Recovery Planning for Pacific Marine Species at Risk in the Wake of Climate Change and Ocean Acidification: Canadian Practice, Future Courses[†]

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This article evaluates how Canadian recovery planning[1] *for Pacific marine species at risk incorporates two pressing 21st century concerns: global climate change and ocean acidification (OA). While many recovery strategies for Pacific species at risk show some understanding of climate change or OA, they generally fail to incorporate key climate and OA information or to consider how these two issues will actually affect the species in question. Two strategies for progress are suggested. First is an administrative strategy that includes the development of a national climate change adaptation strategy that clarifies how projected climate and ocean acidification impacts should be incorporated into decision-making under the Species at Risk Act (SARA). Second is a legal course that includes an amendment of SARA or regulations thereunder that require up-to-date climate and ocean acidification information to be incorporated during recovery planning. In addition to the administrative and legal courses suggested, a precautionary, yet bold and flexible approach to recovery planning is advocated that aims to achieve species resilience rather than meeting historical population levels (which may already be impossible to achieve given shifting ecological, biological and physical*

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† Research for this article was made possible with funding from the Marine Environmental Observation, Prediction and Response Network (MEOPAR). Established in 2012 and headquartered at Dalhousie University, the MEOPAR network is a team of Canadian researchers dedicated to addressing critical issues related to human activity in the marine environment, and the impact of marine hazards on human activities in coastal regions. The research support of the Social Sciences and Humanities Research Council of Canada is also gratefully acknowledged.

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1 The terms “recovery planning” and “recovery planner” are used frequently in this article. They are used in accordance with Environment Canada’s “recovery planner” definition: “a generic reference to those who are undertaking the recovery planning and/or action planning for a particular species at risk.” *Species at Risk* Recovery Program, Federal Policy Discussion Paper: Critical Habitat (EC, 2009) at 5.

baselines). This article is a follow up to a similar piece that examined Atlantic species at risk.[2]

Dans cet article, les auteurs analysent la manière dont les efforts du Canada en matière de rétablissement des espèces marines en péril tiennent en compte de deux inquiétudes urgentes typiques du 21ème siècle : les changements climatiques globaux et l'acidification des océans (AO). Bien que plusieurs stratégies de rétablissement des espèces du Pacifique en péril révèlent une certaine compréhension des changements climatiques ou de l'AO, elles ne tiennent généralement pas compte de données pertinentes relatives aux changements climatiques ou à l'AO ou ne prennent pas en considération l'impact véritable de ces enjeux sur les espèces en question. Les auteurs suggèrent de mettre en œuvre deux stratégies d'avenir. La première est une stratégie administrative visant à développer une politique nationale d'adaptation aux changements climatiques afin de clarifier la manière dont les juges et les décideurs devraient tenir compte des impacts appréhendés de l'acidification du climat et des océans lorsqu'ils interprètent la Loi sur les espèces en péril (LEP). La deuxième est un processus législatif visant à modifier la LEP ou ses règlements afin d'exiger que l'on tienne dorénavant compte de données à jour concernant l'acidification du climat et des océans dans le cadre du plan de rétablissement. En plus de ces stratégies, les auteurs proposent d'élaborer une approche de rétablissement prudente qui soit également audacieuse et souple afin de favoriser la résilience des espèces plutôt que de viser à atteindre des seuils de population historiques (ce qui risque d'être d'ores et déjà impossible à atteindre compte tenu de modifications fondamentales au point de vue écologique, biologique et physique). Cet article est la suite d'un article similaire portant sur les espèces de l'Atlantique en péril.

