), the SEMS manuals will become the key repository of all this information. It will be the place for "one stop shopping" on MMMP. Consequently, rather than train to the MARCORD as is currently done, with the upcoming change to the NAVORD and SEMS, the formal training should be changed to train to the SOPs located in both formation and ship class SEMS. To this end, the following is recommended:

a. Naval Training Establishments should undertake a review of the NAVORD and SEMS SOP E5 and determine what changes need to be made to the existing qualifications and lesson plans. Emphasis should be placed on enhancing Operations Room Officers (ORO) training and awareness of planning considerations for exercises, and Navigating Officers (NAVO) training on ship passage planning and marine mammal reporting;
b. In the RCN context, OOWs and Lookouts are marine mammal observers. Special attention needs to be paid to improve their skills by introducing formal training

into their curricula. As seen in the scientific review, the quality of the observer training plays a major role in the number and accuracy of sightings. The FSO offices on each coast can provide subject matter expertise to develop this training;

c. Prospective and current commanding officers will have, as a minimum, received training on MMMP at the ORO level in their careers. However, nothing beyond that is provided as a specific requirement. Consequently, it is recommended that the Command Development Course include the formalized requirement for a specific MMMP briefing from MARPAC FSE to emphasize the regulatory framework, planning considerations and procedures relevant to the command level;

d. Coastal Sea Training Staffs, in consultation with formation FSE offices, should develop Environmental Diligence Briefings that include MMMP and that this is presented as part of the Work Ups lecture series; and

e. As planning to avoid marine mammal habitat is the single, most effective measure to minimize adverse impacts on marine mammals, Fleet exercise planning staff should be made aware of, and trained in, the available products and environmental planning considerations. These products include charts depicting sensitive areas, marine mammal areas of concentration by time of year and environmental assessments on normal operating areas. Although formation FSE offices provide this service to planners, primarily on an “as requested” basis, the requirement for awareness briefings for planners should be institutionalized to ensure all planning staff receive this information as they rotate into these positions to ensure exercises are not planned in areas of marine mammal concentrations.

It is understood that any additional training will need to compete for student time and staff resources with a myriad of other requirements, but it can be made to happen if this issue is a sufficient priority.

Chapter 9: Additional Considerations and Recommendations

Both the old MARCORD and the new NAVORD apply to shipboard helicopter and maritime patrol aircraft aircrews. These assets frequently operate under RCN control and direction, but often they do not. It is unclear whether the active sonar mitigation measures for helicopter dipping sonars and active sonobuoys used by both helicopters and MPA are addressed in their training programs. Further, aircrews have a major role to play in the recording and reporting of marine mammal detections but again, it is unclear how this is implemented in the RCAF. Beyond training airborne sensor operators in aural recognition of marine mammals, awareness and training of MMMP in the maritime air community is an issue beyond the scope of this project but will need to be addressed. This also applies to awareness and training of submarine crews.

New active sonar equipment is delivered to the fleet on a continual basis. The introduction of low frequency active (LFA) sonar and continuous active sonar (CAS) with likely force changes to be made in active sonar mitigation measures. This will have to be addressed in the near future.

New active sonars are being developed to improve marine mammal detections with a minimum of disturbance to these animals. On-going cooperation with DRDC(A) scientists should be undertaken to assess the effectiveness of these systems with a view towards developing or acquiring these systems for RCN use.

It would be appropriate for the Comd RCN to announce the promulgation of the new NAVORD. This should be done by means of a general message to all naval personnel (NAVGEN) and also to draw attention to the amendments to the class SEMS manuals for MMMP. This message should also endorse training and awareness recommendations previously identified.

Beyond addressing the implementation of naval MMMP, an opportunity exists for the RCN to contribute to the improvement of the quality of the scientific body of knowledge regarding marine mammal distribution and behaviour. By ensuring adherence to marine mammal reporting requirements that are already promulgated, and by sharing that information with DFO or other agencies for use in the updating of marine mammal databases, continuous refinement of these data is possible. In addition, standardizing marine mammal reporting in format and otherwise and making it broadly accessible will help maximize its worth. This in turn will make for a better planning product for the RCN when FSEs obtain the latest data from DFO. Liaison with DFO should be enhanced to ensure the type of information collected is optimized for both DFO and navy purposes. In this manner, the RCN will not only be showing due diligence in mitigating harm to marine mammals, but it will also be contributing in a positive way to the breadth of knowledge on marine mammal locations and behaviours. And this is not a static situation. Climate change and other environmental factors are changing the habitats of marine mammals and a continual process of reporting, recording and disseminating of this information will be required.

Chapter 10: Conclusion

This project was an ambitious undertaking to assist the RCN in developing and implementing marine mammal mitigation procedures for active sonar use. As it is their goal to be responsible stewards of the environment, they were eager to sponsor this project as it dovetailed neatly into the on-going effort to update guidance documents on this issue.

The project unfolded in two distinct parts. Firstly, a literature review and discussions with subject matter experts were conducted to identify what was known regarding the impacts of man-made noise, and active sonars in particular, on marine mammals. This included a review of mitigation measures commonly used and an informal assessment of their effectiveness. In so doing, mitigation measures could be identified for incorporation into RCN policies and procedures.

