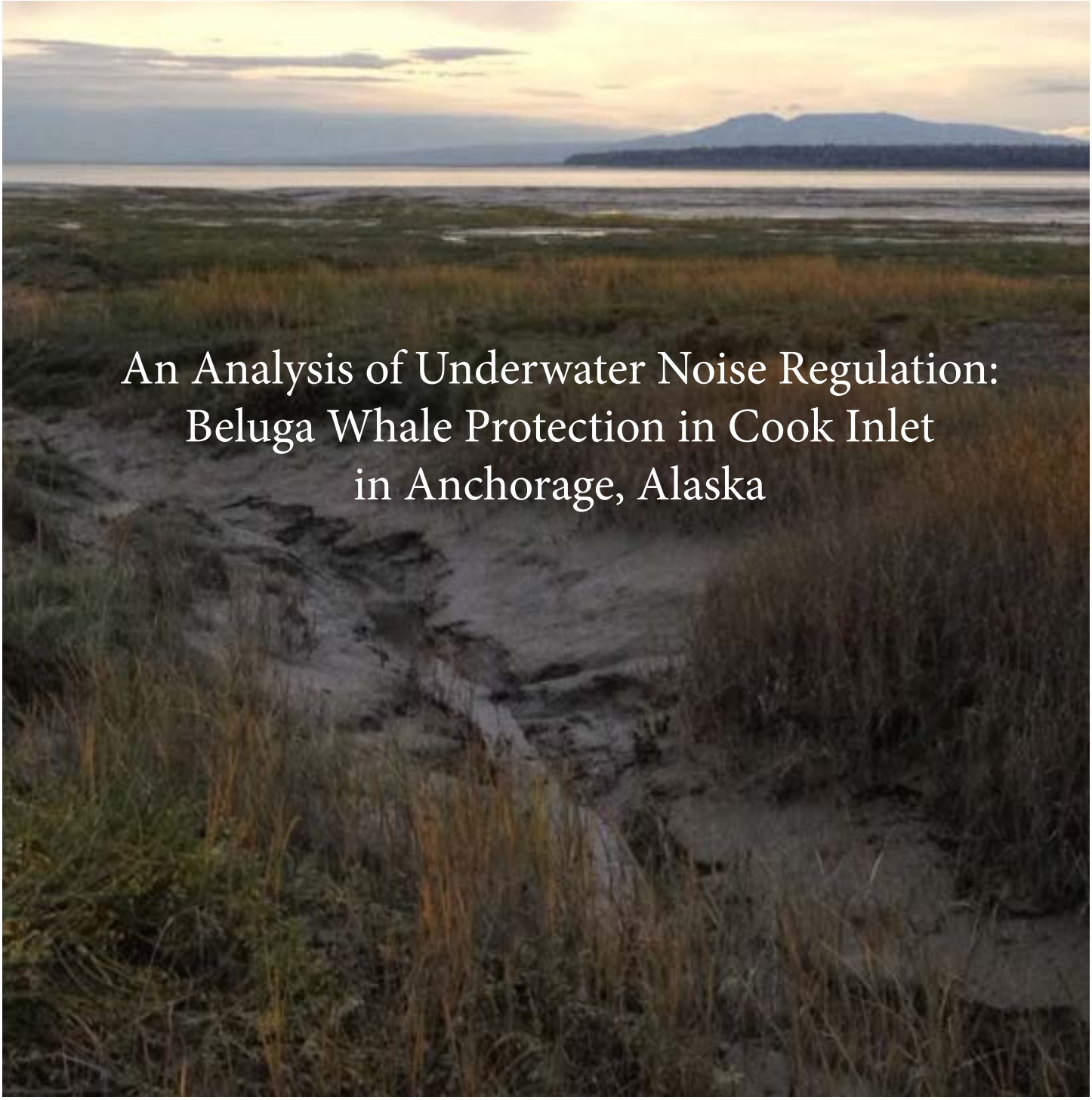

An Analysis of Underwater Noise Regulation: Beluga Whale Protection in Cook Inlet in Anchorage, Alaska

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Author's Note

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The beauty and intelligence of the Cook Inlet beluga and the majesty of their northern home are truly inspiring.

This paper is dedicated to the extraordinary people who through scientific observation and documentation will substantiate the plight of the Cook Inlet beluga, in order to increase international, national, regional, and probably most importantly, local concern for this endangered specie in context of the anthropogenic noise pollution of its habitat.

Alexander Miller
March 2015

Photo: Chris Garner

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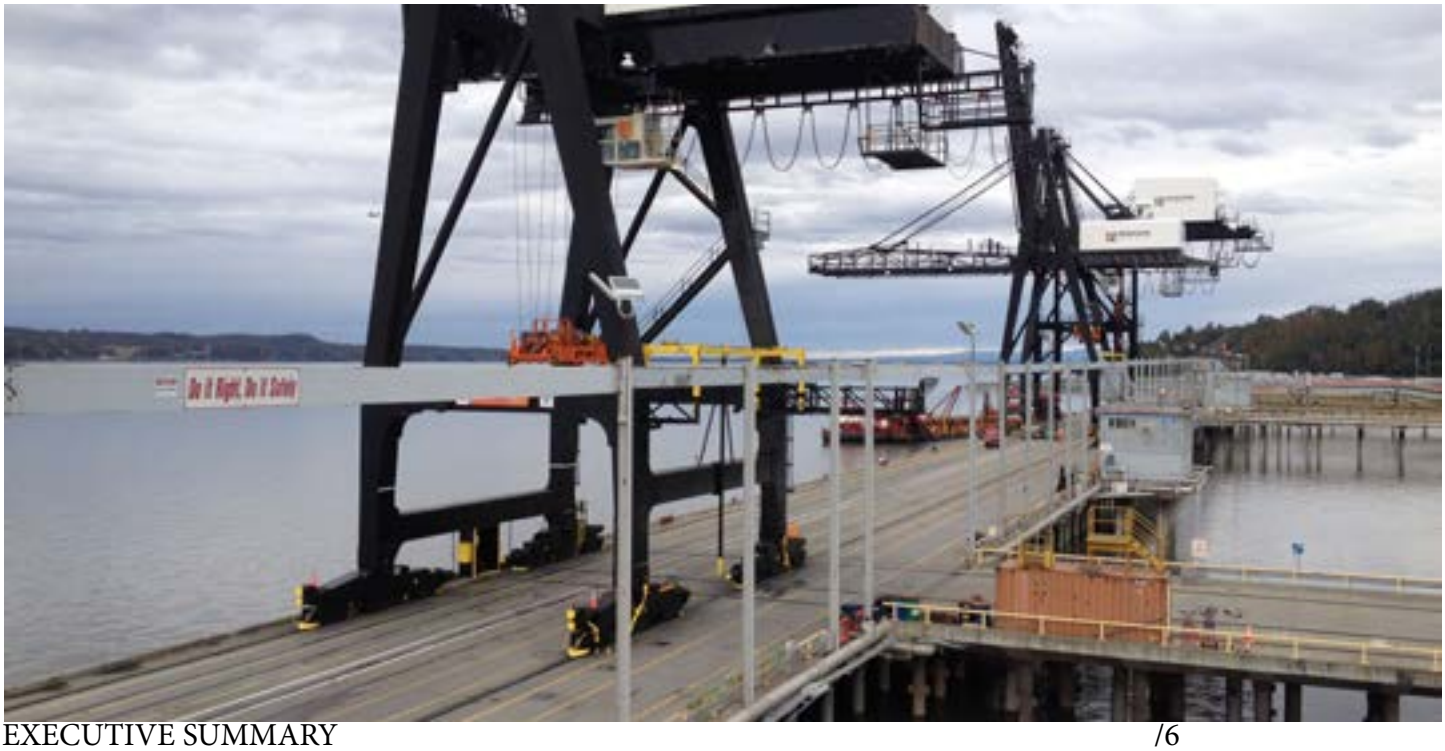

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Appendix of Abbreviations

ASCOBANS – Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas
CI – Cook Inlet
CIB – Cook Inlet Beluga
CIBA – Cook Inlet Beluga Acoustics
ESA – Endangered Species Act
IUCN – World Conservation Union
IWC – International Whaling Commission
MMBD AP – Marine Mammal Behavioural Disturbance Action Plan
MMPA – Marine Mammal Protection Act
MPA – Marine protected area
NMFS – National Marine Fisheries Service
NMSA – National Marine Sanctuaries Act
NMSP – National Marine Sanctuary Program
NOAA – National Oceanic and Atmospheric Administration
OGV – Ocean going vessel
PAM – Passive acoustic monitoring
PTS – Permanent threshold shift
SBNMS – Stellwagen Bank National Marine Sanctuary
SRKW – Southern Resident Killer Whale
TEK – Traditional ecological knowledge
TTS – Temporary threshold shift
USFWS – United States Fish and Wildlife Service
VSR – Voluntary speed reductions

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Cook Inlet is a body of water in south central Alaska that is the site of industrial activity, military activity and commercial vessel traffic. Cook Inlet is also home to a genetically and geographically unique beluga whale population—the Cook Inlet Beluga. As of 2008, the National Marine Fishery Service listed this population as endangered. Anthropogenic (i.e. human-induced) noise from a variety of sources may cause adverse behavioural and health effects to marine mammals. As cetaceans make use of sound as their primary sensory response for a variety of activities (i.e. foraging, navigation, detecting predators, hunting, etc.), increased noise levels from anthropogenic sources can interfere with these activities. Knowing that there is substantial human activity in Cook Inlet, it is reasonable to hypothesize that the noise created by these activities may have some impact upon the Cook Inlet Beluga. The extent and nature of these impacts is currently under investigation; the Cook Inlet Beluga Acoustics Research Program (CIBA) is one of the teams exploring the different noises as well as their sources and intensities. Largely relying on passive acoustic monitoring techniques, this team has categorized 14 different anthropogenic noises in the Inlet.