I. INTRODUCTION

Atmospheric carbon dioxide levels have increased relative to pre-industrial levels by 40% due to anthropogenic activity.[3] This increase is affecting the world's oceans in at least two important ways. First, it is causing the ocean's surface waters to warm, because most of the additional heat in the climate system is absorbed by the ocean (at rates that are unprecedented over decades to millennia).[4] Second, it is causing changes in the ocean's carbonate chemistry including a lowering of seawater pH.[5] Both of these effects have already elicited responses from marine orga-

2 See Aaron Lemkow & David L VanderZwaag, "Recovery Planning under Canada's *Species at Risk Act* in a Changing Ocean: Gauging the Tides, Charting Future Coordinates," (2014) 26:2 J Envtl L & Prac 121 [Lemkow].

3 Intergovernmental Panel on Climate Change, *Climate Change 2014: Impacts, Adaptation, and Vulnerability — Summary for Policy Makers*, WGII AR5, 2014 [IPCC Summary for Policy Makers].

4 *Ibid.*

5 Intergovernmental Panel on Climate Change, *Chapter 6 Ocean Systems*, WGII ARG, 2014 [IPCC Chapter 6].

nisms, which are changing their ranges, timing of key life-history events, and migratory and spawning patterns.[6]

The *Species at Risk Act* protects imperiled species in two ways: by imposing a prohibition on "take" (i.e. killing, harming, harassing, or capturing an individual of a wildlife species) and by implementing a two-stage recovery planning process.[7] In order to receive any of these protections, a species must first be listed via an assessment and approval process initiated by the Committee on the Status of Endangered Wildlife in Canada and then finalized by the Governor in Council on recommendation of the Minister of Fisheries and Oceans (in the case of aquatic species). Once listed, steps must be taken to prohibit take, and to plan the recovery of the species via a recovery strategy and action plan.

Unfortunately, the Act does not make any express mention of the effects of increasing atmospheric CO_2 on Canada's at risk species, and does not impose any requirement on recovery planners to integrate climate or ocean acidification (OA) projections.[8] As atmospheric CO_2 concentrations increase over this century and ecological systems are reshuffled,[9] the need to incorporate climate science into Canadian recovery planning will become more and more acute. Additional challenges faced by marine recovery planners include a shortage of available science compared to terrestrial systems,[10] inherent uncertainties surrounding how climate change and acidification will progress across this century and limited understanding of how increasing atmospheric CO_2 and more traditional anthropogenic stressors will interact.[11]

This article begins by discussing how climate change and OA will affect marine species and the recovery of marine species at risk. Second, it explores the *Species at Risk Act* (SARA), Canada's statutory tool for protecting listed terrestrial and aquatic species. Third, key publications relevant to SARA recovery planning are reviewed. This includes two scientific reports published by Fisheries and Oceans Canada (DFO):[12] Canada's State of the Oceans Report 2012 and the Risk-

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6 Intergovernmental Panel on Climate Change, *Chapter 30 The Ocean*, WGII AR5, 2014.

7 *Species at Risk Act*, S.C. 2002, c. 29 [*SARA*].

8 A similar observation has been made with respect to the US *Endangered Species Act*. See Erin E Seney et al, "Climate Change, Marine Environments, and the U.S. *Endangered Species Act*" (2013) 27:6 Conservation Biology 1138.

9 JB Ruhl, "Climate Change and the *Endangered Species Act*: Building Bridges to the No-Analog Future" (2008) 88:1 BUL Rev 1 [Ruhl].

10 Craig R Groves et al, "Incorporating Climate Change into Systemic Conservation Planning" (2012) 21 Biodiversity Conservation 1651; Michelle M Mcclure et al, "Incorporating Climate Science in Applications of the U.S. *Endangered Species Act* for Aquatic Species" (2013) 27:6 Conservation Biology 1222.

11 Ove Hoegh-Guldberg & John F Bruno, "The Impact of Climate Change on the World's Marine Ecosystems" (2010) 328 Science at 1523; Scott R Loarie1 et al, "The Velocity of Climate Change" (2009) 462 Nature 1052, [Hoegh-Guldberg].