The second part of the internship was initially to be focussed on placing those mitigation measures identified in the first part into appropriate RCN policy and procedural documents, and provide recommendations on implementing the requirements of those directives. This would not prove to be simple. During the second internship it was discovered that the RCN already had a vast amount of documentation, training and guidance materials related to marine mammal mitigation procedures. An assessment was made of the effectiveness of those measures based on what was learned during the first internship period. To do so, it was necessary to review huge amounts of relevant information to determine what documents and processes would be impacted by changes

in the over-arching policy that was included in the NAVORD. In the end, many amendments were made that went beyond the narrow issue of mitigating adverse impact on marine mammals solely from active sonar use.

Implementation of policy and procedures largely depends on how well training is designed and delivered to the RCN personnel who require it. This prompted a review of the training system as it relates to this subject that included assessments on the effectiveness of existing training, and discussions with training staff that led to recommendations for areas for improvement.

The final outcomes of the project are threefold. Firstly, after many revisions, a refined draft of the NAVORD was produced covering the high level policy guidance. This version is undergoing final review within the RCN chain of command. Second, specific mitigation procedures at the user level were incorporated into ship class SEMS manuals. This document has been passed to the MARLANT FSE office for final approval and promulgation to the Fleet once stakeholders have been consulted. Thirdly, formal training was assessed for adequacy given the direction that is included in the aforementioned documents, and recommendations for improvement were suggested as this is a crucial aspect of implementation. These training recommendations have been shared with the sponsor for further consultation with the Naval Training System personnel.

In general, however, in reviewing all of the RCN documentation and training on this issue, it can be stated that the RCN had made significant progress towards a

comprehensive system to mitigate adverse impacts on marine mammals from active sonar use. This project was a partial validation of that system and led to concrete outcomes to improve it.

Appendix A (Note: this appendix is a copy of the actual NAVORD. Formatting is inconsistent with this paper)

NAVORD 4003-6

Naval Orders – Marine Mammal Mitigation Procedures for Active Sonar Use

1. Identification

Date of Issue	XX July 2014
Date of Modification	XX July 2014
Application	This order and directive applies to those members of the Canadian Armed Forces (CAF) and employees of the Department of National Defence (DND) who serve or are employed with the Royal Canadian Navy (RCN).
Supersession	Maritime Command Order (MARCORD) 46-13
Approval Authority	This Naval Order (NAVORD) is issued by the Commander Maritime Forces Atlantic, under the authority of the Commander of the Royal Canadian Navy (CRCN).
Enquiries	Maritime Forces Atlantic (MARLANT) Operations Readiness (N52)

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2. Definitions

Active Sonar System	An underwater detection device that transmits sound and receives echoes to detect and localize targets. These include fitted systems in ships and submarines, helicopter dipping sonar and active sonobuoys.
Areas with Restrictions (AWR)	An area with restrictions due to environmental sensitivities. Restrictions may be on some or all Naval activities, and may be seasonal or year round. AWR may include but are not limited to Marine Protected Areas (MPAs), proposed MPAs, and International Marine Organization (IMO) Areas to be Avoided. RCN or Coastal Commands may promulgate other environmentally sensitive areas where it has been decided to impose operational restrictions.
Mitigation Avoidance Zone (MAZ)	The underwater region surrounding a sound source where marine mammals may be disturbed, harassed or harmed. MAZ size is to be calculated using a sound exposure level that minimizes adverse impacts on marine mammals. Average distances resulting from these calculations for normal Canadian operating areas are to be included in the class SEMS manuals and are to be used in the absence of more refined data.
MMMP Policy and Direction	The suite of instruments containing Marine Mammal Mitigation Procedures (MMMP); including this NAVORD as the Policy, and MMMP Direction in the form of standard operating procedures, directives, manuals, training aids, and other instruments used by the RCN to communicate mandatory requirements.
Operating Authority	For the purposes of MMMP policy implementation, the Operating Authority includes the Officer in Tactical Command, Officer Conducting the Exercise and Commanding Officers for single ship operations and exercises.
Safety and Environment Management System (SEMS)	An integrated management system that includes the organizational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing and maintaining the RCN's safety and environmental policy and programs, including MMMP where appropriate.

3. Strategic Context

3.1.

Background

Some marine mammal strandings around the world have been linked to the use of active military sonar. While the scientific community broadly accepts that more research is still needed to understand the specific relationship of underwater noise on marine mammals, North Atlantic Treaty Organization and other allied countries and their Navies accept the use of marine mammal mitigation measures when using such Active Sonar Systems.

In Canada, marine mammals are primarily protected by the *Fisheries Act* and its regulations and by the *Species at Risk Act* (SARA) for those marine mammals that are at risk.

In accordance with DAOD 4003-0 and the Defence Environmental Strategy, the RCN shall exercise due diligence in complying with all applicable environmental requirements that ensure the protection of marine mammals.

3.2.

Purpose

The purpose of this NAVORD is to provide overarching direction for conducting exercises, trials, maintenance and operations that involve the use of Active Sonar Systems that may disturb, harass or harm marine mammals.

3.3.