This research project focuses on municipal policy relating to the regulation of underwater noise in Anchorage, Alaska. The research employed a mixed-method approach involving literature review, interviews with experts as well as informal consultation (i.e. telephone, email and in-person correspondence). Planners, engineers, scientists and other agents from the Municipalities of Anchorage, Matanuska-Susitna Borough and Port Metro Vancouver were contacted, with limited response. The study begins with an exploration into international, national and regional policies available to reduce underwater noise. In the United States, the National Oceanic and Atmospheric Administration acoustic guidance as well as Marine Protected Areas and National Marine Sanctuaries regulate underwater noise likely causing disturbance to marine mammals. The Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS) in Europe also illustrates some innovative approaches, primarily focused on mitigation measures with respect to naval and civil sonar.

In the case of the Municipality of Anchorage, there are a number of voluntary mechanisms readily available to the Port Authority to reduce noise that may be causing disturbance to the beluga. These measures include: voluntary speed reductions of commercial vessels; bubble curtains and acoustic and visual monitoring for in-water construction; and involvement in the Green Marine Program for environmental performance. Potential for mitigation of acoustic disturbance may also stem from the Municipality of Anchorage Noise Ordinance and (recently withdrawn) Coastal Management Plan. Within Anchorage's existing municipal legislation—including the noise ordinance and recently discarded Coastal Management Plan—there is potential for mitigation of possible noise-related impacts. The research argues that noise protection for the Cook Inlet beluga can be addressed in the noise ordinance regulation based on the premise that the beluga are vital to Anchorage's identity, heritage and quality of life.

Introduction

A. Background: the Cook Inlet Beluga

Up until 2009 there was limited knowledge of beluga whale ecology in Cook Inlet (CI), Alaska. Significant information gaps existed concerning habitat, population distribution, foraging patterns, factors impeding recovery, among other ecological considerations. Subsequently, numerous research projects have been undertaken, including the Cook Inlet Beluga Acoustics (CIBA) research program, involving a team of experts from the Alaska Department of Fish and Game, National Marine Mammal Laboratory, Hawaii Institute of Marine Biology and the University of Alaska Fairbanks—as well as from other organizations—which has been contributing to increased understanding of beluga ecology in the region through the use of Passive Acoustic Monitoring (PAM). Belugas are known as the "Canaries of the Ocean", meaning they are one of the most vocal and communicative marine animals, and thus acoustic techniques lend themselves very effectively to monitoring their activity (National Marine Fisheries Service, 2008). Foraging, migration, communication, and presence of predators are some of the activities that can be studied using PAM.

Cook Inlet is in southcentral Alaska, north of the Gulf of Alaska (Fig 1) and west of the Kenai Peninsula (Fig 2); Anchorage, Alaska's largest city, is in upper Cook Inlet. Large oil and gas deposits are present in CI, which has resulted in substantial energy development, industrial centers, and transportation hubs. Activities associated with energy exploration, development, commercial fishing, municipal discharges, and transport traffic (i.e. aircraft, shipping and tourism), pose risks to the CI environment. In 1979 the Cook Inlet beluga whale population was estimated at 1,300 animals. Abundance of the Cook Inlet beluga is estimated through counts obtained during aerial surveys, through which a 47% decline was calculated between 1994 and 1998 (NMFS, 2008). This report identified unregulated subsistence harvest as the primary cause of this severe population decline. The US National Marine Fisheries Service (NMFS) designated the stock as depleted under the Marine Mammal Protection Act in May of 2000 (NMFS, 2008), and the subsistence harvest has been severely restricted to 0-2 whales per year (NMFS, 2008). Following the depleted designation, surveys indicated a population decline of 1.5% per year, prompting the NMFS in 2006 to reevaluate the stock's status, from which there were several important conclusions (NMFS, 2008, p.1):

i. The contraction of the population range northward into the upper Inlet makes the population more vulnerable to any catastrophic events in that area.
ii. The population was not growing at 2 to 6 percent per year as had been anticipated with the cessation of unregulated hunting.

In 2008, the NMFS listed the genetically distinct and geographically isolated population of Cook Inlet belugas as endangered under the US Endangered Species Act. Factors including stranding events, predation, parasitism, disease, environmental change, and others are likely precluding the recovery of the beluga.
Some belugas live in shallow, coastal waters whereas other stocks in Alaska occupy deep offshore waters; others make seasonal migrations but Cook Inlet belugas remain in the same general area year-round (NMFS, 2008). Specifically, they concentrate in the upper inlet at the mouths of rivers and bays in summer and fall, most likely to forage, and then disperse offshore and move to mid-inlet waters in the winter months (NMFS, 2008). Systematic aerial surveys and traditional ecological knowledge indicate a contraction of the summer range of Cook Inlet belugas; they were once commonly seen in the lower Inlet in summer months, but they are now concentrated in the upper Inlet (NMFS, 2008). This pattern of habitat distribution has been attributed to the reduced population seeking the highest quality habitat; this area now offers the most abundant prey, most favourable feeding conditions, and the best calving area with safety from predators (NMFS, 2008).

Introduction

Figure 1: Location of Cook Inlet in southcentral Alaska

Source: Apache Corporation, 2014

Figure 2: Cook Inlet, Alaska

Source: Cook Inlet Risk Assessment Advisory Panel, 2011

B. Project Scope

This project reviews measures for the regulation of underwater anthropogenic noise. While the focus of the research is intended to be on local policy initiative, the trans-boundary nature of the marine environment necessitates an exploration into senior level and international measures. This project begins with an overview of how anthropogenic noise affects marine mammals. What follows is a description of some international, national, regional, and municipal approaches to regulating underwater noise from anthropogenic sources. Then, the project specifically discusses underwater noise and protection of the Cook Inlet beluga, and measures for the protection of the Cook Inlet beluga from acoustic disturbance. Finally, in addition to presenting some of the challenges of research in this area, the project makes some observations and recommendations.

C. The Approach to the Project

The research questions (and interview questions) were as follows:

- What tools, policies or instruments may Municipalities apply to regulate underwater noise?
- Which activities causing noise are under the jurisdiction of municipal or city governments?
- What are feasible and cost-effective policies that may be taken by the Municipality of Anchorage to protect Cook Inlet Beluga whales from acoustic disturbance?

Interviews vs. Literature Review and Informal Consultation

Answers to the research questions are addressed mostly from literature review, supplemented by insightful information obtained from informal interviews or consultation with experts via telephone, in-person and email correspondence. The following authorities and agencies were contacted and provided with interview questions:

a) Municipality of Anchorage:
- Port of Anchorage
- Port Engineering Department
- Long Range Planning
- Health and Human Services
- Air Quality Program
- Watershed Management

b) Municipality of Matanuska-Susitna Borough
- Port Mackenzie
- Animal Care
- Community Development
- Environmental Planning
- Land Use Planning

c) Port Metro Vancouver
- Container Expansion
- Environmental Programs
- Marine Mammal Monitoring Program (ORCA RADAR)

d) World Wildlife Fund Canada

D. Ethics

The University of British Columbia Research Ethics Board granted ethics approval for this project.

E. Methods

This project used a mixed methods approach; a literature review was combined with expert interviews and less formal consultation. The literature review involved researching the scientific literature on marine mammals and underwater noise, various planning documents (i.e. noise ordinances, community plans, coastal management plans), as well as the literature on noise policy and international, national, regional, and municipal measures for marine mammal protection.

The interview component involved interviewing experts in the field, both formally and informally (i.e. consultation while visiting Anchorage, during on-water observation in Cook Inlet, and in email communication and telephone conversation, but with no formal questions asked or answered) concerning municipal policy and other measures for underwater noise. Interviews and consultation were only conducted at the municipal level in Anchorage and Matanuska-Susitna Borough, and not with respect to regulation at state, federal or international level.

PART 2 THE PROBLEM: EFFECT OF ANTHROPOGENIC NOISE ON COOK INLET BELUGA

A. Role of Cook Inlet Beluga Acoustics (CIBA) Research Program

The Cook Inlet Beluga Acoustics (CIBA) Research Program began in 2009 and has collected over 4 years of sounds recordings at over 10 different locations in the upper, mid and lower Cook Inlet. To date, this is the most comprehensive set of sound recordings in the region. The initial goal of the research was to describe the seasonal distribution of the Cook Inlet beluga; however, the data collected can also be used to document anthropogenic noise sources and their frequency of occurrence in Cook Inlet and beluga habitat.

The objectives of the recordings are as follows (Castellote et al., 2014, p.1):

i. Describe the detailed acoustic characteristics of the different anthropogenic noise sources detected from a selection of the available recordings, with emphasis on the potential impact on Cook Inlet beluga hearing and communication.
ii. Describe the frequency of occurrence of these different types of noise in their habitat.
iii. Quantify the potential impact on Cook Inlet beluga based on the current NOAA regulatory acoustic thresholds.
iv. Provide a summary of the seasonal acoustic detection of beluga whales.

Based largely on passive acoustic monitoring (PAM) techniques, the research team has categorized 14 anthropogenic 'noise events' (Castellote at al., 2014, p.3):

1. Outboard engine (small skiffs, rafts)
2. Commercial ship
3. Dredging
4. Pile Driving
5. Air gun
6. Commercial airplane
7. Military jet
8. Propeller aircraft
9. Military detonation
10. Depth sounder
11. Unclassified machinery (continuous mechanical sound [e.g. engine])
12. Unknown up-or-down-sweep (modulated tone of mechanical origin [e.g. hydraulics])*
13. Unidentified "clank-bang" (impulsive mechanical sound, e.g. barge dumping)
14. Unidentified (unclassifiable anthropogenic sound)

* The source(s) of "Unknown up-or-down-sweep noises" are not fully understood, and the acoustic structure of the sound is similar to cetacean whistles or calls, such as that of a killer whale call (Castellote et al., 2014).

B. Harmful Effect of Noise on Marine Animals

International concern about the impact of noise pollution in our world's oceans is growing due to the mounting scientific evidence that anthropogenic noise can harm and even kill marine species, including many endangered marine mammals. This evidence calls for a decision on what could and should be done to mitigate the effects of noise pollution.

-Angela Haren, 2007

A growing body of literature highlights the effects of marine noise on marine ecosystems and particularly on marine mammals (Scott, 2008; Heise and Aladina, 2012; Nordtvedt Reeve, 2012). As a result, there is a growing understanding of the significant threat posed by anthropogenic noise to marine animals and the need to mitigate potential impacts. According to Scott (2008), "Pollution of an acoustic nature is currently omitted from traditional works on the protection of the marine environment and is as yet the subject of very little jurisprudential discussion." Although underwater noise can be recorded and measured, correlating changes in behaviour or impact to marine life with underwater noise is problematic; thus, effectively implementing such information into policy and practice is similarly difficult.