12 Note that although the applied title of DFO is now Fisheries and Oceans Canada, its old applied title — the Department of Fisheries and Oceans — continues to serve as its legal name (or the name given to the department by its enabling legislation, the *Depart-*

Based Assessment of Climate Change Impacts and Risks on the Biological Systems and Infrastructure within Fisheries and Oceans Canada's Mandate. The reports are examined and evaluated in terms of how well they equip recovery planners to incorporate the effects of rising atmospheric CO_2. Fourth, the seven published recovery strategies for Pacific marine species at risk are evaluated according to how well they incorporate climate change and OA information. Finally, suggestions are made as to how DFO and the Canadian federal government can ensure that the effects of climate change and OA are better incorporated into recovery planning for imperiled species. These suggestions are administrative (or policy oriented) as well as legal in nature. How SARA's listing process incorporates the impacts of increasing atmospheric CO_2 will not be examined[13] (although this could be a valuable area of future research).[14]

II. MARINE ENVIRONMENTAL EFFECTS OF CLIMATE CHANGE AND OCEAN ACIDIFICATION

Rapid climate change and ocean acidification will affect marine species in many ways. Impacts already observed include large irreversible shifts in species distribution, range, migration, as well as changes in species growth, development, behaviour, productivity, feeding, organismal physiology, trophodynamics and survival. These impacts will likely become more pronounced as warming increases and the world's oceans become more acidic, making adaptive management an increasingly important priority.

(a) Effects of Changes in Temperature on Marine Species

Global warming is essentially ocean warming: 90% of the heat energy that has accumulated in the climate system between 1971 and 2010 due to anthropogenic greenhouse gases has been absorbed by the ocean.[15] It is likely that the surface ocean warmed between the 1870s and 1971, and it is virtually certain that it warmed between 1971 and 2010 (by >0.1 °C per decade).[16] In its latest report, the IPCC projects that by 2090 average ocean surface temperatures could be a stagger-

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ment of Fisheries and Oceans Act, RSC 1985, c F-15). Therefore, DFO is still the correct acronym to use for the department.

13 For an article on listing under the US *Endangered Species Act*, see Michael C Blumm & Kya B Marienfeld, "*Endangered Species Act* Listing and Climate Change: Avoiding the Elephant in the Room" (2014) 20:1 Animal Law Review [forthcoming in 2014].

14 The Northern Fur Seal would make an interesting case study for an article on listing under SARA. The species was assessed by COSEWIC as threatened in 2009 (and climate change was listed as one of the threats), but this assessment was sent back by the Governor in Council (on recommendation of the Minister of Fisheries and Oceans) because of new information regarding fur seal's ability to move between rookeries. COSEWIC then re-assessed the species, again as threatened, in 2011 but DFO decided to enter into a "consultation process" in 2012 which has yet to result in a decision (as of 06/2014) on whether to list the species or not.

15 IPCC Summary for Policy Makers, *supra*, note 3 at 8.

16 IPCC Chapter 6, *supra*, note 5 at 7.

ing 2.7°C warmer than in 1990.[17] But these global averages mask the fact that warming will be more pronounced in some regions. Most of the surface ocean warming will occur in mid and high latitudes and some coastal regions may see larger than average temperature increases as well. Since marine animals experience their local environment and tend to exist in their optimal temperature range — where the ratio of oxygen supply to usage is maximized[18] — these temperature increases will have important implications for the range and migratory patterns of marine species, especially in mid and high latitudes.

Higher trophic-level marine species (e.g. fish, mammals) usually forage in areas enriched by oceanic upwelling, a phenomenon caused by a combination of certain wind patterns and Earth's rotation primarily along coasts and at the equator. Upwelling supplies nutrient-rich water to the surface ocean fueling photosynthesis, which supports the marine food web. Patterns of wind and consequently of upwelling will likely shift and become less predictable because of climate change,[19] which could lead to temporal and spatial mismatches between prey availability and the need for food by migratory species. Further, migratory patterns appear to be constrained by thermal fronts, which will likely be altered as the ocean warms.[20] Although all extant marine species have the capacity to evolve and adapt to changing ocean conditions, none have encountered the magnitude or rapid rate of change that is currently predicted.[21] Further, migratory species are thought to have even less capacity to adapt to changing ocean conditions,[22] a point relevant to the recovery of many Pacific species currently protected under SARA.