Scope

This NAVORD applies to all Canadian ships, submarines, helicopters, and long range patrol aircraft deploying Active Sonar Systems when conducting peacetime exercises and domestic operations.

There are no restrictions applied to the use of sonar systems in the passive mode or for navigation purposes.

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4. General Requirements

4.1.

Principles

The underlying principle of the MMMP Policy in this NAVORD is that it serves to guide the implementation of precautionary measures that will result in the identification of low risk areas for exercises and operations. Planners and operators shall carry out mitigation measures specified by the following requirements and through further MMMP Direction found in Formation and Ship Class SEMS Manuals.

4.2.

Planning

Planners shall utilize operating area management tools in order to select areas that present the lowest risk of marine mammal encounter and to avoid planning activities within an AWR. These tools are available from the MARANT Safety and Environment/MARPAC Formation Safety and Environment (FSE) Offices and include information such as marine mammal habitats, migration routes, breeding areas, and associated timings. This type of information is subject to frequent updates; as a result, planners are required to consult with FSE Offices to verify that they possess the most up-to-date tools necessary for informed decision-making.

All efforts and alternatives shall be made to:

- plan operations during daylight hours to maximize marine mammal detection opportunities;
- avoid scheduling operations in areas where the MAZ is predicted to be greater than normal; and
- Ensure RCN MMMP Policy and Direction is conveyed to foreign vessels when operations are planned.

4.3

Canadian Vessels in Foreign Waters

Units conducting bilateral or multinational operations, outside the Canadian AOR, in which there are limited marine mammal mitigation procedures, shall advise allies of the requirement for RCN units to comply with national direction contained herein.

4.4

Foreign Vessels in Canadian Waters

These procedures also apply to all foreign naval units and assets under CAF control within the Canadian area of responsibility. For visiting foreign naval units not under CAF control, formations are to inform the foreign units of RCN policies.

4.5

Areas with Restrictions Considerations

Exercises involving active sonar operations should not be planned or conducted within an AWR. When deemed necessary to use Active Sonar Systems within an AWR where active sonar is restricted, the Operating Authority shall be prepared to:

- justify that active sonar operations are necessary for national security and public safety;
- document this decision;
- ensure that the MMMP in the class SEMS manual is strictly followed by unit(s) involved; and
- contact FSE Offices for further guidance and advice.

4.6

Education and Awareness

To achieve and sustain the requirements of this NAVORD, training organizations are to ensure existing training on MMMP complies with this NAVORD and the procedures identified in the Formation and Class SEMS manuals.

FSE offices shall ensure that awareness briefs, and ongoing operational training remain aligned with this NAVORD and applicable procedures outlined in Formation and Class SEMS manuals.

Educational briefings and awareness materials will be provided to Operational Planners, Ships, Helicopter and Maritime Patrol Aircraft personnel by Formation FSE offices upon request.

5. **Responsibilities**

The…	has/have the responsibility to …
DComd RCN	• establish MMMP Policy.

DNTE	• ensure the Naval Training System provides instruction on MMMP to the personnel responsible to execute this policy and procedures.
Formation Commanders	• implement Formation directives consistent with RCN MMMP Policy and provide appropriate direction, support and oversight.
Fleet Commanders	• implement Fleet MMMP Direction.
Commanding Officers	• ensure personnel under their command are aware of MMMP Policy and Direction and have access to training aids including identification materials provided by FSE Offices. Specific mitigation measures outlined in the class SEMS manuals are to be followed.
MARLANT N52	• as NAVORD OPI, oversee, develop and manage MMMP Policy and Direction.
MARLANT Safety and Environment/MARPAC Formation Safety and Environment Offices	• develop, update and manage SEMS MMMP Direction and training tools. • provide MMMP expertise and guidance to Fleet and Formations.

6. References

Source References

Fisheries Act and its *Marine Mammal Regulations*

Species at Risk Act

NAVORD 1004-0 Safety and Environment Program Management

MARCORD 46-3 Safety Firing Orders for Ships & Submarines

MARLANTORD 44-4 Requests For Service Support

Safety and Environmental Management System (SEMS):
- Ship Class SEMS Manuals
- MARLANT Formation SEMS Manual
- MARPAC Formation SEMS Manual

Related References

DAOD 4003-0 Environmental Protection and Stewardship

Defence Environmental Strategy

Appendix B (Note: This appendix is an extract from the Halifax Class SEMS manual. The two annexes to this SOP have not been included and formatting is inconsistent with this paper.)

SOP E5 – MARINE MAMMALS AND REPTILES

References

A. Fisheries Act, DFO, 1985
B. Marine Mammal Regulations of the Fisheries Act, 1993
C. Marine Mammals of Atlantic Canada, Communication Directorate, DFO, 1994
D. 2006 Annual Notices To Mariners: A.2 Marine Mammal Guidelines and Marine Protected Areas
E. Watching Whales, Communication Directorate, DFO, 1984
F. NAVORD 4003-6 Marine Mammal Mitigation Procedures for Active Sonar Use
G. Formation SEMS Manuals
H. MARCORD 46-03 Safety Firing Orders For Ships & Submarines
I. MARLANT OP Area Management Plan (MOAMP) User's Guide
J. Marine Mammal Identification Tools – Identifying Whales, Dolphins, Seals and Sea Turtles in the MARLANT Operations Area
K. Marine Mammal Identification Tools – Posters (Identifying Whales, Identifying Dolphins and Porpoises)
L. Marine Mammal Database (ADAC CD)

Purpose

1. To minimize the environmental impacts on marine mammals, reptiles, and species at risk (SAR) especially while operating and training in designated Op Areas. This is accomplished by adhering to mitigation measures promulgated in RCN and coastal directives such as references F, G and I, and as outlined in this SOP, and by the use of reporting and recording procedures by DND vessels, HMC Ships and Submarines, auxiliary vessels, and aircraft to support applicable databases that assist in operational planning. This SOP may also be used for stewardship practices in other maritime areas.

