Scoping Suggestions for the Risk of Underwater Noise from Vessel Traffic to Endangered Species, and Southern Resident Killer Whales in Particular

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The base problem and the need for a cumulative view

Each year, around 11,000 large vessels and oil barges transit to and from the San Juan Islands Figure 1). This figure includes over 1,322 oil tankers, each of which carries an average of 30 to 40 million gallons of crude oil. Around 4,300 of these large vessels are destined for United States' ports in Puget Sound. The other 6,250 make for Canadian ports.[1]

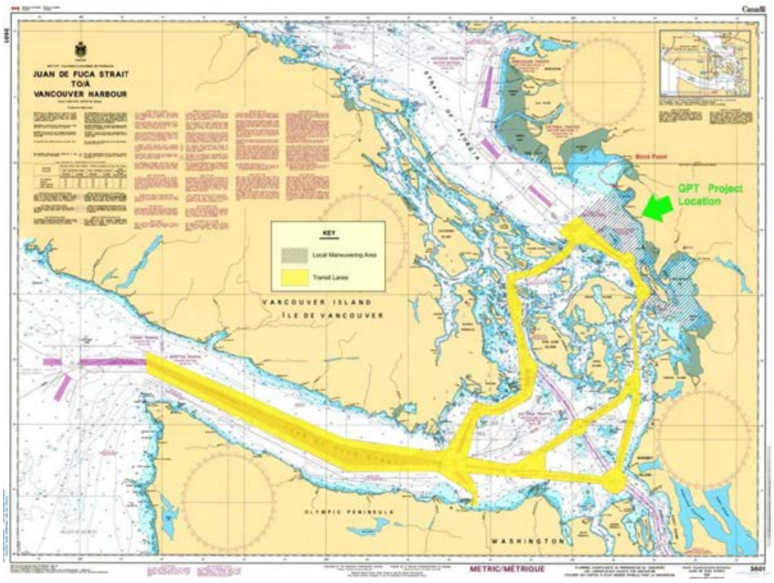

Figure 1. *Main shipping routes of Southern Puget Sound*

The proposed Gateway Pacific Terminal (GPT) will add approximately 440 ship transits per year, equating to a 4% increase to the 2011 traffic once it becomes operational. After it becomes fully operational, the GPT is projected to generate an additional increase of about 950 transits per year, or an increase of 9%, within 15 years.[2] This increase will be over and above other future expansion in other shipping operations. Impacts, in terms of emissions of underwater noise, from the specific increase in shipping from the development of the GPT needs to be understood and modeled. However, the impact assessment of the underwater noise must also evaluate the cumulative risks of all existing and projected transits through this area, as only this type of evaluation will reveal the true extent of the significant risk at

[1] Hass, T. (2012). *The Vessel Traffic Risk Assessment for BP Cherry Point and Maritime Risk Management in Puget Sound*. (Puget Sound Partnership). 5. van Dorp, J. (2008). *Assessment of Oil Spill Risk due to Potential Increased Vessel Traffic at Cherry Point, Washington*. (Final Report - Submitted to BP : 8/31/2008**).**

[2] Pacific International Terminals, Inc. (2011). *Project Information Document, Gateway Pacific Terminal*, Whatcom County, Washington. 304 p. Also, *Vessel Entries and Transits: 2011* WDOE Publication 12-08-003 April 2012

hand. A cumulative assessment is required and essential as it will reveal risks that, while perhaps appearing to be minor on an individual level, once quantified in a cumulative assessment framework, may actually turn out to be highly relevant contributors to the risk profile when placed in the context of the overall risk of noise pollution to the critical habitat of endangered species.[3]

In addition to the past, present and the currently proposed 8% increases in shipping traffic for the GPT development, the cumulative assessment should also scope the likely, further future additional expansions of vessel traffic in this area (even if they are not yet formal or approved proposals). This requirement is especially important when dealing with inter-related projects that will all utilize the same limited resource, in this case, shipping routes. That is, a forward projected assessment should also include data in the cumulative equation on traffic increases that can reasonably be foreseen including general increases in vessel traffic from other sources and also vessel traffic projections for other proposed major developments (including in Canada) that will need to use the same shipping route. This will greatly assist the authorities in providing the necessary information to achieve meaningful regional planning at a reasonable cost, in which uncertainties can be evaluated and effective, appropriate, and sustainable (in economic, social and environmental) choices can be made.[4]

It is essential to evaluate the cumulative impacts on vessel noise from the various port expansion projects through the Salish Sea including at minimum the twinning of the Trans Mountain pipeline and associated tanker traffic, expansion of the Delta Port container terminal as well as the Westshore Coal Terminal. However, it is also critical for the Corps to recognize the fact that if all five of the proposed coal terminals are built in the Pacific Northwest it would result in approximately an additional 2000 bulk carriers transiting through

[3] Kern v. United States Bureau of Land Mgmt., 284 F.3d 1062, 1075 (9th Cir. 2002) (quoting Churchill County v. Norton, 276 F.3d 1060, 1072 (9th Cir. 2001).