On the one hand, temperature directly affects the physiology of marine organisms by determining the rates of fundamental cellular processes including enzyme reactions, diffusion, transport across membranes and metabolism.[23] On the other hand, the composition and trophic efficiency of plankton communities are strongly tied to ocean temperatures.[24] With respect to trophic transfer, the most efficient plankton communities are those that support high levels of photosynthesis fueled

17 *Ibid.*

18 *Ibid.*, at 16.

19 John Harwood, "Marine Mammals and Their Environment in the Twenty-First Century" (2001) 82:3 Journal of Mammalogy at 630.

20 Ewan Hunter et al, "Impacts of Migratory Behaviour on Population Structure in North Sea Plaice" (2004) Journal of Animal Ecology at 377; David W Sims et al, "Encounter Success of Free-Ranging Marine Predator Movements Across a Dynamic Prey Landscape" (2006) 273 Proceedings of the Royal Society B 1195.

21 Brian Huntley et al, "Potential Impacts of Climate Change Upon Geographic Distributions of Birds" (2006) 148 Ibis 8.

22 Robert A Robinson et al, "Travelling Through a Warming World: Climate Change and Migratory Species" (2009) 7 Endangered Species Research 87 [Robinson].

23 Hoegh-Guldberg, *supra*, note 11 at 1525.

24 *Ibid*. Anthony J Richardson, "In Hot Water: Zooplankton and Climate Change" (2008) 65 ICES Journal of Marine Science 279.

by nutrient input from the cold, deep ocean.[25] An established paradigm in oceanography is that increased vertical density stratification due to surface warming will reduce nutrient supply to the surface, thus decreasing photosynthetic productivity and the ability of the food web to support large predators and mammals.[26] Current warming has already caused large irreversible shifts in species distribution, growth, development, behaviour, productivity and feeding.[27]

(b) Effects of Changes in pH on Marine Species

Increasing atmospheric carbon dioxide, while acting as the principle anthropogenic driver of climate change, is also causing fundamental changes in ocean carbonate chemistry.[28] The ocean has absorbed about a quarter to a third of anthropogenic carbon dioxide emissions.[29] While this uptake is mitigating anthropogenic global warming to some degree, it is causing well-understood changes to ocean chemistry with potentially severe impacts on marine organisms and ecosystems. When carbon dioxide is taken up by the ocean it does not merely dissolve in seawater; instead most of the dissolving gas (also referred to as aqueous carbon dioxide) reacts with water to form carbonic acid, which then dissociates to form bicarbonate ions, carbonate ions and hydrogen ions.[30] The addition of anthropogenic carbon dioxide to the ocean shifts the equilibrium between its aqueous form, carbonate and bicarbonate such that the concentrations of hydrogen and bicarbonate ions increase compared to preindustrial concentrations (the increase in hydrogen ions is synonym with increasing acidity) while the concentration of carbonate ions (required by many shell-forming organisms) decreases. The acidity of seawater is expressed in pH, defined as the negative logarithm of hydrogen ion concentration. Because of this convention a decrease in pH refers to an increase in acidity, and a change by one pH unit corresponds to a change in hydrogen ion concentration by a factor of 10. The pre-industrial surface ocean had an average pH of 8.2, which has already fallen to 8.1.[31] This corresponds to an increase in surface ocean acidity by 26%. By the year 2100, pH values are projected to drop to 7.8 or 7.9, which would represent a doubling in acidity.[32]

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25 Daniel Kamykowski & Sara-Joan Zentara, "Predicting Plant Nutrient Concentrations From Temperature and Sigma-T in the Upper Kilometer of the World Ocean" (1986) 33:1 Deep Sea Research 89.