Scope

2. This SOP applies to all ship personnel.

Definitions

3. Area with Restriction (AWR). An area with restrictions due to environmental sensitivities. Restrictions may be on some or all Naval activities, and may be seasonal or

year round. AWR may include but are not limited to Marine Protected Areas (MPAs), proposed MPAs, and International Marine Organization (IMO) Areas to be Avoided. RCN or Coastal Commands may promulgate other environmentally sensitive areas where it has been decided to impose operational restrictions.

4. Distress - any behaviour that would appear to be abnormal and indicative of suffering or being in danger, this includes but is not limited to beaching, entanglement and fleeing.

5. Disturbance - an attempt to pursue, hunt, chase, follow, disperse, drive, herd or encircle marine mammals or reptiles, and any intentional act of negligence resulting in the disruption of their normal behaviour.

6. Marine Mammal - any warm-blooded animal produced by or found in the sea or large body of water. This includes, but is not limited to whales, dolphins, porpoises and seals.

7. **Marine Protected Area (MPA)** - Canada's Oceans Act (Section 35 (1)) states that a marine protected area is an area of sea that forms part of the internal waters of Canada, the territorial sea of Canada or the exclusive economic zone of Canada and has been designated under this section for special protection for one or more of the following reasons:

a. the conservation and protection of commercial and non-commercial fishery resources, including marine mammals, and their habitats;

b. the conservation and protection of endangered or threatened marine species, and their habitats;

c. the conservation and protection of unique habitats;

d. the conservation and protection of marine areas of high biodiversity or biological productivity; and

e. the conservation and protection of any other marine resource or habitat as is necessary to fulfill the mandate of the Minister of Fisheries and Oceans Canada.

8. Normal Behaviour - for marine mammals and reptiles usually relates to their ability to migrate, hunt, feed, communicate, socialize, rest, breed and care for young.

9. Reptiles - any cold-blooded marine or freshwater animal, encased in a shell of bony plates, and having flippers or webbed toes used in swimming (e.g. sea turtle).

Organization/Personnel Responsibilities

10. The Commanding Officer (CO) is responsible for compliance and commitment to this SOP.

11. The Navigating Officer (NavO) is responsible for assessing the risk of encountering marine mammals during transit planning, avoiding those areas if possible, and the reporting of detections of marine mammals.

12. The Officer of the Watch (OOW) is responsible to ensure that required records are completed IAW this SOP.

13. The on-watch Operations Room Officer (ORO) shall coordinate all activities while within an MPA and work with the Heads of Department (HODs) to ensure activities are controlled IAW this SOP in any area where marine mammals may be encountered.

Mitigation Measures:
Ships Movements (General)

The Department of Fisheries and Oceans (DFO) is responsible for ensuring the conservation and protection of marine mammals and reptiles. In most instances of ship strike or disturbance, a marine mammal or reptile is either not observed, or observed too late for avoidance action by the vessel operator. In order to mitigate these circumstances, the following guidelines shall be followed:

a. avoid exercises or operations in areas and time periods identified by DFO as whale sanctuaries, concentration areas for feeding, or breeding. This information can be obtained from FSE offices on each coast. If areas cannot be avoided, proceed at slow speeds, navigate away from the marine mammal and post additional lookouts;

b. when encountering marine mammals or reptiles, do not expect them to get out of your way. Steer clear of them to avoid collision;

c. if it is not possible to manoeuvre around an individual or group of marine mammals or reptiles, slow down immediately and wait until you are more than 400 m away before resuming speed; and

d. in conditions of limited visibility, the CO shall reasonably decide whether to continue operations with underwater sound generating systems based upon most recent observation and reports from maritime assets of marine mammal activity in the operating area, and adopt reasonable risk mitigation measures based upon predicted marine mammal presence.

Mitigation Measures:

Transiting a Marine Protected Area or Area with Restrictions

14. While transiting an MPA or other Area with Restrictions, the ship shall observe strict controls on all emissions and activities that could threaten the environment.

15. Unless in an emergency or with the COs approval, the ship shall not conduct the following activities within an MPA or within an AWR if the area has been restricted due to concerns regarding the presence of marine mammals:

e. refuel the RIB;

f. conduct diesel generator decoking;

g. exercise full power manoeuvres;

h. launch smokes or flares;

i. conduct gunnery or small arms firings of any kind;

j. discharge oily water;

k. dump gash;

l. discharge black or grey water;

m. transmit on active HMS sonar;

n. tow the CANTASS or NIXIE;

o. drop bathys, sonobuoys or EMATTs;

p. drop scare charges, diver recalls or anti-frogmen devices; and

q. conduct multi-ship manoeuvres such as TOWEX, RAS or OOW manoeuvres.