[4] Zhao, M. (2012). 'Barriers and Opportunities for Effective Cumulative Impact Assessment Within State-Level Environmental Review Frameworks in the United States'. *Journal of Environmental Planning and Management.* 55(7): 961-978. Senner, R. (2011). 'Appraising the Sustainability of Project Alternatives: An Increasing Role for Cumulative Impact Assessment'. *Environmental Impact Assessment Review.* 31: 502-505. Hegmann, G. (2011). 'Alchemy to Reason: Effective Use of Cumulative Effects Assessment in Resource Management'. 31 *Environmental Impact Assessment Review*. 31: 484-490. Gunn, J. (2011). 'Conceptual and Methodological Challenges to Cumulative Effects Assessment'. *Environmental Impact Assessment Review.* 31: 154-160. Therivel, R. (2007). 'Cumulative Effects Assessment: Does Scale Matter ?' *Environmental Impact Assessment Review*. 27: 365-385. Burris, R. (1997). 'Facilitating Cumulative Impact Assessment in the EIA Process'. *International Journal of Environmental Studies*. 53: 1-2, 11-29. Thatcher, T. (1990). 'Understanding Interdependence in the Natural Environment: Some Thoughts on Cumulative Impact Assessment Under the National Environmental Policy Act'. 20 *Environmental Law*. 611. Eckberg, D. (1986). 'Cumulative Impacts Under NEPA'. 16 *Environmental Law*. 673. http://www.aleutiansriskassessment.com/passing.htm

Unimak Pass in Alaska. This would approximately double the volume of traffic that currently ply through these biologically rich and vulnerable waters.

2. Indicators of significant risk

In order to be approved, the GPT development must reconcile a large number of relevant standards of regulatory, legislative and other legal and policy instruments from regional, state, federal and international agencies that are indicators of significant risk. A summary of some of the more relevant standards are provided below:

- The Endangered Species Act.
- The Marine Mammal Protection Act
- In Winter v NRDC the Supreme Court of the United States recognized the need to regulate oceanic noise and its impact upon cetaceans.[5] Accordingly, it is now clear that, due to the importance of the Endangered Species Act and the Marine Mammals Protection Act, the significant impacts of underwater noise pollution on protected cetaceans must be considered and all possible attempts at mitigation and alternatives seriously examined, unless matters of utmost national security are involved.[6]
- The United Nations General Assembly called for scientific investigations into underwater noise pollution in 2010, a resolution supported by the United States.[7]
- The Parties to the International Whaling Commission (including the United States) have issued recommendations to control noise pollution around the critical habitats of some endangered whale species.[8]
- In 2008, the United States proposed that the International Maritime Organization begin to examine the issue of underwater noise from commercial shipping.[9]

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[5] Winter v. NRDC, 555 U.S. 7, 9 (2008). For a full discussion of this area, see Gillespie, A. (2012). 'The Limits of International Environmental Law: Military Necessity v. Conservation'. *Colorado Journal of International Environmental Law and Policy*. 32: 1.

[6] Horowitz, C. (2007). 'Precautionary Management of Noise: Lessons from the U.S. Marine Mammal Protection Act'. *Journal of International Wildlife Law and Policy,* 10:225–232.

[7] UNGA Resolution (2010) 64/71 Oceans and the Law of the Sea. Para 162.

[8] (2004) 'The Western North Pacific Gray Whale' Resolution 1, IWC 56th Report, 66; (2005) 'The Western North Pacific Gray Whale' Resolution 3, IWC/57/25.

[9] See United States. (2008). Work Programme of the Committee and Subsidiary Bodies: Minimising the Introduction of Incidental Noise from Commercial Shipping Operations. MEPC 58/19. June 25.

- The Convention on Biological Diversity (CBD), to which the United States is not a signatory, called for scientific investigations into underwater noise pollution in 2010.[10]
- The Convention on Migratory Species (CMS), to which the United States is not a signatory, has urged Parties and non-Parties with jurisdiction over any part of the range of marine species listed in the appendices of CMS (which include Killer whales), or over flag vessels which are engaged within or beyond national jurisdictional limits, to take special care and, where appropriate, endeavour to control the impact of emission of man-made noise pollution in the habitats of vulnerable species.[11]
- Similar recommendations to control noise pollution around cetaceans have been made by the Subsidiary Agreements to the CMS, to which the United States is not Party, including the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS)[12] and the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ACCOBANS).[13]

3. The particular species at risk: Southern Resident killer whales

Puget Sound is frequented by a number of marine mammal species including, *inter alia*, harbor seals, river otters, Steller sea lions, common minke whales and Dall's porpoise and habour porpoise. Humpback whales have also been recorded coming back to Haro Strait. Although many of these are of conservation concern, one sub-species in particular, the resident pods of Killer whales around the San Juan Islands known as the Southern Resident killer whale community (SRKW), are of a very high concern. The SRKW represent the smallest of four resident sub-species of Killer Whale within the eastern North Pacific Ocean. The SRKW comprises three pods (termed J, K and L). The SRKW population has fluctuated considerably over the 30 years that it has been studied. All three southern resident pods were reduced in number between 1965 and 1975 because of captures for marine parks. In 1974, the