Cetaceans use sound as their primary sensory response for a variety of activities including (but not limited to) foraging, detecting predators, navigation and hunting. Sounds can be used both passively and actively. Active uses include social communication (for making contact and conveying status, to maintain group cohesion and for territorial defense; intergroup and interspecies communication (for competition and intimidation); hunting and foraging (for prey detection); as well as object detection using echolocation (Barrett-Lennard, 2014). Passive uses of sound include detection of predators and rivals (by hearing vocalization); hunting and foraging (by hearing prey's vocalizations and other incidental sounds); and to orient and navigate (by referring to consistent sounds such as waterfalls and surf noise and by assessing reverberation and resonance of external sounds) (Barrett-Lennard, 2014).

Increased noise levels—especially those from human sources—can hinder passive listening by increasing the challenge to locate prey, to navigate and orient silently, to communicate and avoid competition. Noise can muffle swimming sounds, which may increase the difficulty for prey to detect predators. Nowacek et al. (2007) have identified 3 categories of response to noise for cetaceans including behavioural (e.g. changes in surfacing and diving), acoustic (e.g. changes in type or timing of vocalizations relative to the noise source) as well as physiological (e.g. auditory threshold shift and 'stress'). Nowacek et al. (2007) also identified 4 primary concerns for cetaceans exposed to elevated noise levels:

- permanent threshold shifts (PTS)
- temporary threshold shifts (TTS)
- acoustic masking
- behavioural disturbance

Effects of underwater noise on marine mammals

i) Changes to auditory signals: Permanent Threshold Shift and Temporary Threshold Shift

The hearing threshold is the amplitude necessary for detection and the threshold varies according to the frequency across the hearing range of a given individual. Permanent and temporary threshold shifts are actual change in the animal's ability to hear, usually occurring at a given frequency, whereby hearing becomes less sensitive at other frequencies following exposure to a particular sound (Nowacek et al, 2007). The former represents a permanent change to auditory sensitivity and the latter a temporary alteration; the duration of the threshold shift varies according to the magnitude of the noise. Temporary and permanent threshold shifts are thought to have parallel effects on marine mammals as masking: reduction in foraging efficiency, reproduction, social cohesion and the ability to detect predators (Weilgart, 2007).

ii) Masking

Masking occurs when a sound makes a whale's signal difficult or impossible to detect. Masking is thought to particularly affect cetaceans that communicate over large distances of open ocean; for example, blue whale (Balanaeoptera musculus) and fin whale (Balaenoptera physalus) calls can be heard over thousands of kilometers and are thought to function in attracting widely dispersed mates (Croll et al., 2002). If these reproductive calls are masked, the widely distributed mates will not be able to locate one another and reproductive rates could decline. Cetaceans also likely need to hear the sounds of their prey or predators, mates, or navigation signals; faint acoustic noises from distant sources may be critical for navigation and orientation (Weilgart, 2007). According to Erbe and Farmer (2000) the ramming noise from ice breakers was interpreted to mask beluga calls to ranges of 40km and cause disturbances over ranges of 46km.

iii) Displacement from important habitat and avoidance

Behavioural responses are an observable or measurable change in the activity of an animal in response to sound. An example would be the termination of an important activity (e.g. feeding or nursing) in response to a noise; continual abandonment of such activity can lead to immediate or eventual consequence for the animal in question. In one example, two different research teams and data from several years indicated that beluga whales usually avoided icebreakers at distances of 35-50km, at the point where they could probably just perceive them. They travelled approximately 80km from the ship track and usually remained away for periods of up to 2 days (Finley et al. 1990; Cosens and Dueck 1993). In another example, sperm whales that were approached very closely by an active seismic vessel did not make their habitual foraging dives. The whales substantially reduced their fluke stroke effort by 6% during exposure to seismic noise compared with after; all 7 sperm whales in the study reduced their fluke strokes on foraging dives in the presence of seismic noise (International Whaling Commission, 2007).

iv) Strandings

Cetacean "strandings" are one particular behavioural response to noise that has received particular attention due to its immediate, devastating and highly visible consequences to many different whale species. Essentially, stranding is a marine mammal found in the following circumstances: dead on shore; alive on shore but unable to return to the water; or in a foreign habitat (i.e. river or shallow water) and unable to return to its own habitat (i.e. deeper water) without assistance (Weilgart, 2007). The exact reasons for cetaceans stranding events are not fully understood: some strandings have been attributed to biotoxins or disease; other events have been determined as being related to disease and injury; finally, mass stranding events—where multiple whales, usually of the same species become stranded—take place in healthy animals (Weilgart, 2007).

v) Blast injuries

Blast injuries are another consequence that noise—in this case very loud, abrupt noise—can have on cetaceans. Explosions are used for coastal deconstruction, the removal of underwater structures (decommissioning oil rigs, for instance), in naval exercises, or for naval "ship-shock" trial to test the strength of a ship's hull. These noises comprise a separate category, as they contain a shock wave in addition to an acoustic wave. The blast waves cause a drastic pressure drop across a very short time-span and are relatively broadband in frequency; this results in mechanical impact (Weilgart, 2007). Consequences from this type of exposure include organ damage and the rupture of gas-filled cavities such as lungs, sinuses, and ears; for example, a 5000kg explosion apparently caused severe injury to the temporal bones of two humpback whales found dead near the explosion site (Weilgart, 2007).

vi) Auditory development

Though less readily observable than stranding and blast events, impacts to auditory development from the long-term, continuous exposure to the increased levels of background noise in the oceans can be detrimental to cetacean health. This problem poses particular harm to auditory development in young animals; in fact, even moderately elevated levels of background noise have been shown to cause developmental delays in the brain and auditory system (Chang and Merzenich, 2003).

vii) Noise and stress

Studies of the effects of stress caused by noise on cetaceans are currently derived mainly from extrapolations on terrestrial mammals (OSPAR Commission, 2009), and inferences indicate that underwater noise can act as a stressor in marine mammals with consequences to individual health and population viability. However, this area of study is relatively new and the conclusions are only preliminary (OSPAR Commission, 2009). These preliminary conclusions, however, do not only apply to cetaceans; underwater sound has also been associated with both physiological and behavioural effects on some fish and some invertebrates, which serve as food for marine mammals.

C. Commercial Shipping: Source of Particularly Detrimental Sound

Ships transport approximately 95% of the world's trade tonnage; commercial shipping is by and large central to the global economy (Haren, 2007). Ocean shipping is an efficient mode of transporting large quantities of goods across long distances at an affordable rate. With no current substitute to meet the transport capacity, there is strong economic incentive for companies to use commercial shipping. In fact, there has been steady growth in vessel traffic over the past few decades, according to vessel operation statistics (Haren, 2007). How might Cook Inlet belugas be affected by commercial shipping? Supertankers and container ships emit low frequency tones—which travel across long ranges—and source levels in the order of 180-190dB (re 1 microPA@1m); sound generated by large commercial vessels is in the same frequency range produced by many whale species, predominantly at low sonic (<1000 Hz) and infrasonic (<20Hz) (Haren, 2007).

Essentially, this means that the noise from large commercial shipping vessels interferes with different whale signals at the same frequencies—a phenomenon known as "masking." This process of masking essentially increases the background noise level in the ocean to the point that it interferes with natural species communication. Since hearing is the primary sense for marine life, this type of "acoustic smog" could essentially blind marine life and limit the range over which they can navigate and find food (Haren, 2007).

Research in the Stellwagen Bank National Marine Sanctuary (see: Case Study 1) has shown that masking has substantially reduced the communication space of whales by up to 67% since the advent of modern shipping (Petruny et al., 2007). According to Petruny et al. (2014), "Commercial shipping has substantially raised background noise levels in the oceans, especially at low frequencies…and is now recognized as a major challenge to the protection of marine mammals and other sea life…Behavioural reactions to disturbance from shipping may occur, but the interpretation and ultimate significance is unclear" (p.3). Apart from masking, the noise from commercial ships is also known to cause psychological stress to aquatic life and particularly to whales. Prolonged exposure of noise and the need to cope with the associated masking likely leads to chronic stress of a species. In a study by Petruny et al. (2014) reductions in the level of cortisol—one of the primary mammalian hormones associated with the stress response—was witnessed in North Atlantic right whales during a reduction in shipping traffic in 2001. Chronic stress is likely associated with adverse health effects to whales as it is to humans, but the exact complications are not well understood. Given that Anchorage is Alaska's busiest port, there is reason to believe that vessel traffic may be affecting beluga behaviour.

The growing use of the ocean for international shipping is thought to be making a major contribution to the overall ambient underwater noise at low frequencies. Commercial ships—defined here as those greater than 100m in length and including container/cargo ships, super-tanker and cruise liners—are not only increasing in number, but also in terms of propulsion power and size, and are producing increasingly greater amounts of noise as a result of regular operation (OSPAR Commission, 2009). The majority of the acoustic environment surrounding these large vessels is the result of propeller cavitation that occurs when vacuum bubbles created by the motion of propellers collapse; this causes ships at their servicing speed to emit low-frequency tonal sounds at multiples of the propeller blade rate (i.e. [shaft speed in revolutions per second] X [number of propeller blades]) and high-frequency noise spectra up to tens of kHz very close to vessels (OSPAR Commission, 2009). Other sources of noise associated with the operation of these vessels include onboard operations such as engine room and auxiliary equipment. In addition to operating speeds affecting overall acoustic emissions from commercial ships, propeller depth is also important with respect to long-range propagation (OSPAR Commission, 2009). Propeller depth has increased in recent years and, as a result, so too has long-range propagation. Importantly, although commercial ships predominantly emit low frequencies that effect animals using low frequencies to hear and communicate, they also can radiate high frequency noise. Noise in the high frequency bands emitted by these vessels has the potential to disturb the communication signals of a variety of marine mammals not commonly associated with ship noise masking (OSPAR Commission, 2009).