26 Laurent Bopp et al, "Potential Impact of Climate Change on Marine Export Production" (2001) 15:1 Global Biogeochemical Cycles 81.

27 Anthony J Richardson, "In Hot Water: Zooplankton and Climate Change" (2008) 65 ICES Journal of Marine Science 279, [Richardson].

28 IPCC Chapter 6, *supra*, note 5 at 4.

29 CL Sabine & T Tanhua, "Estimation of Anthropogenic CO_2 Inventories in the Ocean" (2010) 2 Annual Review of Marine Science 175.

30 RE Zeebe & D Wolf-Gladrow, *CO_2 in Seawater: Equilibrium, Kinetics, Isotopes* (Amsterdam: Elsevier Oceanography Series, 2001) at 346.

31 JP Gattuso & H Lavigne, "Technical Note: Approaches and Software Tools to Investigate the Impact of Ocean Acidification" (2009) 6 Biogeosciences 2121.

32 JC Orr et al, "Anthropogenic Ocean Acidification Over the Twenty-First Century and its Impact on Calcifying Organisms" (2005) 437:7059 Nature 681; L Bopp et al, "Mul-

Impacts of ocean acidification include direct effects on organisms with calcareous shells and skeletons, direct effects on organismal physiology and behaviour, and more indirect effects on population structure and trophodynamics.[33] Direct effects on calcareous organisms, i.e. those that have a shell or exoskeleton made of calcium carbonate, have received the most scientific attention. Organisms precipitate calcium carbonate using dissolved carbonate ions in seawater. As the pH of seawater drops and the concentration of carbonate ions declines, seawater becomes more corrosive to calcium carbonate making it harder for organisms to precipitate and maintain their calcareous shells. Examples include benthic invertebrates such as corals, clams, mussels, oysters, crabs, lobsters and sea urchins, and planktonic organisms.[34] There are two common forms of calcium carbonate: aragonite, which is built by corals, sea snails and many mollusks and is relatively soluble, and calcite, which is less soluble and built by calcerous phytoplankton and zooplankton and some mollusks. Studies on corals consistently show decreased rates of calcification following acidification,[35] and many studies on mussels, oysters, gastropods and sea urchins show decreased rates of calcification as well.[36] Of particular concern for the species examined in this manuscript is the ability of sea snails to withstand corrosive conditions and adapt quickly enough to live in the rapidly acidifying high-latitude surface ocean.[37] Sea snails contribute to the diet of other zooplankton, myctophid[38] and notothenid[39] fishes,[40] North Pacific Salmon,[41]

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tiple Stressors of Ocean Ecosystems in the 21st Century: Projections With CMIP5 Models" (2013) 10 Biogeosciences 6225.

33 *Ibid.*

34 Calcareous planktonic organisms include photosynthetic coccolithophores, herbivorous foraminifera and multicellular organisms like pteropods (free-swimming sea snails and sea slugs).

35 SC Doney et al, "Ocean Acidification: The Other CO_2 Problem" (2009) 1 Annual Review of Marine Science 169.

36 F Gazeau et al, "Impact of Elevated CO_2 on Shellfish Calcification" (2007) 34:L07603 Geophysical Research Letters; Y Shirayama & H Thornton, "Effect of Increased Atmospheric CO_2 on Shallow Water Marine Benthos" (2005) 110 Journal of Geophysical Research C09S08.

37 James C Orr, "Anthropogenic Ocean Acidification Over the Twenty-First Century and its Impact on Calcifying Organisms" (2005) 437 Nature 681.

38 Myctophids, or lantern fish, are both diverse and extremely populous and therefore play an important role in marine food webs.