[10] (2010) 'New and Emerging Issues' Decision X/13.
[11] (2008) 'Adverse Anthropogenic Marine/Ocean Noise Impacts On Cetaceans and Other Biota' Resolution 9.19.
[12] (2010) 'Guidelines to Address the Impact of Anthropogenic Noise on Cetaceans in the ACCOBAMS Area Resolution 4.17. (2004) 'Assessment and Impact Assessment Of Man-Made Noise' Resolution 2.16.
[13] (2003) 'Effects of Noise and of Vessels' Resolution 5.

group comprised 71 whales and it peaked at 97 animals in 1996, before falling to 86 as of the end of 2010.[14] Numbers may have fallen since then, as there were estimated to be fewer Killer Whale in the middle of 2012 than there were in the 2010 baseline year (N=83).[15]

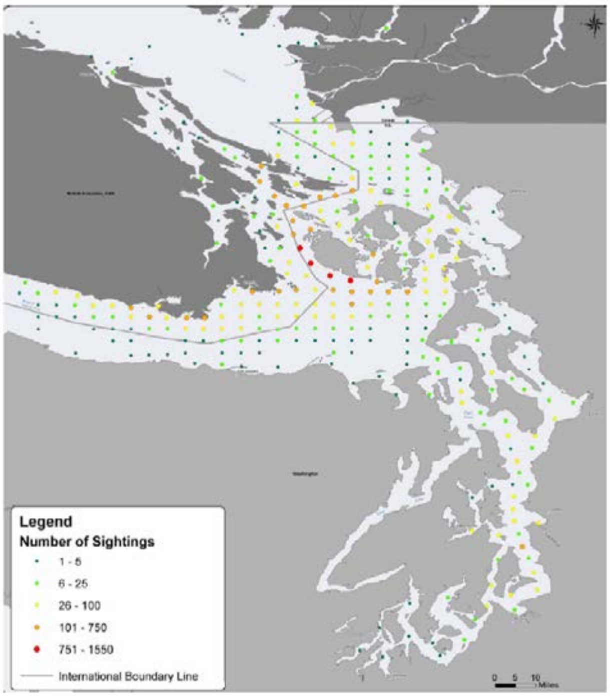

Figure 2. *Distribution of Southern Resident killer whale sightings from 1990-2005.*[16]

Due to being a distinct and significant population of very limited numbers, with a slow growth rate and low productivity,[17] after prolonged scientific and legal consideration,[18] the National Marine Fisheries Service (NMFS) of the National Oceanic and Atmospheric Administration decided that SRKWs constituted a 'distinct population segment' that was endangered due to being 'threatened' with extinction, as per the 1973 Endangered Species Act (ESA).[19] This categorization was supplemental to their status as depleted (i.e., below its

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[14] National Marine Fisheries Service (2011). *Southern Resident Killer Whales: Five Year Review* (NMFS, Seattle).

[15] Puget Sound Partnership (2012). *The 2012 State of the Sound: A Biennial Report on the Recovery of Puget Sound*. (PSP, Seattle). 22, 24. NOAA (2008). *Recovery Plan for Southern Resident Killer Whales*. (NOAA, Washington). 2, 56-58.

[16] Source: NOAA (2008). Recovery Plan for Southern Resident Killer Whales. (NOAA, Washington). Figure 5. p. II-27. [*http://www.nwr.noaa.gov/Marine-Mammals/Whales-Dolphins-Porpoise/Killer-Whales/ESA-Status/upload/SRKW-Recov-Plan.pdf*]

[17] There is a limited number of reproductive-age Southern Resident males and several females of reproductive age are not having calves. This is a particular concern with the largest pod (L) with only three surviving females producing surviving female offspring in recent years.

[18] Center for Biological Diversity v. Lohn, 296 F. Supp. 2d. 1223 (W.D. Wash. 2003).

[19] Department of Commerce, NOAA, *Endangered Status for Southern Resident Killer Whales*. 50 CFR Part 224. Final Rule. As printed in the Federal Register /Vol. 70, No. 222 / Friday, November 18, 2005 /Rules and Regulations 69907.

optimum sustainable population) under the Marine Mammal Protection Act (MMPA).[20] The national obligations upon authorities to conserve these species successfully are strengthened through both regional[21] and international conservation instruments, the latter through the International Convention for the Regulation of Whaling.[22]

The obligations imposed by all of these pieces of legislation mean that it is critical to protect the most important habitat on which a threatened/depleted species depends (Figure 2). This obligation is required under both the MMPA[23] and the ESA.[24] The designation of critical habitat[25] under the ESA is specifically focused upon the need to conserve habitat which is directly linked to the survival of the species. This designated habitat, which must not be destroyed or adversely modified, is well defined for the SRKW. Specifically, all pods use Haro Strait (i.e., west side of San Juan Island), particularly for transit. The southwest portion of San Juan Island is important for foraging and the southwest of Lopez Island is important for resting (as well as the south and west of Henry Island), whilst one pod (L) alone appears to frequent the area in the Strait of Juan de Fuca south of Vancouver Island.[26] In 2006, the NMFS designated critical habitat for SRKW as the Summer Core Area in Haro Strait and the waters around the San Juan Islands, Puget Sound, and the Strait of Juan de Fuca (which overall compromises approximately 2,560 square miles of marine habitat).[27] This critical habitat is shown in the following figure.