16. If the ship engages in any of the aforementioned activities, the OOW shall record the activity in the OOW Notebook.

17. The ship should conduct the following activities prior to transiting a MPA or AWR:

r. educate the on-watch crew on the MPA and ship limitations within it;

s. make a general awareness "pipe" to the ship's company;

t. record environmental factors within the MPA, including weather, radar and sonar ranges, in the OOW Notebook;

u. listen for marine mammal calls if possible, and log detections;

v. log all sightings of marine mammals and reptiles in the Marine Mammal Sighting Records;

w. post-report MPA or AWR transit to the relevant Fleet Commander; and

x. direct garburator discharge to black/grey water tanks.

18. The on-watch ORO shall coordinate all activities within the MPA or AWR and work with the HODs to control the activities as listed above. All aspects require close direction by OOWs, HODs and on-watch supervisors.

Mitigation Measures:

Ordnance and Weapons Firing

19. Conducting weapons firing exercises when marine mammals and reptiles are known to be in the impact area can carry a severe penalty under the *Fisheries Act* (reference A). Mitigations to be employed by the ship during weapon firing exercises include avoiding times and places where Maritime Operations could interact with marine mammals and reptiles. References G and H provide the following direction with respect to firing exercises and marine mammals:

a. firing shall cease if it is apparent that projectiles may fall within 2000 yards of marine mammals;

b. to the greatest extent possible during range clearance procedures, check that weapon splash points and predicted weapons track are clear of any sighted MM for a 4000 yd radius; and

c. to the greatest extent possible during range clearance procedures, check that EMATT splash points and predicted track are clear of any sighted MM for a 500 yd radius.

21. In the event an encounter with a marine mammal occurs while conducting a weapons firing exercise, "Check Fire" procedures shall be implemented until the animal is safely out of the line of fire or the firing arc, or the marine mammals have not been sighted for ten minutes. Further mitigation includes:

a. utilization of "Best Available Control Technology" to limit excessive noise or water, air, or sediment quality impacts;

b. establishing a buffer zone (radius dependent on weapons system) around intended targets;

c. ensuring no visible signs of marine wild life in established buffer zones;

d. upon sighting marine wildlife, a visual scan should be conducted to determine if others are present, and approximate locations and numbers of any wildlife shall be reported to the bridge;

e. exercises are only to be conducted if the buffer zone is clear of marine wildlife;

f. ships personnel shall employ the most effective search tactics and capabilities to increase the probability that marine mammals and/or reptiles will be detected within the buffer or exercise area;

g. ships lookouts shall be briefed on the possible presence of marine wildlife, what to look for, and that all sightings need to be reported to the bridge. Whales and pinnipeds often travel in groups and a sighting indicates the possibility of others in the vicinity. Upon sighting the aforementioned, lookouts will visually scan for others that may be present and adjust course and speed as necessary to maintain a safe distance from wildlife, consistent with prudent seamanship; and

h. take reasonable measures to alert other ships and/or aircraft in the area of the presence of marine mammals or reptiles and record and report marine mammal sightings IAW Annex E5A and E5B.

22. Icebergs are not to be used as targets due to the potential habitation by many marine and avian species.

Mitigation Measures:

Active Sonar Use

23. The proximity of marine mammals shall be considered whenever exercises or operations involve the use of underwater sound generating equipment due to the potential adverse effects that can result. Explosive devices, underwater telephones, active sonobuoys, active sonars, NIXIE decoys, etc. may pose a pervasive disturbance, harassment or injury risk to marine mammals and shall be conducted as described below. There are, however, no restrictions applied to the use of sonar systems in the passive mode or for navigational purposes.

24. **Visual Observation and Passive Acoustic Monitoring.** Conduct surveillance of exercise/operation area if possible. Traditionally, the most effective sensors in detecting MM activity have been (in descending order): Visual; UWT below 12 kts; Passive Sonobuoys; CANTASS; and HMS Passive. Specifically:

a. OOW, lookouts, and lifebuoy sentry to conduct and maintain visual and infrared, search for MM;

b. maintain bridge and ops room radar watch for MM, IAW EMCON policy;

c. at a minimum of 30 minutes prior to energizing active sonar systems, set watch on passives systems to include UWT, Passive Sonobuoys, CANTASS (if deployed), and HMS passive to detect MM; and

d. when available, make use of aerial vehicles, and underwater vehicles to locate and monitor MM.