There is substantial commercial vessel traffic in Cook Inlet because Anchorage is one of the region's busiest ports. Since commercial vessels in general have been shown to adversely impact cetacean activity, any management plan for beluga recovery or conservation in Cook Inlet should incorporate plans to mitigate the potential impact of these ships. Most likely, direction for such mitigation will come largely from the port authority. Changing shipping tracks or lanes, reducing engine speeds, instituting "no-go" zones as well as implementing ship quieting technologies are all options for reducing the impact of commercial vessels on beluga activity and livelihood.

PART 3 MARINE SPECIES PROTECTION MEASURES

This section highlights innovative conservation measures for underwater noise management. While the context of this project is municipal, it is necessary to first explore the relevant international, national and regional policy.

A. International Measures to Reduce Marine Acoustic Disturbance

The International Whaling Commission (IWC), a leading organization on conservation and management of global whale stocks, has stated that there is "compelling evidence" that noise pollution is a serious threat to marine mammals and is cause for "serious concern" (IWC, 2004). Furthermore, inclusion of anthropogenic noise assessments within the framework of national and international ocean conservation plans have been recommended (e.g. consideration during designation of critical habitats, marine protected areas and ocean zoning) (IWC, 2004).

The World Conservation Union (IUCN) is another international organization advocating restrictions of underwater noise for the betterment of aquatic species. In 2004, the IUCN made a resolution calling for member countries to limit—until impacts are more completely understood—the use of loud ocean noise sources including military sonar, oil and gas exploration as well as commercial shipping. The resolution calls for members to consider noise restrictions in marine protected areas and to avoid the use of such sources in habitat of vulnerable species and in areas where marine mammals or endangered species may be concentrated (IUCN, 2004). Unfortunately the US, as a member of the IUCN, abstained from voting on this motion mainly due to federal investment in military sonar at the time (IUCN 2004).

B. National and Regional Measures to Reduce Marine Acoustic Disturbance

This section explores the National Oceanic and Atmospheric Administration's acoustic guidance, as well as the benefits of marine protected areas and marine sanctuaries in relation to mitigating underwater noise.

i) Development of Acoustic Guidelines

The National Oceanic and Atmospheric Administration (NOAA) is in the process of developing acoustic guidance for assessing the effects of anthropogenic sound on marine mammals species under their jurisdiction. These guidelines seek to provide acoustic threshold levels for the inset of permanent and temporary threshold shift for all sound sources (NOAA, 2014). The guidelines will be used by NOAA decision-makers and policy analysts—among stakeholders from other groups—to better predict a marine mammal's response to sound exposure. The goal is to facilitate the implementation of statutory requirements under one of NOAA's rulings (i.e. MMPA, ESA, and the National Marine Sanctuaries Act) (NOAA, 2014). Within the guidelines, sound sources are divided into two groups based on the potential of noises to affect hearing sensitivity: impulsive sound sources and non-impulsive sound sources. Impulsive sound sources are transient and brief, usually lasting less than 1 second; they are typically broadband and consist of high peak pressure with rapid rise time and decay (NOAA 2014).

Based on these characteristics, impulsive noises are more likely to affect hearing sensitivity. Examples include airguns and impact pile-drivers. Non-impulsive noises are broadband, narrowband or tonal in nature; they are brief or prolonged, continuous or intermittent and typically do not have the high peak pressure with rapid rise time that impulsive signals do (NOAA 2014). NOAA also divides mammals into functional hearing groups. The rationale behind this division is the scientific evidence supporting the theory that not all marine mammals hear and use sound in the same manner (NOAA, 2014). NOAA (2014, p. 5) has defined five functional hearing groups:

- Low-frequency cetaceans: hearing range 7 Hz to 30 kHz (large, baleen whales)
- Mid-frequency cetaceans: hearing range 150 Hz to 10 kHz (dolphin species)
- High-frequency cetaceans: hearing range 200 Hz to 18 kHz (porpoise species)
- Otariid pinnipeds: hearing range 100 Hz to 40 kHz (eared seals [e.g. sea lions])
- Phocid pinnipeds hearing range 75 Hz to 100 kHz (true earless seals [e.g. harbor seals])

Beluga whales can hear across a large range of frequencies but can hear most acutely in the low-frequency range; as such they would be most likely classified under the low-frequency cetaceans.

The goal of the acoustic guidance is to trigger one of NOAA's statutory requirements, which requires acoustic disturbance to be legally considered as a form of "take", which means to harass, hunt, capture or kill or attempt to harass, hunt, capture or kill any marine mammals (NOAA, 2014). Under the Marine Mammal Protection Act (MMPA), harassment is defined as an action which (NOAA, 2014, p.21):

- Has the potential to injure a marine mammal or marine mammal stock in the wild [Level A Harassment].
- Has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioural patterns including migration, breathing, nursing, breeding, feeding or sheltering [Level B Harassment].

The Endangered Species Act (ESA) "prohibits the take of ESA-listed species with limited exceptions" (NOAA, 2014, p.21). The ESA requires that each federal agency, in consultation with NMFS and/or the USFWS ensure that any action authorized, funded or carried out by the agency is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of designated critical habitat (NOAA, 2014).

In essence, NOAA's acoustic guidance relies upon proving that acoustic disturbance does actually constitute a form of "take"; when it does, one of a number of regulatory statutes including ESA and MMPA can be operationalized to legally manage that noise.

ii) Establishment of Marine Protected Areas

Marine protected areas (MPAs) are an effective mechanism to provide multijurisdictional, coordinated approaches to marine habitat protection. Usually under national jurisdiction, MPAs "Provide one of the most effective means of protecting cetaceans and their habitats from the cumulative and synergistic effects of noise as well as from other stressors" (Dolman, 2007, p.220). MPAs incorporate the precautionary principle in their approach to management. Specifically, based on the significant basis for global concern, the primary goal of these management systems is to reduce, modify, or eliminate noise and other threats with large-scale protection (Dolman, 2007), acknowledging the high level of uncertainty and incomplete understanding with respect to cetacean population status and impacts, as well as the unlikelihood of increasing certainty in the future. Therefore, the basic requirements for any MPA are outlined below (Fig 3). Marine protected areas designed to conserve species could be valuable in controlling noise. One of the first requirements would be to make larger MPAs; most are currently too small to effectively mitigate noise pollution (Hoyt, 2011). Special noise-threat buffer zones could be established around MPAs to provide sufficient or precautionary distances between identified noise sources and known or suspected cetacean habitat. An example of this is at the Abrolhos Bank, Brazil, where a 92.7 km radius buffer zone was established and implemented in 2003 surrounding the 913 km2 Abrolhos National Marine Park to protect humpback whales and other species from seismic surveys from oil and gas development (Hoyt, 2011).

iii) Establishment of National Marine Sanctuaries

The National Marine Sanctuaries Act (NMSA) authorizes the U.S. Secretary of Commerce to designate and protect areas of the marine environment with special national significance due to their conservation, recreational, ecological, historical, scientific, cultural, archaeological, educational or esthetic qualities as national marine sanctuaries (NOAA, 2013). Essentially, sanctuary management involves the protection of marine resources including—but not limited to—reefs, sunken historical vessels or unique marine wildlife habitat. Operations of the sanctuaries fall under the jurisdiction of the Secretary of Commerce to NOAA's Office of National Marine Sanctuaries (NOAA, 2013). Interestingly, some sanctuaries have recognized growing concerns associated with underwater noise pollution and are conducting research, making recommendations and implementing policy to mitigate them. One example that illustrates some of the functions of a marine sanctuary as well as noise pollution mitigation strategies is the Stellwagen Bank National Marine Sanctuary in the eastern coastal region of the US (Case Study 1). This example illustrates how sanctuaries are being used to research the effects of anthropogenic noise on marine mammals and also how they can be used to create and implement tangible objectives and mitigation strategies.

Figure 3: Basic requirements for establishing a marine protected area (MPA)

Marine protected areas are most effective when they include:

- A carefully defined purpose, with specific goals
- Scientific background research on critical habitat requirements of cetaceans and other species, as well as the marine ecology of the area
- Early multidisciplinary input to choose, plan, implement and review the protected area
- A good relationship with local communities and all stakeholders who participate in the protected area process because they see tangible benefits for themselves and others
- Reasonable boundaries in view of the species, ecosystems and ecosystems processes that are being protected
- Good protected area design, built around IUCN Category I core areas, with additional zones or levels of protection, such as the biosphere reserve model
- Creation and sufficient funding for staff (management body) and operations including research, a management plan, monitoring and enforcement
- A comprehensive ecosystem-based and socioeconomic management plan
- Legal recognition as well as broad public acceptance
- An educational programme that is interactive, reciprocal and continuous for those who will use, travel through or visit the protected area
- Attention paid to the big picture: links to networks and marine planning and zoning initiatives
- Management of pollution, both marine and land based
- Reassessment and re-evaluation (both self and third party) at periodic intervals with stakeholder input

Source: Hoyt, 2011.

Case Study 1: Marine Sanctuary approach—Stellwagen Bank National Marine Sanctuary (SBNMS)

The Stellwagen Bank National Marine sanctuary, in the US Eastern Coastal Region, is managed under the National Marine Sanctuary Program (NMSP) to protect and conserve its resources and allow uses that are compatible with resource protection. Under the Marine Mammal Protection Plan, the Marine Mammal Behavioural Disturbance Action Plan (MMBD AP) establishes the potential for marine mammal harassment and behavioural disturbance resulting from whale watching, tuna fishing, aircraft overflights and *noise pollution.*

Goal: The goal of the MMBD AP is to strengthen the protection of marine mammals, particularly the threatened and endangered large whales, by assessing and minimizing behavioural disturbance and harassment and by fostering cooperation with agencies having cross-jurisdictional responsibilities that affect them.

Objective: One of the objectives under the broader MMBD AP is to reduce marine mammal behavioural disturbance by noise (MMBD.2)

Reduce Marine Mammal Behavioural Disturbance by Noise (objective 2) strategies:

2.1: Establish a Marine Noise Consortium to identify noise sources and possible effects.
2.2: Develop a marine acoustics research program to establish baseline noise levels and long-term noise budgets.
2.3: Develop a policy framework for investigating and mitigating noise impacts within SBNMS

Current situation: Within and surrounding SBNMS numerous sources of anthropogenic underwater sound contribute to the overall noise budget. Commercial, recreational, military and research vessels all contribute to ambient underwater noise in the sanctuary whether directly through their marine operations (i.e. engines, propellers and electronics) or indirectly through the activities they perform (e.g. towing and dredging). Unfortunately, whales tend to aggregate in proximity to shipping lanes and their long-term acoustic exposure to vessel traffic may represent a source of chronic impact.