[20] 68 FR 31980; May 29, 2003.
[21] The Canadians concur that the SRKW are endangered.
[22] See Gillespie, A. (2006). *Whaling Diplomacy*. (Edward Elgar, London). Chapter 6.
[23] 'In particular, efforts should be made to protect essential habitats, including the rookeries, mating grounds, and areas of similar significance for each species of marine mammal from the adverse effect of man's actions'. See Section 2 (2). Findings and Declaration of Policy 16 U.S.C. 1361.
[24] *The 1973 Endangered Species Act*. Public Law 93–205, Approved Dec. 28, 1973, 87 Stat. 884; as Amended Through Public Law 107–136, Jan. 24, 2002. See section 4(2).
[25] The term ''critical habitat'' for a threatened or endangered species means the specific areas within the geographical area occupied by the species, at the time it is listed in accordance with the provisions of the ESA which are found as physical or biological features essential to the conservation of the species and which may require special management considerations or protection.
[26] National Marine Fisheries Service (2011). *Southern Resident Killer Whales: Five Year Review* (NMFS, Seattle). 5.
[27] NOAA (2008). *Recovery Plan for Southern Resident Killer Whales*. (NOAA, Washington). II-67, 76-78.

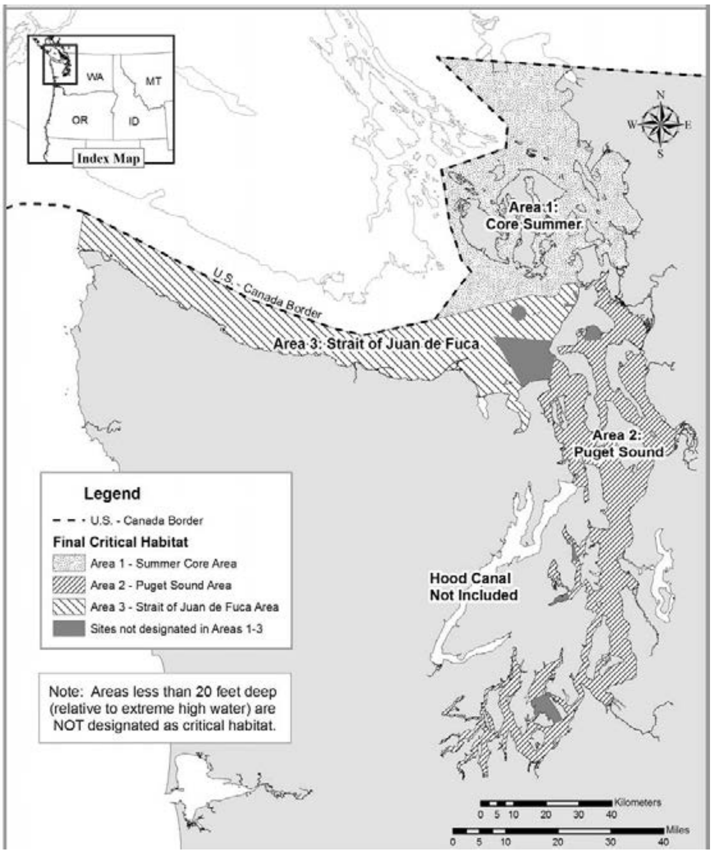

Figure 3. *Designated critical habitat for Southern Resident killer whales under the Endangered Species Act*[28]

4. The significant risk of underwater noise

Noise (i.e., sound) behaves differently in water than in air. Although the ocean is relatively opaque to light, it is relatively transparent to sound. Background, or ambient, noise occurs in all oceans and seas. Natural geophysical sources of noise include wind-generated waves, earthquakes, precipitation, and cracking ice. Natural biological sounds include whale songs, dolphin clicks, and fish vocalizations. Anthropogenic sounds are generated by a variety of activities, including commercial shipping, geophysical surveys, oil drilling and production, dredging and construction, sonar systems, and oceanographic research. Due to the physical properties of sound in water, low frequency noise can travel thousands of miles and thus can increase ambient noise levels in large areas of ocean. Moreover, as the oceans change in

[28] Source: NOAA (2008). *Recovery Plan for Southern Resident Killer Whales*. (NOAA, Washington). Figure 7. p. II-38. [*http://www.nwr.noaa.gov/Marine-Mammals/Whales-Dolphins-Porpoise/Killer-Whales/ESA-Status/upload/SRKW-Recov-Plan.pdf*]

terms of acidity, it appears that, in some areas, existing noise absorption of sound below 1 kHz, could be decreased by up to 40%.[29]