39 Notothenids are the dominant fish taxa in the Antarctic.

40 Brian A Foster & John C Montgomery, "Planktivory in Benthic Nototheniid Fish in McMurdo Sound, Antarctica" (1993) 36 Environmental Biology of Fishes 313; EA Pakhomov, R Perissinotto & CD McQuaid, "Prey Composition and Daily Rations of Myctophid Fishes in the Southern Ocean" (1996) 134 Mar Ecol Prog Ser 1; M La Mesa, M Vacchi & T Zunini Sertorio, "Feeding Plasticity of Trematomus Newnesi (Pisces, Nototheniidae) in Terra Nova Bay, Ross Sea, in Relation to Environmental Conditions" (2000) 23 Polar Biol 38.

41 TM Willette, RT Cooney et al, "Ecological Processes Influencing Mortality of Juvenile Pink Salmon in Prince William Sound, Alaska" (2001) 10 Fisheries Oceanography 14; Jennifer L Boldt & Lewis J Haldorsen, "Seasonal and Geographic Variation in Juvenile

mackerel, herring, cod and baleen whales[42] (a number of Pacific baleen whale species are currently listed under SARA).

Furthermore, the larval development and fertilization success of many benthic invertebrate species are impaired by acidification.[43] Acidification of the Pacific is thought to be responsible for significant negative effects on commercially reared shellfish larvae on the coast of Washington State, Oregon and British Columbia.[44] This impact of OA has direct economic impacts, and is predicted to worsen as atmospheric CO_2 concentrations increase.[45]

Decreasing ocean pH may not only affect calcifying organisms but may also have detrimental effects on the survival, growth and reproduction of marine animals in general. For example, fishes require their blood pH to remain within certain limits. Disturbances of blood pH are known to impair oxygen transport by the circulatory system and thus overall fitness of the animal. Information to date suggests that most marine fishes can effectively maintain their blood pH even at extreme ambient pH levels (regulation involves the excretion of acid primarily through gills but also kidneys and gut as compensatory mechanism[46]). However, the energetic costs associated with pH regulation may impair other energy-demanding bodily functions such as swimming, immune defense, digestion, reproduction and growth,

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Pink Salmon Diets in the Northern Gulf of Alaska and Prince Williams Sound" (2003) 132:6 Transactions of the American Fisheries Society 1035.

42 Carol M Lalli & Ronal W Gilmer, *Pelagic Snails: The Biology of Holoplanktonic Gastropod Molusks*, (Stanford: Stanford University Press, 1989).

43 H Kurihara & Y Shirayama, "Effects of Increased Atmospheric CO_2 on Sea Urchin Early Development" (2004) 274 Marine Ecology Progress Series, 161.

44 Alan Barton et al, "The Pacific Oyster, Crassostrea Gigas, Shows Negative Correlation to Naturally Elevated Carbon Dioxide Levels: Implications for Near-Term Ocean Acidification Effects" (2012) 57:3 Limnology and Oceanography 698; Elizabeth Grossman, "Northwest Oyster Die-Offs Show Ocean Acidification Has Arrived" (2011) Yale Environment 360 (blog) at para 4, online: <http://e360.yale.edu/feature/northwest_oyster_die-offs_show_ocean_acidification_has_arrived/2466/>; British Columbia, Legislative Assembly, *Official Report of Debates of the Legislative Assembly (Hansard)*, No. 9 (27 February, 2013) at 1705 (Chandra Herbert); British Columbia, Legislative Assembly, *Debates of the Legislative Assembly (Hansard)*, No 7 (9 April 2014) at 3057 (S Fraser); *House of Commons Debates* No 53 (27 February 2014) at 3305 (Hon Francoise Choquette).

45 Daiju Narita, Katrin Rehdanz & Richard SJ Tol, "Economic Costs of Ocean Acidification: A Look Into the Impacts on Global Shellfish Production" (2012) 113 Climate Change 1049; A Whitman Miller et al, "Shellfish Face Uncertain Future in High CO2 World: Influence of Acidification on Oyster Larvae Calcification and Growth in Estuaries" (2009) 4:5 PLoS ONE e5661.