Management approach: The management approach of SBNMS involves characterizing the status of the sanctuary's acoustic environment and identifying potential threats to sanctuary resources. These two programs are necessary both in meeting National Marine Sanctuary Act objectives for each site and to develop partnerships both within NOAA and between agencies to implement ecologically holistic, ecosystem-based management of sanctuary resources.

(Stellwagen Bank National Marine Sanctuary)

Strategies to Reduce Marine Mammal Behavioural Disturbance by Noise:
The following strategies provide the framework to assess and mitigate anthropogenic noise in the SBNMS occurring at levels where behavioural disturbance is clearly evident and when behavioural disturbance is not apparent, but where animals have habituated to detrimental noise levels.

1) *Establish a Marine Noise Consortium to identify noise sources and possible effects.* With the recognition of the need for independent targeted research and for maintaining the scientific integrity of data sets, members of the Marine Noise Consortium would agree to partner with the sanctuary and would make raw data available through an established data-use policy. (Priority: high; Status: ongoing).
2) *Develop a marine acoustics research program to establish baseline noise levels and long-term noise budgets.* This strategy involves the measurement and evaluation of baseline values as well as variation in background noise levels from activities within or propagating into the sanctuary. The marine acoustic research program should be an extension of the sanctuary's current ocean observing system for large-scale monitoring and mapping of noise within SBNMS. It should involve identifying noise sources and evaluating potential impacts on marine mammals. (Priority: high; Status: ongoing).
3) *Develop a policy framework for investigating and mitigating noise impacts within SBNMS.* This strategy involves developing a marine acoustics policy framework with the following requirements:

i. Addresses the potential for harm to marine mammals from excessive noise.
ii. Contends with the scarcity of data on the amount of sound introduced into the oceans by human activity and its associated impacts on marine mammals
iii. Identifies opportunities for collaboration with sound producers (e.g. vessel owners/ operators) in mitigating and/or monitoring their impacts on sanctuary resources
iv. Highlights the possible utility of sanctuaries as case studies for establishing domestic and international policies pertaining to noise in the marine environment.

(Priority: high; Status: ongoing)

Source: US Department of Commerce, National Oceanic and Atmospheric Administration, 2010.

C. European Measures for Marine Noise Regulation (ASCOBANS)

In Europe there are initiatives taking place to mitigate underwater noise pollution that is impacting the livelihood of cetaceans. Their focus is the impact of military and civil sonar, which is applicable to other cetacean habitats located in the vicinity of busy commercial ports—like Cook Inlet—or naval operation or exercise locations. For example, the Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS), has illuminated the issues, particularly the negative impacts of active sonar on beaked whales.

In 2003, the Advisory Committee of ASCOBANS reviewed the impacts of shipping, recreational and military activity upon small Cetaceans in the Agreement Area (Fig 4). The proposed mitigation measures are as follows:

- Develop effective mitigation measures to reduce the disturbance and possibly physical damage to small cetaceans with the military and other relevant authorities.
- Conduct research and develop measures, guidelines and technical adaptations to minimize any adverse effects on small cetaceans from identified sound sources.
- Develop and implement procedures to assess the effectiveness of any guidelines or management measures introduced (Dolman et al., 2011, p. 30).

Subsequently, in 2008, an intersessional Noise Working Group was created on behalf of the Advisory Committee of ASCOBANS. This Working Group developed a number of draft guidelines containing recommendations to improve monitoring and mitigation within the ASCOBANS Agreement Area; the main recommendations targeted military sonar and civil high-powered sonar, in planning, real-time mitigation, and post-exercise monitoring and reporting (Dolman et al., 2011, p. 30). The following summarized recommendations are particularly important:

(1) Planning phase

- Military exercise areas need to be well researched beforehand
- Oceanographic features including canyons, steep walls, and seamounts, persistent upwellings, and bays, as well as Marine Protected Areas, and known habitat areas must be avoided.
- Navies should adopt passive acoustic monitoring as a tool for identifying high-density cetacean areas in exercise planning.

(2) Real-time mitigation

- Scientific and precautionary basis for an exclusionary zone should be adopted.
- Mitigation should always include monitoring and reporting protocols.
- Operation should be stopped if any abnormal animal behaviour is observed, including stranding or death.
- The operation of high-power sources at night and during periods of minimal visibility should be restricted.
- Passive acoustic monitoring (PAM) should be used for more effective detection and should be mandatory for operation in low visibility (i.e. at night, in storms).
- Prior to any sonar emission, there should be a dedicated watch of at least 30 minutes to make sure that no animals are within the area. This time should be extended to 120 minutes if divers such as beaked whales have been observed during on the vessel track line or if potential habitats for them are being approached.

(3) Post-exercise monitoring and reporting

- Post-exercise monitoring should include cetacean surveys within the exercise area
- Transparent reporting to the national authorities should take place within an established timeframe

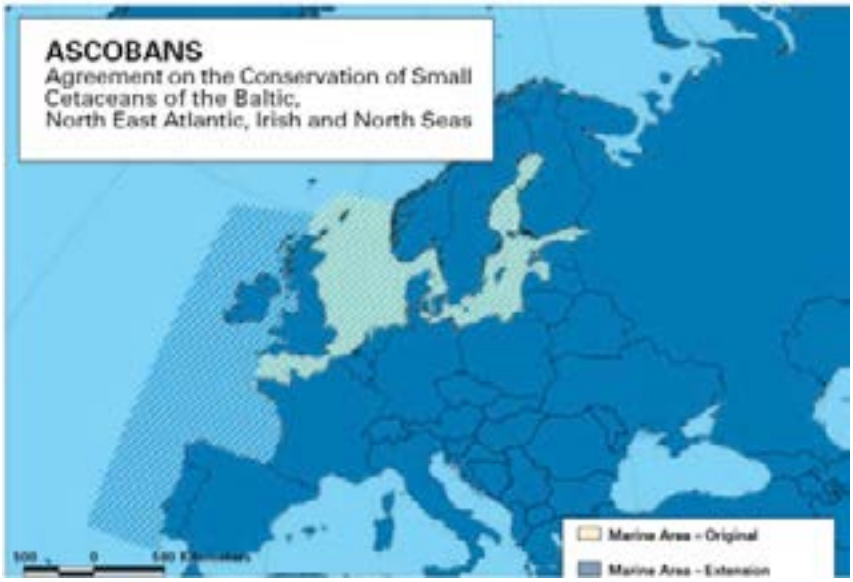
Recurring themes and protocols that seem to transcend national boundaries in innovative approaches to underwater noise management for cetaceans include the establishing of baseline data, the application of the precautionary approach as well as different forms of mitigation that are held accountable to different measurement techniques. This would apply not only to the European recommendations set out above, but as fundamental principles to all approaches to marine noise mitigation and wildlife protection measures.

The importance of the precautionary principle was emphasized by Dolman (2007), precaution—recognized as a general principle in international environmental law—is required given:

i. our lack of knowledge of the population status of the majority of cetacean species
ii. the uncertainty surrounding impacts (but acknowledging the potential for harm to occur before detection)
iii. the unlikelihood of increasing certainty to any significant extent in the near future

Given the incomplete understanding of cetacean distribution and impacts from noise, careful consideration is required to ensure that management activities, such as the designation of MPAs, do not move harmful activities into areas that may in fact be more sensitive.

Figure 4: ASCOBANS Agreement Area



Source: Dolman et al., 2011

D. Municipal Measures to Reduce Marine Acoustic Disturbance

At the municipal level, planning for anthropogenic underwater noise management is largely in the hands of port authorities and planning and land use departments. In many cases the plans of municipal governments and ports do not incorporate marine wildlife into their noise management activities, largely because of concerns that marine conservation and marine wildlife protection are outside municipal jurisdiction and not the mandate of municipal authorities or municipally elected representatives. However, there is the potential for municipal governments to address anthropogenic underwater noise management through a number of mechanisms.

Noise studies are often conducted at the human scale to monitor and mitigate the effects of noise-emitting activities to communities. For example, in Alaska the Matanuska-Susitna Borough planning and land-use department, in the Port Mackenzie Master Plan Update, has mandated a noise study within the number of environmental studies taking place as the port develops, including a noise description of the buffering necessary to mitigate identified potential negative effects of noise (Matanuska-Susitna Borough, Planning and Land Use Department, 2011). Port Metro Vancouver in British Columbia provides another example of a Port taking action to monitor and mitigate some of the effects of anthropogenic noise on marine mammals. Case Study 2 highlights some of the items under the Port's Marine Mammal Monitoring Program.