The conventional accounting of noise in the ocean suggests that the two largest contributors to the overall (space- and time-averaged) deep ocean noise budget are wind-generated ocean waves over the frequency band from 1 Hz to at least 100 kHz and commercial shipping at low frequencies (from 5 Hz to a few hundred Hz). Commercial ships generate external noise in the water via their shaft-line dynamics, propeller radiated pressures and bearing forces, air conditioning, cargo handling and mooring machinery, intakes and exhausts, and thrusters. However, it is engines, propellers, and vibration, all of which are directly related to the speed of the vessel, that are usually the principal sources of noise from vessels.[30]

In the Northern hemisphere, shipping noise is the dominant contributor in the band from 10 Hz to 200 Hz. In the Southern hemisphere, this band is less dominated by shipping given the significantly lower levels of shipping. In both hemispheres there is considerable spatial variation, with maximum ambient noise in this band being close to major shipping lanes. Shipping accounts for more than 75% of all human sound in the sea. It is estimated that from 1950 to 2000, there was a total increase of 16 dB in low-frequency noise in the oceans. This is unsurprising given that during this period the number of ships in the world tripled during the same time period. Given that shipping traffic is projected to grow in coming decades, so too is their expected contribution to underwater noise pollution. Shipping's contribution to ocean noise has been projected to increase greatly, especially in coastal areas, in the next 20 years.[31]

Noise pollution can produce detrimental impacts on all animals, including marine species. The most observable effect of noise on wild animals appears to be behavioral changes. Whilst many animals learn to differentiate among acoustic stimuli and to adapt and live with

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[29] Brahic, C. (2008). 'Hearing the Carbon Jolt Loud and Clear'. *New Scientist*. Sep 27. 10.

[30] Southall, B. (2005). '*Shipping Noise and Marine Mammals*'. Final Report of the National of the National Oceanic and Atmospheric Administration Symposium. (NOAA, 2004, May 18).

31 McDonald, M. (2006). 'Increases in Deep Ocean Ambient Noise in the Northeast Pacific'. *Journal of the Acoustic Society of America*. 120: 711-718. Andrew, R. (2002). 'Ocean Ambient Sound: Comparing the 1960s With the 1990s For a Receiver off the California Coast'. *Acoustics Research Letters Online*. 3 :65-70. National Research Council (2003). *Potential Impacts of Ambient Noise in the Ocean on Marine Mammals* (National Academies Press, Washington). 3. ICES Advisory Committee on Ecosystems (2005). *Report of the Ad-hoc Group on the Impacts of Sonar on Cetaceans and Fish* (AGISC). ICES CM 2005/ACE:06 (2nd Edn). at 3. Heitmeyer, R. (2004). 'Shipping Noise Predictions: Capabilities and Limitations'. *Marine Technology Society Journal*. 37: 54-65.

different types of noise pollution, others have gone in the opposite direction, and have shown strong sensitivities to noise pollution.[32] Within the marine environment, evidence of significant impacts has been steadily accumulating since the first study on this topic in 1971.[33]

Some species of fish appear to also be impacted by some sources of noise pollution. Most fish species hear noise sounds from below 50 Hz up to between 500-1,500 Hz. If excessive noise overlaps with a species' hearing band, especially if the noise is repeated and at close range, long-term biological damage can result if the fish species does not move away from the source. Additional evidence also suggests that the survival rate of eggs and larvae of a number of fish species, when exposed to sound levels of 120 dB or above, *may* show statistically significant decreases.[34]

The relationship between underwater noise and marine mammals is much stronger than it is with fish because the acoustic output of underwater noise at relatively low frequencies of 10 to 200 Hz, overlaps extensively with the low frequency sound produced by baleen whales in the 12 to 500 Hz bandwidth. Studies suggest that the effects of this overlap span from negligible to fatal. At the fatal end, a few cases of beaked whale strandings appear to have

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32 Hopkins,C. (1979). 'Effects of Noise on Wildlife'. 29 *Bioscience* 547.

33 Payne, R. (1971). 'Orientation by Means of Long Range Acoustic Signaling in Baleen Whales'. 188 *Annual New York Academy of Sciences* 110–141.