46 SF Perry & KM Gilmour, "Acid-Base Balance and CO_2 Excretion in Fish: Unanswered Questions and Emerging Models" (2006) 154 Respiratory Physiology & Neurology 199.

and thus overall fitness.[47] Most temperate fish species appear to be well adapted to handle pH variations in ambient water,[48] but only few species have been studied systematically in terms of their response to decreasing pH.

In addition to the direct effects on calcareous species and organismal physiology, ocean acidification will likely alter ecological relationships and trophic dynamics, which determine the flow of energy and nutrients through the marine food web. Acidification will affect different species differently, which can result in cascading effects across the food web. Major reorganizations of pelagic and benthic ecosystems are possible, but projecting such ecosystem-level responses is extremely difficult.

The lowering of ocean pH also leads to decreased sound absorption.[49] OA has an especially noticeable effect on sounds between 100Hz and 1kHz, causing these sounds to travel further and thus increasing ambient noise.[50] This range happens to contain much of the noise generated by shipping (which has itself increased ocean ambient noise by 19 dB, or about 28%, since 1950[51]) and seismic testing. Also, since cetaceans can detect sounds within this range, OA may make anthropogenic interference with the calls of baleen whales (which are used to facilitate mating and other social interactions[52]) and toothed whales (which are used to sense and track prey[53]) worse.

III. THE SPECIES AT RISK ACT AND CANADIAN RECOVERY PLANNING

Unfortunately, the *Species at Risk Act* has been relatively ineffective at addressing the impacts outlined in the previous section.[54] Further, SARA has been criticized for being slow, ineffective and for giving socio-economic considerations too much priority at the expense of species protection.[55] Before examining how SARA may be more effectively applied — or even legally amended — to better in-

47 F Melzner et al, "Physiological Basis for High CO_2 Tolerance in Marine Ectothermic Animals: Pre-Adaptation Through Lifestyle and Ontogeny?" (2009) 6 Biogeoscience 2313.

48 H-O Pörtner et al, "Effects of Ocean Acidification on Nektonic Organisms" in J-P Gattuso & L Hansson eds., *Ocean Acidification* (Oxford University Press, 2011) 154.

49 Keith C Hester et al, "Unanticipated Consequences of Ocean Acidification: A Noisier Ocean at Lower pH" (2008) 35 Geophysical Research Letters L19601.

50 John A Hildebrand, "Anthropogenic and Natural Sources of Ambient Noise in the Ocean" (2009) 395 Marine Ecological Progress Series 5 [Hildebrand].

51 George V Frisk, "Noiseonomics: The Relationship Between Ambient Noise Levels in the Sea and Global Economic Trends" (2012) 2:437 Scientific Reports 437.

52 Peggy L Edds-Walton, "Acoustic Communication Signals of Mysticete Whales" (1997) 8:1-2 Bioacoustics 47.

53 WL Whitlow, *The Sonar of Dolphins*, (Germany: Springer-Verlag, 1993).

54 *SARA*, *supra*, note 7, s 142.

55 Kaitlyn Chewka, *The Politics of Protecting Species: Examination of Environmental Interest Group Strategies Before and After the Species at Risk Act* (MA Thesis, University of Victoria, 2011) [unpublished] at 131.

corporate climate and OA impacts, the Act's structure and scheme will be explained.

(a) Listing Under SARA

Before a species receives legal protection, it must first be listed under Schedule 1 of the Act. The first stage of a species' listing is an assessment by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC),[56] which operates at arm's length from government.[57] An assessment must:

> (a) assess the species as extinct, extirpated, endangered, threatened or of special concern;
>
> (b) indicate that COSEWIC lacks sufficient information to make a classification; or
>
> (c) conclude that the species is not at risk.