25. **Mitigation Avoidance Zone (MAZ**). Sound intensity underwater decreases with range due primarily to attenuation and geometric spreading losses. METOC centres on both coasts have computed the Transmission Loss (TL) at a number of sites in Canadian Operational Areas (OPAREAS). A minimum of 1 hour prior to event start, launch bathythermograph to calculate current sound velocity profile and compare with acoustic range prediction systems to assess potential for increased ranges beyond normal MAZ. By considering the Source Levels of Canadian Active Sonar Systems and the estimated TL in the vast majority of cases in the Canadian OPAREAS, the following MAZ have been established:

a.	SQS 510	4000 yds,
b.	Thomson 2024	1000 yds,
c.	AQS-502	1000 yds
d.	SLQ 25/25A	1000 yds (not applicable if HMS active)
e.	DICASS Buoys	300 yds
f.	MH HELRAS	TBD
g.	SSQ-565 Buoy	TBD
h.	DM 21/other HE	6000 yds

26. Procedures when a MM is located within MAZ:

a. to the greatest extent possible, suspend active sonar transmissions until MM is outside MAZ;

b. establish/estimate MM position and track;

c. Convey MM last known position and track to participating units;

d. helos conducting dipped sonar transducer operations are to suspend transmissions until MM moves outside 1000 yd radius of sonar transducer or break dip and relocate outside the MAZ;

e. Maintain passive listening watch on underwater warfare equipment;

f. so far as practicable manoeuvre to prevent CANTASS and/or Nixie crossing the path of MM;

g. cease dropping SUS, E-SUS or explosive charges; and

h. video record and/or photograph MM sightings.

27. **Ramp-Up Procedures**: This practice assumes the principle that local MM will either avoid or become accustomed to the sonar's sounds and thus reduce the potential negative consequences on their health and safety. Because the SQS-510 sonar was not designed with a ramp-up mode capability, the ramp-up procedure described below provides what is achievable based on the current SQS-510 hardware configuration. Furthermore, the range of vocalization frequencies for a variety of MM species indicates that little is gained in varying between the 3 selectable SQS-510 frequencies. As a result, the SQS-510 sonar is to be employed in the 7.2 kHz, Mine Avoidance Linear Period (LPM) waveform mode, for the majority of the ramp-up period. This mode emits the least amount of energy for a given transmission mode. The 700 Hz sweep width is to be used as it minimizes the possibility of exciting any MM cavity resonance.

a. **Phase 1: 0 to 5 minutes**;

i. Directional Transmission Wide (DTW);
ii. Low power;
iii. 1 emission in manual mode, in the exercise grid direction or, if already in the grid, in the direction of least MM encounters probability; and
iv. Ships are to listen for any MM feedback.

b. **Phase 2: 5 to 10 minutes**;

v. DTW;
vi. Low power;

vii. Range scale at maximum, in the exercise grid direction or, if already in the grid, in the direction of least MM encounters probability; and
viii. Operators are to maintain passive attention for MM feedback and direction of source.

c. **Phase 3: 10 to 15 minutes**:

ix. Omni transmit;
x. Low power;
xi. Range scale at maximum, and
xii. Operators are to maintain passive attention for MM feedback and direction of source.

d. **Phase 4: 15 to 17 minutes**;

xiii. DTW;
xiv. High power;
xv. Range scale at maximum, and
xvi. Operators are to maintain passive attention for MM feedback and direction of source.

e. **Phase 5: 18 to 20 minutes**;

xvii. Emit 1 Omni Transmission;
xviii. High power;
xix. Range scale at maximum, and
xx. Operators are to maintain passive attention for MM feedback and direction of source.

28. If a unit joins a ship that has commenced or completed Ramp-Up Procedures, the joining unit may commence under water sound transmissions at a phase equal to or earlier of the former unit provided that the joining unit is within the MAZ of the former unit

29. **Recording and Reporting**. Record all MM sightings/interactions in SDM VDR, ship's log, ops room log, sonar logs, and other exercise/operational reporting formats.

a. the OOW shall maintain the sighting log on the bridge IAW the format at Annex E5A. A copy of this log is to be forwarded to the coastal FSE office upon return to home port;

b. convey MM sightings to consorts;

c. be prepared to video record and/or photograph MM sightings;

d. report **ALL** MM sightings (whether transitting an MPA, detecting a marine mammal within the MAZ, or sightings during routine operations whether or not active sonar is being operated) IAW Annex E5B. If EMCON policy or other restrictions make daily reporting problematic, units are to report this information as soon as practicable.

Marine Mammal and Reptile Reporting Procedures for Marine Mammals and Reptiles in Distress.

31. Marine mammals or reptiles may require assistance if found entangled, injured or in distress. *Do not attempt to rescue or disentangle the marine mammal or reptile.* The CO or delegated authority is responsible to contact DFO or the Coast Guard through the respective Emergency Network as soon as possible:

(MARPAC)
Toll Free (24 hours) 1-800-465-4336

(MARLANT)
1-800-565-1633

Or Coast Guard VHF CH. 16

32. Upon sighting a marine mammal or reptile in distress, the CO is responsible to report the information to JIOC and FSE using the Marine Mammal And Reptile Report message at Annex E5B. The vessel may also be asked for assistance with the recovery, rescue, and/or disposal of the marine mammal or reptile. The OOW must record the following information related to the incident in the OOW notebook:

y. type of marine mammal or reptile;

z. latitude and longitude;

aa. contact reference information (Agency contacted and DTG notified); and

bb. brief incident details.

Training and Education

33. Marine mammal identification tools, such as posters and information booklets, are provided to the ships through coastal FSE offices. They are to be available on the bridge and OOWs and Lookouts shall be briefed on their use.