34 Popper, A. (2009). 'The Effects of Human Generated Noise on Fish'. 4 *Integrative Zoology*. 43–52. Popper, A. (2006). 'The Effects of Anthropogenic Noise on Fish'. 28 *Fisheries* 24–31. ICES Advisory Committee on Ecosystems (2005). *Report of the Ad-hoc Group on the Impacts of Sonar on Cetaceans and Fish*. (AGISC). ICES CM 2005/ACE:06 (2nd edn). Popper, A., et al. (2005). 'Effects of Exposure to Seismic Airgun Use on Hearing of Three Fish Species'. *Journal of the Acoustical Society of America* 117(6): 3958–71. Popper, A.N., et al. (2005). 'Effects of Low Frequency Active Sonar on Fish' *Journal of the Acoustical Society of America 117:* 2440. Popper, A.N., et al. (2004). 'Anthropogenic Sound: Effects on the Behavior and Physiology of Fishes' 37(4) *Marine Technology Soc. J.* 35–40. Smith, M., et al. (2003). 'Noise-induced Stress Response and Hearing Loss in Goldfish. The *Journal of Experimental Biology.* 207. Popper, A. (2003). 'Effects of Anthropogenic Sounds on Fishes'. 28(1) *Fisheries* 24–31. Fewtrell, J., et al. (2003). 'High Intensity Anthropogenic Sound Damages Fish Ears'. *Journal of the Acoustical Society of America* 113(1): 638. McCauley, R. (2003). 'High Intensity Anthropogenic Sound Damages Fish Ears'. *Journal of the Acoustical Society of America* 113(1): 631–42. Banner, A. (1973). 'Effects of Noise on Eggs and Larvae of Two Estuarine Fishes'. *Transactions of the American Fisheries Society* 134–36. Kostyuchenko, L.P. (1973). 'Effects of Elastic Waves Generated in Marine Seismic Prospecting of Fish Eggs'. 9(5) *The Hydrobiology Journal* 45–48. Filadelfo et al. (2009). 'Correlating Military Sonar with Beaked Whale Mass Strandings: What do the Historical Data Show? *Aquatic Mammals* 35(4): 435-444. Frantzis (1998). 'Does Acoustic Testing Strand Whales? *Nature* 392(29).

coincided with seismic surveys and military sonar.[35] However, for most species, the extent of the impacts remains mostly or completely unquantified and is still being evaluated.[36]

With particular regard to Killer whale , there is good evidence that this species is impacted upon by various types of vessel noise.[37] Some of the sources of impacts identified during the listing of the SRKW as an endangered species, were commercial shipping, whale watching, ferry operations, and recreational boating traffic and all were linked to short term behavioral changes in this protected species.[38] Subsequent studies have confirmed that vessel noise has the capacity to mask the critical needs of the SRKW by, 'significantly reduc[ing] the range at which echolocating killer whales could detect salmon in the water column'.[39]

Despite the emerging scientific evidence of a potentially significant risk for SRKW in the Puget Sound area, there are a number of uncertainties that need to be resolved with respect to these Killer whale. These uncertainties pertain to, *inter alia*, basic physiology, potential intra-specific variation and responses to different levels of noise. That is, unlike some other cetaceans, Killer whales appear to have a greater reliance on ranges in the 1 khz – 10 khz

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[35] Parsons, E. et al. (2007). 'The Conservation of British Cetaceans: A Review of Threats and Protections'. 13 *Journal of International Wildlife Law and Policy* 29–33. Nieukirk, S. (2004). 'Low Frequency Whale and Seismic Airgun Sounds Recorded in the Mid-Atlantic Ocean'. 115 *J. Acoust. Soc. Am*. 1832–1843. Malakoff, D (2002). 'Suit Ties Whale Deaths to Research Cruise'. *Science* 298. Palacios. D., et al.. 2004. Cetacean Remains and Strandings in the Galápagos Islands, 1923-2003. 3(2) *Latin American Journal of Aquatic Mammals* 127–150.

[36] OSPAR (2009). *Assessment of the Environmental Impact of Underwater Noise* (OSPAR Commission, Paris, Publication Number 436/2009). McDonald, M. (2006). 'Increases in Deep Ocean Ambient Noise in the Northeast Pacific'. *Journal of the Acoustic Society of America*. 120: 711-718. National Research Council. (2005). *Marine Mammal Populations and Ocean Noise: Determining When Noise Causes Biologically Significant Effects*. (National Academies Press, Washington). National Research Council. (2000). *Marine Mammals and Low-Frequency Sound: Progress Since 1994*. (NRC, Washington). National Research Council. (2003). *Potential Impacts of Ocean Noise*. (NRC, Washington). Hecht, J. (2005). 'Quest for Oil Could Injure Marine Life'. *New Scientist*. Aug 20. p.14. Edwards, R. (2003). 'Sonar Kills Whales.' *New Scientist*. Oct 11. p.10. Jones, N. (2003). 'Is Undersea Noise Harming Whales ?' *New Scientist*. Feb 22. p.8. Doleman, S. (2002). 'Noise Sources in the Cetacean Environment.' SC/54/E7 (unpublished report to the Scientific Committee of the IWC, 2002). Anon. (2002). 'Not So Pacific Ocean.' *New Scientist*. March 30. p.23. Marks, P. (2000). 'Cracking Up: Is the Din in the Arctic a Headache for Beluga Whales ?' *New Scientist*. September 30. p.12. Hrynyshyn, J. (2001). 'Going Round the Bend.' New Scientist. Dec pp.15. pp.17. Holmes, B. (1997). 'Noises Off.' *New Scientist*. March 22. p.24-27. Anon. (2005). 'Sonar Lawsuit'. *New Scientist*. Oct 29. p.4.