i) Voluntary Mechanisms

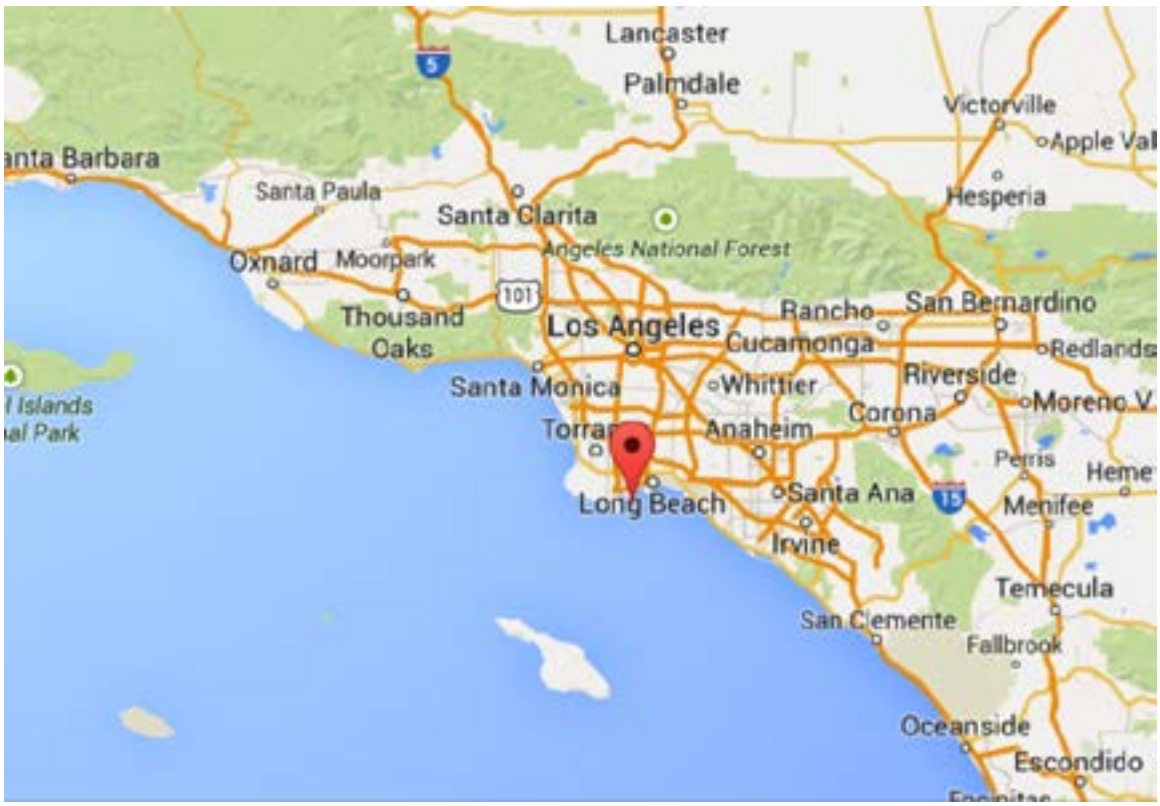
There is the potential at the municipal level for voluntary mechanisms to reduce anthropogenic noise that threatens the livelihood of marine mammals. Though voluntary mechanisms are often not held to the same regulatory standards and enforcement mechanisms as mandatory management plans, they still should be an option to consider, possibly in the advent or in addition to municipal and other regulation.

The Green Marine Program is a voluntary mechanism to improve environmental performance within the marine industry. This program consists of a framework for maritime companies to first establish and then reduce their environmental footprint. Participants include ship owners, ports, seaway corporations, terminals and shipyards. Essentially, what is involved is a detailed annual self-evaluation; the results determine the participant's ranking for each performance indicator on a 1-to-5 scale (1 = regulatory monitoring; 5 = leadership and excellence). Reports are independently verified every two years to ensure program quality and the results are made public (Green Marine, 2014).

ii) Voluntary Mechanisms, Los Angeles, California

An example of another voluntary mechanism to reduce underwater noise from ships is seen in The Port of Los Angeles, California. Here, San Pedro Bay Ports' voluntary speed reduction (VSR) program requests ocean going vessels (OGVs or ships) entering or leaving the ports to observe a 12-knot speed limit within 20 nautical miles of Point Fermin. (Fig 5) (Port of Los Angeles, 2014). The objective of the VSR program is to reduce overall nitrogen oxide emissions from OGVs by slowing their approaching and departing speeds; reduced vessel speeds demand less power from the main engine, which in turn reduces NOx emissions and fuel consumption (Port of Los Angeles, 2014). Reduction in ship speed could lead to reductions in underwater noise created by ships. This means that as a corollary of reduced emissions from ships, underwater noise may also be reduced. Furthermore, there may be cost savings associated with reduced fuel consumption as a result of reduced speed.

Figure 5: Point Fermin and the Port of Los Angeles (LA) (Los Angeles Harbour)



Source: Google Maps, 2015

Case Study 2: Port Metro Vancouver—Marine Mammal Monitoring Program and Initiatives

Port Metro Vancouver is one of North America's largest ports and is continuing to grow. With the port expansion there are concerns for marine mammals—particularly the Southern Resident Killer Whale (SRKW). The two categories of concerns associated with the port expansion (as well as current operations) include: construction concerns (potential noise associated with pile driving, vibrodensification and dredging); and operational concerns associated mainly with vessel traffic.

Port Metro Vancouver jurisdictional map

Port Acoustics Program

Port Metro Vancouver's acoustic program involves recording existing noise levels and determining how much noise is caused as a result of port operations compared to other community noise sources. Its goal is to help identify where there are problems and how it can work with terminal operators and tenants to make operational improvements to reduce the noise. The expansion of the Delta Port Third Berth (DP3) in 2003 involved the recording of ambient pre-construction measurements to determine the potential effect the project would have on the SRKW, among other species.

Zones of influence of noise on the killer whales were estimated and it was determined that behavioural disturbance is likely limited to within 1km of the expansion, although some masking may take place at greater distances. Mitigation methods—as determined based on the DP3 studies—involve the use of bubble curtains (to reduce the sound of construction activity) as well as the use of visual monitors for whales within a km radius, and a shutdown of construction activities when whales are within that zone.

In the case of jurisdiction, Port Metro Vancouver is an agent of the federal government, accountable to the Federal Minister of Transport; the port does not have municipal oversight.

Source: Gilbert, 2008

PART 4 FINDINGS: WHAT CAN BE DONE LOCALLY TO REGULATE UNDERWATER NOISE IN ANCHORAGE?

This section addresses the findings for the project's research questions. The research determined that municipalities generally have authority over noise from a variety of activities in the terrestrial environment. In the case of the marine environment, regulation is more limited.

A) Role of Local Government: Engagement, Collaboration, and Coordination

In the case of habitat protection in general (i.e. terrestrial, aquatic and marine), local governments can have an important role in species conservation. However, what is needed is strong collaboration with state and federal governments to achieve conservation and protection goals.

Habitat requirements of species are transboundary in nature. This means that—legislation aside—animal populations (and especially marine mammals) live within and across multiple jurisdictions. The laws of nature rarely coincide with governmental boundaries. So, although protection of a species at risk may technically fall under the authority of multiple governments and different levels of government, their habitat requirements also transcend multiple jurisdictions. Essentially, collaboration is needed among different jurisdictions as well as between different levels of government. The Cook Inlet beluga's critical habitat area, for example, falls within the waters surrounded by Anchorage, Matanuska-Susitna Borough and the Joint Base Elmendorf-Richardson (JBER) in Alaska. What is needed is coordination between these different regulating bodies in order to manage the entire beluga habitat and not only segmented portions of it.

There are numerous obstacles preventing municipalities from engaging in species at risk conservation. Local governments are generally challenged by competing priorities, and direction from senior government to respond to such initiatives can be perceived as a downloading of responsibility (Species at Risk Local Working Group, 2010). Furthermore, there are often few incentives for local governments to address these matters; many are also not equipped with the resources and expertise to engage (Species at Risk Local Working Group, 2010). The limited response rate of participants in the interviews is likely indicative of these challenges.

B) Limited Tools for a Marine Environment

Municipalities generally will have more capacity to engage with wildlife conservation in the terrestrial environment than in marine ecosystems. In general, there are a number of tools that local governments can use to facilitate and promote species at risk protection on local government and private lands. Some of these include: regulatory tools such as tree protection bylaws and restrictive covenants; planning tools including development permit areas and requirements for park plans; financial tools such as property tax incentives; and educational tools such as workshops or brochures (Species at Risk Local Working Group, 2010).

Many of these measures pertain only to land-based planning processes. The tools are not applicable to the marine environment, which is not under the jurisdiction of local government. What is possible, however, is to encourage and support the development of local government plans and strategies that address species at risk as part of broader sustainability initiatives, including official community plans and regional growth strategies (Species at Risk Local Working Group, 2010). However, without the support of senior government and their associated policy mechanisms and resources, municipal governments seeking to protect species at risk in the marine environment have very little remedy. In summary, while local initiatives operating for species at risk protection in terrestrial environments have a number of tools and policies available to them, conservation initiatives at the local level in marine environment are more limited. While support in educational and public engagement initiatives at the local level is vital, it is important that collaboration with government agencies with higher jurisdiction over the marine environment and the species within those environments is undertaken.

C) Ecosystem Mapping

Ecosystem mapping and data sharing is another strategy to promote collaboration between different levels of government in species at risk protection initiatives. The basic premise is that local governments can work toward the protection of a species at risk where there exists up-to-date mapping of where a species is (and is not) present. Ecosystem mapping can take many different forms, including—but not limited to—sensitive ecosystem inventory mapping, terrestrial ecosystem mapping, foreshore inventory mapping, watershed mapping and ecosystem features mapping (Species at Risk Local Working Group, 2010). Ecosystem mapping initiatives, especially in British Columbia, have become in high demand from resource professionals and staff working at the local level (Species at Risk Local Working Group, 2010). While ecosystem mapping of the marine environment may not be of direct relevance to decision-making at the municipal level, shore-based development could be informed and influenced from such valuable information.

D) A Coastal Management Plan

In the case of Cook Inlet, municipalities do not have control over coastal management activities, particularly since the removal of the Coastal Management Plan (2007) (Tobish, 2007). Currently, all 35 coastal and Great Lakes States and territories participate in the National Coastal Zone Management program—with exception of Alaska. Reintroducing some form of municipal coastal management could provide one very important mechanism for greater municipal control over coastal activities potentially affecting marine habitat; in this case managing anthropogenic noise would be a specific objective within broader species at risk protection (i.e. beluga whale conservation). Although the legislation provides basic requirements for state partners, it also accommodates for strategies to address local challenges and work within state and local laws and regulations (NOAA, n.d.). The program uses both state and federal funds in order to strengthen the asset base to address coastal issues (NOAA, n.d.).

The original Coastal Management Plan, which included a range of policies regulating the coastal area, was revised and updated between 2005-2007. The new plan—adopted in 2007—contained fewer policies than the original and did not contain any relating to marine noise, nor cetaceans (Tobish, 2014). This plan has since been canceled and is no longer effective. Effectively, there is no coastal zone regulation at the municipal level in Anchorage and much of Alaska, for that matter (Tobish, 2014). The research was unable to determine through the literature review or through consultation why the Anchorage Coastal Management Plan is not in effect.