34. FSE will provide the applicable units with a briefing on marine mammal recognition and reporting procedures upon request. As a minimum, this is a mandatory requirement of the WorkUps lecture series.

35. Specific formal training responsibility is also outlined at reference F.

Records

Annex E5A - Marine Mammal Sighting Record
Annex E5B - Marine Mammal and Reptile Report Message

Bibliography and References

Ainslie, M.A. and Von Benda-Beckmann, A.M., Optimal soft start and shutdown procedures of stationary or moving sound sources. (2012). *Proceedings of Meetings on Acoustics - ECUA 2012 11th European Conference on Underwater Acoustics.* Edinburgh.

Baker, K. Eppersone, D., Gitschlag, G., Goldstein, H., Lewandowski, J., Skrupky, K., Smith, B. and Turk, T. (2013). National standards for a Protected Species Observer and data management program: a model using geological and geophysical surveys. *US Department of Commerce. NOAA Technical Memorandum. NMFS-OPR-49. P. 73*. Retrieved from: http://www.nmfs.noaa.gov/pr/publications/techmemo/observers_nmfsopr49.pdf

Von Benda-Beckmann, A.M., Wensveen, P.J., Kvadsheim, P.H., Lam, F.A., Miller, P.J., Tyack, P.L. and Ainslie, M.A. (2013). Modeling Effectiveness of Gradual Increases in Source Level to Mitigate Effects of Sonar on Marine Mammals. *Conservation Biology, 28(1)*, 119–128.

Canada. Coast Guard Canada (CCG), (2014). Annual Edition April 2014 to March 2015. *NOTICES TO MARINERS 1 to 46*. Retrieved from: http://www.notmar.gc.ca/eng/services/annual/annual-notices-to-mariners-eng.pdf

Canada. Department of Environment (EC), (no date). *Species at Risk Public Registry – Offshore Killer Whale*. Retrieved from: http://www.sararegistry.gc.ca/default.asp?lang=En&n=F6FD3521-1&offset=1&toc=show

Canada. Department of Fisheries and Oceans (DFO). (2002) *Species at Risk Act*. Retrieved from: http://www.sararegistry.gc.ca/species/schedules_e.cfm?id=1.

Canada. Department of Fisheries and Oceans (DFO). (2010). *Guidance related to the efficacy of measures used to mitigate potential impacts of seismic sound on marine mammals. Department of Fisheries and Oceans (Canada) Canadian Science Advisory Secretariat Research Document 2010/043*. Page 13. Retrieved from: http://www.dfo-mpo.gc.ca/Library/341565.pdf

Claridge, D.E. (2013). *Population ecology of Blainville's beaked whales* (*Mesoplodon densirostris*). Thesis presented for Doctor of Philosophy in Marine Biology at University of St Andrews, Scotland, UK. 313 pp.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). (2013). *Canadian Wildlife Species at Risk.* Retrieved from: http://www.cosewic.gc.ca/eng/sct0/rpt/rpt_csar_e.cfm

DeRuiter, S.L., Southall, B.L., Calambokidis, J., Zimmer, W.M.X., Sadykova, D., Falcone, E.A., Friedlaender, A.S., Joseph, J.E., Moretti, D., Schorr, G.S., Thomas, L and Tyack, P.L. (2013). First direct measurements of behavioural responses by Cuvier's beaked whales to mid-frequency active (MFA) sonar. *Biology Letters 9: 20130223.*

Dolman, S.J., Weir, C.R., and Jasny, M. (2009). Comparative review of marine mammal guidance implemented during naval exercises. *Marine Pollution Bulletin 58*, 465–477.

Erbe, C. (2013). International Regulation of Underwater Noise. *Acoustics Australia. 41(1), 12.*

Finneran, J.J. and Branstetter, B.K. (2013). Chapter 10. Effects of Noise on Sound Perception in Marine Mammals. In H. Brumm (Ed.), *Animal Communication and Noise, 273 Animal Signals and Communication 2* (p. 277), Berlin: Springer-Verlag.

Goldbogen JA, Southall BL, DeRuiter SL, Calambokidis J, Friedlaender AS,Hazen EL, Falcone EA, Schorr GS, Douglas A, Moretti DJ, Kyburg C, McKenna MF, Tyack PL (2013). Blue whales respond to simulated mid-frequency military sonar. *Proceedings of the Royal Society B 280: 20130657*. Retrieved from: http://dx.doi.org/10.1098/rspb.2013.0657

Hatch, L.T and Wright, A.J. (2007) A Brief Review of Anthropogenic Sound in the Oceans. *International Journal of Comparative Psychology, 20*, 121-133.

Hildebrand, J. (2009). Anthropogenic and natural sources of ambient noise in the ocean. *Marine Ecology Progress Series, 395 (5).* 5-20.

International Association of Geophysical Contractors (IAGC) (2014). *IAGC Guidance on the Use of Towed Passive Acoustic Monitoring during Geophysical Operations*. Retrieved from: http://www.iagc.org/media/files/page/912e7c50/IAGC_Guidance_PAMGuide_VF_2014.pdf.