[37] Slaughter, G. (2011). 'The Impacts of Sound Pollution on Killer Whales'. *Canadian Geographer*. 131(6): 17-20. Holt, M. et al. (2009). 'Speaking Up: Killer Whales (Orcinus orca) Increase Their Call Amplitude in Response to Vessel Noise'. *Journal of the Acoustical Society of America (JASA) Express Letters*. 125: EL27-EL32. Malene, S. (2007). 'The Relationship Between Acoustic Behavior and Surface Activity of Killer Whales That Feed on Herring'. *Acta ethologica* 10(2): 47-53. Williams, R. (2006). 'Estimating Relative Energetic Costs of Human Disturbance to Killer Whales'. *Biological Conservation*. 133(3): 301-311. Boisvert, I. (2004). 'Puget Sound Orcas, Vessel Noise, and Whalewatching'. *Ocean and Coastal Law*. 10(1): 117-130. Morton, A. (2002). 'Displacement of Orca by High Amplitude Sound in British Columbia, Canada'. *ICES Journal of Marine Science*. 59(1): 71-80. Szymanski, M. et al, (1999). 'Killer Whale (Orcinusorca) Hearing: Auditory Brainstem Response and Behavioral Audiograms'. *Journal of the Acoustical Society of America* 106 (2): 1134-1141.

[38] Department of Commerce, NOAA, *Endangered Status for Southern Resident Killer Whales*. 50 CFR Part 224. Final Rule. As printed in the Federal Register /Vol. 70, No. 222 / Friday, November 18, 2005 /Rules and Regulations 69907.

[39] National Marine Fisheries Service (2011). *Southern Resident Killer Whales: Five Year Review* (NMFS, Seattle). 10-11. NOAA (2008). Recovery Plan for Southern Resident Killer Whales. (NOAA, Washington). II-107. Anon. (2004). 'Boats Drown Out Orcas Cries.' *New Scientist*. May 1. p.19.

band, where most of the energy in orca calls resides and in the 10khz-30khz where most of the energy in their echolocation clicks resides. This inter-relationship between the Killer whale and these bands of underwater noise is different to some other cetacean species as much higher frequencies of noise, where the negative relationship is much more direct. In the instance of the Killer whale, the science required needs to show what are the 'safe' levels for this species in both the short- and long-term, and the question of at what point does noise pollution become 'biologically significant' needs to be addressed. This last area of uncertainty is critical because it relates to the issue of when noise may induce long-term abandonment of an area important for feeding, breeding or rearing the young, leading to a reduction in fecundity, carrying capacity, or both. It may be that these long-term but less apparent impacts directly impact on efficiencies in foraging, navigating or communicating over the long-term. These same impacts can in turn directly impact upon reproductive success and, therefore, it is possible that these long-term but less apparent impacts are the defining features for the survival of the SRKW and must be examined.[40] There is good evidence of this outcome for marine mammals in that the cumulative impacts of long-term but low level impacts (i.e. tourism and disturbance) have been shown to directly affect key demographic parameters and lead to both population decline and reduced population viability for small populations.[41]

5. Alternatives

The most obvious alternative available to attempt to reduce the impact of underwater noise from existing, proposed and future shipping traffic is the selection of alternative routes which would reduce, not increase, the esonification of the critical habitat of the SRKW. This search for alternative routes would be consistent with the jurisprudence in this area which requires

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[40] ICES Advisory Committee on Ecosystems (2005), ibid, 15-17, 36-37. National Research Council. (2005), ibid, at 3. National Research Council. (2003). Potential Impacts, ibid, at 4-7. National Research Council. (2000), ibid, at 3. Department of Commerce, NOAA, Endangered Status for Southern Resident Killer Whales. 50 CFR Part 224. Final Rule. As printed in the Federal Register /Vol. 70, No. 222 / Friday, November 18, 2005 /Rules and Regulations 69907. National Marine Fisheries Service (2011). *Southern Resident Killer Whales: Five Year Review* (NMFS, Seattle). 8- 9. NOAA (2008). Recovery Plan for Southern Resident Killer Whales. (NOAA, Washington). V-14-15. Note also the earlier comments by the Department of Commerce, NOAA, Endangered Status for Southern Resident Killer Whales. 50 CFR Part 224. Final Rule. As printed in the Federal Register /Vol. 70, No. 222 / Friday, November 18, 2005 /Rules and Regulations 69907.

[41] Bejder et al. (2006). 'Decline in Relative Abundance of Bottlenose Dolphins (*Tursiops* sp) Exposed to Long-Term Disturbance. *Conservation Biology*. 20 (6), 1791–1798. Bejder et al. (2006). 'Interpreting Short-Term Behavioural Responses to Disturbance within a Longitudinal Perspective'. *Animal Behaviour*. 72 (5): 1149-1158. Lusseau. & Bejder (2007). 'The Long-term Consequences of Short-term Responses to Disturbance'. *International Journal of Comparative Psychology* (Special Issue) 20: 228-236.

the meaningful exploration of alternative sites that are not, ‘uniquely populous’ or ‘biologically important’.[42]