Anchorage's Coastal Management Plan (2007) did contain *potential* for managing anthropogenic noise in coastal areas. Specifically, it mandated for regulation of "Uses and activities that may have the potential to affect the physical, biological, or cultural use of coastal resources upon which recreational uses depend, and that have the potential to have a direct and significant impact on habitats" (p.5). The central issues of the Anchorage Coastal Management Plan are set out in section 3.1.1 Issues of Local Concern. Several of these issues pertain to coastal habitat conservation (2007, p.5):

- (2) Natural resource areas and open spaces are valued by Anchorage residents for fish and wildlife, and plant habitats. The corresponding ecological functions and values of these habitats contribute significantly to create a livable, dynamic, and economically viable city.
- (5) Important habitat may be negatively and cumulatively impacted by poor-quality development and construction practices.
- (6) Encroachment…and inadequate construction setbacks from shorelines and stream banks can pose direct and significant cumulative and secondary impacts to the water quality of the marine waters, streams and lakes thereby negatively impacting habitats and recreation areas.

The plan recognizes disturbance caused to fish and wildlife by construction activity. The plan acknowledges that "During construction and operation of development sites and facilities, the physical presence of equipment, machinery, ships, motor vehicles, and human beings can discourage or preclude the used of specific sites or areas important to wildlife populations" (2007, p. 38). The plan recognizes some correlation between anthropogenic noise and adverse effects to wildlife activity and behaviour. According to the Municipality of Anchorage (2007), "Some marine mammals have been shown to be vulnerable to disruptions caused by development activities. Helicopters, low-flying aircraft, boat traffic, and human presence have been associated with pup mortality and declining use of some habitats by marine mammals" (p. 38).

The only mechanism mentioned in the plan to authorize enforceable policies is through the designation of a specific portion of the MOA coastal zone boundary as "Recreation Use Areas." According to the MOA (2007), this designation provides the municipality with the legal authority to address the prioritization of uses and activities within these areas. This designation entitles physical, biological and cultural features upon which recreational use depends. In this case, recreation uses in the area designated includes existing and planned features for trails, organized sports and for passive activities including tourism and wildlife viewing (MOA, 2007). Through the designation of "Recreation Use Areas" there are five applicable, enforceable policies:

1) Uses, Activities and Setbacks
2) Buffering and Screening
3) Waterfront Development
4) Coastal Access
5) Capital Improvements

The first of these enforceable policies, "Uses, Activities and Setbacks", provides for allowance of activities in the Recreation Use Area, should they meet certain setback requirements. (See; "Uses, Activities and Setbacks", Anchorage Coastal Management Plan, 5.5.1). This policy comes from the State Habitat Standard 11 AAC 112.300 (a) (2, 3, 8, and 9) and the Recreation Use Designation. The "Buffering and Screening" policy provides for natural or vegetated buffers or other screening measures for commercial, industrial, or institutional projects and associated activities within 200-feet of streams or water bodies within the Recreation Use Area Designation (MOA, 2007). Though this policy does not directly pertain to noise management in the marine environment, having some kind of buffer and screening between these noise-making activities and the ocean could reduce disturbance to marine habitat. This policy is from the State Utility Routes and Facilities Standard 11 AAC 112.240 and the Transportation Routes and Facilities Standard 11 AAC 112.280, and applies to the Municipality's Recreation Use Area Designation. The other three enforceable policies have little relevance to noise regulation and are more to do with access and development permitting.

It must be noted that while the Anchorage Coastal Management Plan is no longer in effect, the enforceable measures within it stem from standard municipal policies. These enforceable policies could be implemented even without a new Coastal Management Plan. Should the plan be reinstated, there exist opportunities within it to protect coastal habitat from anthropogenic noise transcending natural coastal boundaries.

E) Port Mackenzie Mitigation Measures Must Be Mirrored

Port Mackenzie, nearby in the Matanuska-Susitna Borough has considered anthropogenic noise regulation in its operations and activities. For example, in 2006 they recommended mitigation measures for pile driving (Fig 6.1). These mitigation measures were proposed to the Corps of Engineers, NMFS, NOAA, F&G, F&W, among other agencies when it became apparent in 2006 that the CIB was going to be listed as "Threatened" (Van Dongen, 2014). In essence, these mitigation measures would enable marine development projects to operationalize while still providing adequate protection to the belugas from the sound of pile driving. In fact, these measures were eventually adopted and have since been modified. While they do increase the overall cost to projects, they allow "in-water" construction projects to continue while providing a level of protection to the whales (Van Dongen, 2014). Thus, it is important for the Port of Anchorage to implement this initiative.

Figure 6: Mitigation Measures for Pile Driving at Ship Creek Ferry Landing, Matanuska-Susitna Borough

1. Conduct a noise study while driving the first pile at Ship Creek to determine the radius surrounding pile driving activities that ensures belugas are not exposed to sound levels above 160 dB (SPL) without a Small Take Authorization (under section 101 (a) (5) of the MMPA) or 180 dB with an Authorization.
2. Mark the safety radius with buoys or use of a transit.
3. Require an independent paid beluga whale spotter be present at the construction site whenever in-water pile driving (impact hammer) takes place.
4. If any belugas are spotted within the safety radius, the contractor must immediately stop all in-water pile driving work until the whales pass outside the safety perimeter.
5. Require a "standby" rate with the contractor which will be paid whenever in-water pile driving is suspended due to the presence of belugas.
6. Require the contractor to initially use a vibratory hammer to drive piles to refusal, then switch to an impact hammer to complete the pile driving.
7. Require that the contractor's maximum number of pile driving hours with an impact hammer not exceed 6 hours per day.
8. Develop, in consultation with the National Marine Fisheries Service (NMFS) and US Fish and Wildlife Service, an underwater noise reduction plan through use of structural design and/or operational procedures.
9. Schedule pile driving at Ship Creek in the best 2 – 3 month timeframe (between 1 May and 30 September) (per NMFS and USFWS) and conduct pile driving at Port MacKenzie the remaining 2 – 3 months.
10. Coordinate with the pile driving contractor at the Port of Anchorage project so only one pile driving (impact hammer) operation is happening at a time.
11. Develop, in consultation with the National Marine Fisheries Service (NMFS) and US Fish and Wildlife Service, an underwater noise reduction plan through use of structural design and/or operational procedures.

Source: Port Mackenzie Director, 2006

F) Municipal regulation in Anchorage: possible tools for change

In summary, the informal consultation reinforced the understanding that marine policy is beyond the scope of municipal government; also, issues of wildlife management and regulation regarding ports, shipping, and commercial and military activity are under the authority or senior (i.e. state and federal) legislation. The single formal interview conducted also reinforced these themes.

Currently, the Municipality of Anchorage does not have any regulation for noise in the marine environment (Tobish, 2014). The Port of Anchorage has been the target of different monitoring and noise regulation; however, this has been within the context of a military permit and depended upon NMFS and USFWS consultations and recommendations (Tobish, 2014).

When it comes to noise regulation in the terrestrial environment, there are a number of policies that are applicable. In general, municipalities use noise ordinances to regulate acoustic disturbance, and to make exceptions for permitted use. The noise ordinance in Anchorage does not have specific policies for the marine environment. Generally speaking, there are very few policies at the municipal level—if any—that can regulate underwater acoustics in the marine environment. Regulation of the marine environment, in general, is under the jurisdiction of state and federal government.

What activities causing noise are under the jurisdiction of the municipal government?

In general, anthropogenic activities causing noise in the terrestrial environment are under the jurisdiction of municipal governments. Municipalities usually have some kind of noise ordinance that establishes acceptable and permitted noise-creating activities, as well as acceptable sound levels produced by those activities. The ordinance also establishes which activities might be granted exceptions to allowable noise levels.

In Anchorage the municipal noise ordinance manages the following activities (Municipality of Anchorage, n.d.):

- Aircraft and airport operations
- Animals (creating noise)
- Construction; domestic power tools
- Emergency signaling devices (e.g. fire, defense alarms)
- Explosives, firearms and similar devices
- Loading and unloading
- Loudspeakers and public address systems
- Operation of motorboats
- Noise-sensitive zones
- Places of public entertainment
- Powered model vehicles
- Public service utilities
- Radios, televisions, musical instruments and similar devices
- Stationary nonemergency signaling devices
- Street sales
- Tampering with noise control device or sound monitoring equipment
- Vibration

The noise ordinance manages acoustics exclusively in the terrestrial environment, causing disturbance to people. The only exception is the operation of motorboats. Nevertheless, this regulation is designed to keep the noise away from the shoreline, presumably to avoid disturbing people living in Anchorage. There is no clause for disturbance to marine wildlife from motorboat operations (Municipality of Anchorage, n.d.): "No person shall operate or permit the operation of any motorboat in any lake, river, stream, or other waterway in such a manner as to exceed a sound level of 80 dB(A) at 50 feet (15 meters) or the nearest shoreline (15.70.060)".
Anchorage's Municipal Noise Ordinance

Anchorage's Municipal Noise Ordinance (AMC 15.70) limits the level of allowable noise based on location and time of day. It focuses on human health as opposed to environmental or marine life protection concerns. The noise ordinance reads:

> Whereas excessive sound and vibration are a serious hazard to public health and welfare and the quality of life, whereas a substantial body of science and technology exists by which excessive sound and vibration may be significantly abated, and whereas the people of the municipality have a right to an environment free from excessive sound and vibration that may jeopardize their health and welfare or degrade the quality of life, it is therefore the policy of the municipality to prevent excessive noise that may jeopardize the health or welfare of its citizens or degrade the quality of life. (Municipality of Anchorage, n.d., p.1)

Arguably, conservation of Cook Inlet belugas is pertinent to the noise ordinance in context of the ordinance's concern about noise that may "degrade the quality of life" of Anchorage's citizens. The premise would be that the welfare of this iconic species, which makes its permanent home in the area, contributes dramatically to the distinct identity of Cook Inlet and the Anchorage community. What is needed is greater understanding and recognition of the value(s) this whale affords. While there is currently minimal whale watching activity in the area—possibly due to safety concerns associated with extensive tidal fluctuations—there is potential for increasing the profile of the beluga and promoting its welfare as crucial to the community.