International Whaling Commission (IWC) (2014). *Report of the Scientific Committee. Bled, Slovenia, 12-24 May 2014*. Retrieved from: https://archive.iwc.int/pages/view.php?ref=3436

Moors-Murphy, H.B. and Theriault, J. (2014 – in preparation). *Review of mitigation measures for cetacean Species at Risk during seismic survey operations. Department of Fisheries and Oceans (Canada) Canadian Science Advisory Secretariat Research Document 2014/nn.*

National Oceanographic and Atmospheric Organization (NOAA), (2012). *International Marine Mammal Action Plan 2012-2016*. Retrieved from: http://www.nmfs.noaa.gov/ia/species/marine_mammals/immap.pdf

National Oceanic and Atmospheric Administration (NOAA). (2013). *Draft Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammals. Acoustic Threshold Levels for Onset of Permanent and Temporary Threshold Shifts*. Retrieved from: http://www.nmfs.noaa.gov/pr/acoustics/draft_acoustic_guidance_2013.pdf

National Research Council (NRC) (2003). *Ocean Noise and Marine Mammals*. National Academy Press, Washington, D.C.

Nichol, L. (2009). *An assessment of some of the factors affecting observer efficacy during cetacean surveys in Canada's Pacific region. . Department of Fisheries and Oceans (Canada) Canadian Science Advisory Secretariat Research Document 2009/065.* Page 26. Retrieved from: http://www.dfo-mpo.gc.ca/csas-sccs/publications/resdocs-docrech/2009/2009_065-eng.htm

Rolland, R.M., Parks, S.E., Hunt, K.E., Castellote, M., Corkeron, P.J., Nowacek, D.P., Wasser, S.K. and Kraus, S.D. (2012). Evidence that ship noise increases stress in right whales. *Proceedings of the Royal Society, 0*, 1-6.

Romano, T.A., Keogh, M.J., Kelly, C., Feng, P., Berk, L., Schlundt, C.E., et al (2004). Anthropogenic sound and marine mammal health: Measures of the nervous and immune systems before and after intense sound exposure. *Canadian Journal of Fisheries and Aquatic Sciences. 61*, 1124-1134.

Southall, B.L., Bowles, A.E., Ellison, W.T., Finneram, J.J., Gentry, R.L., Greene Jr., C.R., Kastak, D., Ketten, D.R., Miller, J.H., Nachigall, P.E., Richardson, W.J., Thomas, J.A. and Tyack, P.L. (2007). Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations. *Aquatic Mammals, 33(4)*.

Theriault, J.A.; Fisher, G.; Pecknold, S., (2005). 2005 synopsis on Canadian environmental legislation and policies affecting active sonar research based in Nova Scotia, *Oceans 2005 - Europe , vol.2*, pp.1015,1019. Vol. 2, 20-23 June 2005 doi: 10.1109/OCEANSE.2005.1513196

Theriault, J. and Moors-Murphy, H.B. (2014a – in preparation). *Species at Risk criteria and seismic survey noise thresholds for cetaceans. Department of Fisheries and Oceans (Canada) Canadian Science Advisory Secretariat Research Document 2014/nn.*

Theriault, J.A and Moors-Murphy, H.B. (2014b). Marine Mammal Mitigation Impact

Efficiency. *Presentation to the Maritime Acoustic Symposium, Halifax, N.S.* June 2014. Slides 9 and 10.

Tyack, P.L., Zimmer, W.M.X., Moretti, D., Southall, B.L., Claridge, D.E., et al. (2011) Beaked Whales Respond to Simulated and Actual Navy Sonar. *PLoS ONE 6(3):* e17009. doi:10.1371/journal.pone.0017009

United States Environmental Protection Agency (EPA). (No date). Southern and Northern Resident Killer Whale Critical Habitats in the Georgia Basin-Puget Sound Region. Retrieved from: http://www2.epa.gov/sites/production/files/2013-06/orca-critical-habitat.jpg

Vanderlaan, A.S and Taggart, T.T. (2009). Efficacy of a Voluntary Area to be Avoided to Reduce Risk of Lethal Vessel Strikes to Endangered Whales. *Conservation Biology 23(6),*1467.

Walmsley, D. and Theriault, J. (2011). *Ocean Noise: State of the Scotian Shelf Report*. Retrieved from: http://coinatlantic.ca/docs/ocean-noise.pdf

Weilgart, L.S. (2007). The impacts of anthropogenic ocean noise on cetaceans and implications for management. *Canadian Journal of Zoology, 85,* 1091-1116,

Weilgart, L.S. (2014). Are We Mitigating Underwater Noise-Producing Activities Adequately? A Comparison of Level A and Level B Cetacean Takes. *IWC Scientific Committee Annual Meeting 2014 (SC65B).* Retrieved from: https://events.iwc.int/index.php/scientific/SC65B/paper/view/795

Weir, C.R. and Dolman, S.J. (2007). Comparative Review of the Regional Marine Mammal Mitigation Guidelines Implemented during Industrial Seismic Surveys, and Guidance Towards a Worldwide Standard. *Journal of International Wildlife Law and Policy, 10,* 1-7.

Wright, A.J. (2014). *Reducing Impacts of Human Ocean Noise on Cetaceans: Knowledge Gap Analysis and Recommendations*. Gland, Switzerland: WWF International.