6. Mitigation

Technology has a very important role to play in the reduction of under-water noise pollution. Some vessels are already very noise sensitive, such as those involved in research, luxury travel or military work. Basic ship design and construction and choice of machinery can result in large reductions in noise emissions. This outcome is especially so in terms of the propellers, hull shapes and other methods necessary to counter vibration and associated noise problems.[43]

Despite the desirability of long-term technological change to improve noise emissions, these changes are unlikely to occur in the shorter term and therefore more immediate mitigation options are required. For immediate improvements in risk reduction, the foremost options that need to be examined are restricted times of entry for the dominant noise sources at key points of the year in the critical habitats. Such quiet zones, as NOAA originally recognized when it proposed to have a half-mile wide no-go zone along the west side of San Juan Island from May 1 through to the end of September,[44] need to be carefully re-examined.

A secondary form of mitigation relates to situations where the vessels cannot be excluded completely from critical areas at key times then they are obliged to operate in a manner which minimizes their noise emissions. The foremost method for this form of mitigation is to ensure that vessels operate at a reduced speed, thereby reducing the risk of both collision and noise impacts. The most recent example of utilizing speed restrictions with regard to the protection of endangered cetaceans involved North Atlantic Right Whales whereby vessels of 65 feet and greater in length have been obliged to travel at 10 knots or less near key port entrances and in certain areas of Right Whale aggregation along the U.S. eastern seaboard, known as

[42] See, in particular, NRDC v. Evans, 316 F.3d 904, 907 (9th Cir. 2003). .

[43] Eyres, D. (2006). *Ship Construction*. (BH Publishing, London). 36-39. Wijngaarden, E. (2005). ‘Recent Developments in Predicting Propeller-Induced Hull Pressure Points’. In Lloyds Maritime Academy. (ed). *First International Ship Noise and Vibration Conference*. (Lloyds, London). 17-23. Barrass, C. (2002). *Ship Design and Performance*. (Elsevier, London). 83-92. Rawson, K. (2005). *Basic Ship Theory*. (BH Publishing, London). 408-422.

[44] NOAA (2011). ‘New Rules to Safeguard Puget Sound’s Killer Whales’. Press Release. April 14.

"Seasonal Management Areas".[45] These developments have been mirrored at the regional level, with similar attempts being undertaken to have 10 knot speed limits for vessel traffic within their national marine sanctuaries along the Californian coast.

6. Recommended research programs

Based on the assessment in this report of the various risks posed by increased shipping to and from the proposed GPT and the cumulative impacts of all of the shipping in the region, and a consideration of potential mitigation options, six research programs are recommended to help in understanding and evaluating the cumulative impacts in this area. Four research programs are required for decision makers to reach a full and informed decision with regards to assessing the significant risk of an underwater noise pollution in this region to endangered species. A further two studies are required to assess the possibilities and potential effectiveness of mitigations in this area.

Research programs to support decision makers

(i). A noise map is required of the critical habitat of the endangered SRKW and their critical habitat that may be significantly impacted upon by the transit of vessels. This map should be founded upon the existing baseline levels, the current proposed incremental increase proposed for the GPT, and the additional future traffic (from a cumulative perspective) that may be reasonably foreseen. The particular facts that must be collected from this study include:

- Quantification of underwater noise levels by existing, future and projected traffic. Whilst being aware of historic patterns, and differences between vessel types (e.g., cargo ships, passenger vessels, barges, tugs, tankers, fishing vessels, whale-watching vessels), the study should also differentiate between locations, operating conditions, and times of data collection)
- Focus on the noise frequencies of particular concern to the SRKW, in particular, within the range of 1khz-30 khz.

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[45] Silber, G. (2012). *An Assessment of the Final Rule to Implement Vessel Speed Restrictions to Reduce the Threat of Vessel Collisions with North Atlantic Right Whales*. (US Department of Commerce, NOAA, Washington. NOAA Technical Memorandum NMFS-OPR-48.

- Differentiation between a comparable underwater situation of killer whales that are not being disturbed, and juxtaposition to the current, proposed and future expectations
- Measurements should be both constant and the coverage extensive

(ii). The levels of noise at which impacts approach biological significance should, as far as possible, be identified for the SRKW.

(iii). Once these levels of biological significance have been ascertained, the locations where these levels should not be transgressed should be identified, in addition to adequate safety zones (i.e., buffers). These locations should then be overlaid with the current, proposed and reasonably foreseeable (from a cumulative perspective) noise levels.

(iv). Research should be undertaken on the potential impacts of the noise levels on other marine species in this area, including, in particular, the Chinook and Chum salmon.

Research programs to investigate mitigation options

(v). A study should be undertaken to see if there are any possible alternative routes for vessel traffic that could be utilized to minimize noise impacts on SRKW.

(vi). Research on noise generated from shipping should be investigated to ascertain if there are improvements that can be made in reducing noise from shipping through operational practices such as reducing speeds and prioritizing ship traffic away from critical habitats.[46]

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[46] NOAA (2004). Final Report of the 2004 NOAA symposium *Shipping Noise and Marine Mammals.*