Incorporation of restriction of underwater noise for the protection of marine mammals would necessarily be premised on municipal commitment to the Cook Inlet beluga as an important 'quality of life' consideration for the municipality. It follows that if noise is possibly causing adverse effects to the endangered whale population, then based on the precautionary principle some ordinance should limit the source of that noise (or noises). The actual noise ordinance that would emerge from this rationale would be based upon threshold values. This would reduce underwater noise, in order to maintain a certain "quality of life" for humans. What this means is that the continued existence of the Cook Inlet beluga, to a certain extent, improves or maintains a certain quality aspect of local residents' life. The extinction or disappearance of the Belugas from Cook Inlet would certainly 'degrade' the quality of life of Anchorage residents. Noise regulation to reduce this would be premised on municipal commitment to the Cook Inlet beluga as an iconic municipal treasure, part of the heritage and cultural fabric of Anchorage.

Research from the Cook Inlet Beluga Acoustics Research Program can tell us what noise levels and structures are possibly within the range of triggering a permanent or temporary threshold shift within the beluga whale's auditory system. These threshold values could be incorporated into the noise ordinance for particularly loud activities in areas adjacent to critical habitat areas. For example, if shoreline construction activity adjacent to critical habitat was determined to create noise at levels associated with either a temporary threshold shift or permanent threshold shift, then that activity could be limited to certain times of the year (i.e. when whales are least active in that area) or even prohibited altogether in certain areas. It must be stated that such provisions would only be applicable in instances where anthropogenic noise penetrates and travels through the underwater environment. In this context, results from the Cook Inlet Beluga Acoustics Research Program should be considered when determining what specific noises may need to be restricted at what locations and at what times of the year, according to the whales' seasonal activity (as an "Annex" to the Anchorage Municipal Noise Ordinance). For discussion purposes, the ordinance might state:

> Whereas it is acknowledged that protection of local marine species, in particular the Cook Inlet beluga, is fundamental to the distinct identity of the Anchorage community and that their decline and extinction would significantly and irrevocably degrade quality of life in Anchorage for generations to come. Whereas excessive sound and vibration are a serious and particular hazard to cetacean marine life for which sound is their primary sensory means for communication, foraging, predator detection, navigation and hunting, and can result in their displacement from habitat, and long-term detriment to their health. Whereas a substantial body of science and technology exists by which detrimental sound can be identified and whereby excessive sound and vibration may be significantly abated. Whereas the people of the municipality have a right to adopt and enforce precautionary measures by way of this noise ordinance, as set out in Annex A, to prevent excessive noise that threatens the welfare of local marine species.

Thus, in summary, while the existing noise ordinance does not mention wildlife explicitly, there is means by which noise protection for the Cook Inlet beluga can be addressed in the regulation. The option is premised on considering the noise causing harm to the whales as indirectly affecting the quality of life of humans, since "quality of life" is a part of the noise ordinance. The amendment to the noise ordinance to specifically address marine wildlife protection is based on the premise that the extinction or disappearance of the beluga from Cook Inlet would irreparably 'degrade' the quality of life of Anchorage residents.

PART 5 HOPE FOR THE FUTURE: RECOMMENDATIONS

This section highlights the recommendations of this research study. There is emphasis on municipal policy, in particular, the use of the Anchorage Noise Ordinance to effect noise regulation for the protection of the Cook Inlet beluga habitat in the Anchorage area. However, attention is also directed toward engaging senior government in an effort to identify shared responsibility and opportunity. Here are the key points emanating from this research project:

1) Ecosystem-based Management

If possible, in the case of the critical habitat of the Cook Inlet beluga, policy should follow the boundaries of the ecosystem, rather than political boundaries separating municipalities, military bases and federal and state waters. Though ambitious, this goal would necessitate multi-stakeholder collaboration for noise reduction strategies.

2) Inter-jurisdictional collaboration and local participation

There seems to be a disconnect between perceived responsibilities across different levels of government. On the one hand, municipalities perceive the regulation of underwater noise in the marine environment—and more broadly of marine habitat protection—as falling under the jurisdiction of senior government and international bodies. On the other hand, senior government would like to see more participation in relevant initiatives from local governments. Both perspectives are correct, according to government policy. However, from an ecosystem perspective there is no distinction between different levels of government; the boundaries of ecosystems as well as the habitats and populations within them transcend political boundaries.

3) A multi-jurisdictional marine protected area (MPA)

Cook Inlet is neither a marine protected area, nor a national marine sanctuary. Though either one of these designations would limit economic development in Cook Inlet, there is the potential for them to preserve critical beluga whale habitat in general, and more specifically to reduce underwater noise that may be causing adverse effects to beluga behaviour and activity. Creating a marine protected area would allow for collaboration of resources between different levels of government and increase opportunities for participation. Though it may not be realistic for Anchorage to want an MPA, it is recommended that a study be conducted by the US government to determine whether any elements of an MPA could reasonably be implemented in Cook Inlet.

4) Consideration of the European model for marine noise regulation in context of mitigating harm from military and commercial sonar activity

As set out in Part 3, European initiatives for the protection of cetaceans against underwater noise pollution focus on military and civil sonar. Serious consideration ought to be given to reasonable adoption of these recommendations by the US Military and voluntarily by commercial ships.

5) Voluntary mechanisms: Voluntary ship speed reduction and construction noise mitigation

Following the example of the Port of Los Angeles and Port of Vancouver, the Ports of Anchorage and Mackenzie should undertake voluntary measures to reduce underwater noise. As discussed above the voluntary speed reduction (VSR) program in Los Angeles requests that ocean going vessels entering or leaving the ports observe a 12-knot speed limit within 20 nautical miles of Point Fermin (Port of Los Angeles, 2014). The objective of the VSR program is to reduce overall nitrogen oxide emissions from OGVs by slowing their approaching and departing speeds; reduced vessel speeds demand less power from the main engine, which in turn reduces NOx emissions and fuel consumption (Port of Los Angeles, 2014). However, reduction in ship speed could lead to reductions in underwater noise created by ships. Changing shipping tracks or lanes, reducing engine speeds, instituting "no-go" zones as well as implementing ship quieting technologies are all options for reducing the impact of commercial vessels on beluga activity and livelihood.

The Port of Anchorage should also implement an acoustic program similar to that of Port Metro Vancouver that involves recording existing noise levels and determining how much noise is caused as a result of port operations compared to other community noise sources. The introduction of bubble curtains to reduce the sound of construction activity is a feasible strategy.

6) Reintroduce Anchorage's Coastal Management Plan

Anchorage's Coastal Management Plan, which is no longer active, could be reintroduced. It contains a number of policy mechanisms that can be used by Anchorage to reduce underwater noise by regulating coastal activity. This is an interesting option, since it would not necessarily involve the re-writing of an entirely new plan; parts of the outdated plan could be revised and some new aspects could be developed.

7) Introduce changes to Anchorage's Noise Ordinance

The existing noise ordinance does not mention wildlife explicitly; however, it is argued in this research project, that noise protection for the Cook Inlet beluga can be addressed in the regulation based on the premise that the extinction or disappearance of the belugas from Cook Inlet would irreparably 'degrade' the quality of life of Anchorage residents and extinguish an aspect of Anchorage's identity and heritage.

CONCLUSION

The endangered Cook Inlet beluga has established a permanent, year-roun home in a location where underwater noise from naval activity, commercial shipping and other development may be impeding their recovery. The situation is complicated because various governmental jurisdictions are at play in the protection of their marine habitat. As a result, the people seeking protection of the beluga must make multiple recommendations to engage different players and levels of government with diverse mandates. This paper attempts to enumerate as many of those options as possible and hopes for multi-level, multi-stakeholder engagement and collaboration for noise reduction strategies.

At the local level, there are voluntary measures that can be implemented by the Port of Anchorage to limit the amount of underwater noise created by commercial vessel traffic and other operational activities. Introducing vessel speed reductions in critical habitat areas, for example, is one option that is currently operational in the Port of Los Angeles—with benefits to both marine life and fuel efficiency. In the case of construction activity, bubble curtains and pile driving mitigation techniques—seen in Vancouver and Matanuska-Susitna Borough, respectively—can reduce the amount of underwater noise. Furthermore, participation in the Green Marine Program to monitor overall environmental performance is another option readily available to both Port Mackenzie and the Port of Anchorage.

Within Anchorage's existing municipal legislation—including the noise ordinance and the recently discarded Coastal Management Plan—there is potential for mitigation of possible noise-related impacts. Further, increased public awareness, recognizing and establishing the important ecological, recreational and cultural value of the beluga may trigger momentum for greater regulation of their acoustic environment. As mentioned above, it is arguable that noise protection for the Cook Inlet beluga can be addressed in the noise ordinance regulation based on the premise that they are vital to Anchorage's identity, heritage and quality of life of current Anchorage citizens and subsequent generations.

Though the focus of this project is on municipal policy, regulation of the marine environment is largely under the authority of senior government. As such, comprehensive and effective underwater noise regulation—and wildlife protection in general—will necessitate the inclusion of the federal and state governments. Elsewhere in the United States, such as in the Stellwagen Bank National Marine Sanctuary, marine environments are being protected in relation to underwater noise. Establishment of a marine protected area or sanctuary in Cook Inlet would not likely be feasible; however, the development of related management approaches involving the development of a policy framework for investigating and mitigating the effects of underwater noise impacts should be more thoroughly investigated.

FURTHER RESEARCH

There are a number of other factors likely impeding the recovery of the beluga (i.e. ship strike, parasitism and disease, habitat loss, etc.). Focusing on a management approach that addresses these other factors as well will likely yield better results in terms of marine mammal protection. This research discovered that there is currently no discussion of a spatio-temporal restriction (i.e. a marine protected area or marine sanctuary) as an option for preserving the Cook Inlet ecosystem. Anchorage is a very busy port and, unfortunately, economic interests may compete with ecological considerations here. However, it would be an interesting and important pursuit to discover what obstacles are preventing discussions of establishing a protected area from taking place. The role that municipalities can play in wildlife management and marine decision making processes are other items for consideration.

Further research questions to investigate include:

1) How can municipalities engage in marine management decisions?
2) What role can municipalities play in decision-making processes surrounding wildlife conservation in both terrestrial and marine environments?
3) What activities can municipal agencies pursue in garnering support for wildlife conservation?
4) What opportunities exist for municipalities from endangered species conservation?

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