Once per year, and before a species can become legally protected under SARA, COSEWIC's assessments are forwarded to the Minister of the Environment and the Canadian Endangered Species Conservation Council for consideration. For marine species, the Minister of Fisheries and Oceans (MFO) is a competent Minister.[58] Once the COSEWIC assessment has been forwarded, the MFO has 90 days to publish a statement in SARA's public registry that indicates how the Minister will respond.[59] This statement may reveal that the Minister intends to delay legal listing of the species in order to conduct a public consultation, or that COSEWIC's recommendation will be forwarded within a given period. In any case, the Minister must eventually forward COSEWIC's assessment to the Governor in Council (GIC), triggering a nine-month period within which the GIC must, on recommendation of the Minister:

> (a) accept the assessment and list the species;
>
> (b) decide not to list the species; or
>
> (c) refer the matter back to COSEWIC for further information or consideration.[60]

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56 COSEWIC is currently composed of 31 voting members, including a Co-chair from each of the 10 Species Specialist Subcommittees and a Co-chair from the Aboriginal Traditional Knowledge Subcommittee, one member from each of the 13 provincial and territorial governments, one member from each of four Federal agencies (Canadian Wildlife Service, Parks Canada Agency, Fisheries and Oceans Canada, and the Canadian Museum of Nature), and three non-government science members. However this composition is not statutorily mandated, and the Minister has discretion to appoint members after consultation with the Canadian Endangered Species Conservation Council and with any experts and expert bodies, such as the Royal Society of Canada, that the Minister considers to have relevant expertise (s 16(1) of the SARA).

57 *SARA*, *supra*, note 7, ss 16(4), (6).

58 *Ibid*., s 2(1).

59 *Ibid*., s 25(3).

60 *Ibid*., s 27(1.1). Note that if the GIC (on recommendation of the Minister) decides not to list the species or to refer the matter back to COSEWIC, the GIC must include reasons for doing so in the public registry (s 27(1.2)).

Listed species are reassessed at least every ten years,[61] offering a snap shot of the effectiveness of Canadian species at risk protection. Since COSEWIC formed in 1977, reassessed species have become more imperiled almost twice as often as they have become less imperiled.[62] At the time this article was written, COSEWIC had assessed 654 species as threatened, endangered, or of special concern while only 547 were actually listed under SARA.[63] The federal government has denied the listing of 23% of species suggested by COSEWIC between 2002 and 2007, often for socioeconomic or "process" reasons.[64] In the majority of cases where "process reasons" were given for not listing a species, this referred to consultation with aboriginal groups.[65]

(b) Recovery Planning and the Legal Protection of Species Under SARA

If the GIC lists an aquatic species as threatened or endangered, individuals automatically receive legal protection while in Canadian waters.[66] Further, a two-step recovery planning process occurs where the MFO must publish a recovery strategy[67] and then an action plan.[68] For species listed as endangered or threatened, a proposed recovery strategy must be completed within one and two years, respectively.[69] A final recovery strategy must then be published in SARA's public registry within 90 days.[70]

According to the Commissioner of the Environment and Sustainable Development, 146 recovery strategies (or 41%) were overdue as of 31 March 2013, which included 17% of the recovery strategies for which DFO has responsibility.[71] In a 2014 case filed in response to Environment Canada and DFO's failure to create

61 *Ibid*., s 24.

62 Arne O Mooers et al, "Science, Policy, and Species at Risk in Canada" (2010) 60 BioScience 843.

63 Committee on the Status of Endangered Wildlife in Canada, *Canadian Wildlife Species at Risk (2013), online*: <http://www.cosewic.gc.ca/eng/sct0/rpt/csar_e.html> and see online: <http://www.sararegistry.gc.ca/sar/index/default_e.cfm> for SARA status.

64 C Scott Findlay et al, "Species Listing Under Canada's *Species at Risk Act*" (2009) 23:6 Conservation Biology 1609.

65 *Ibid*., at 1613.

66 Pursuant to s 32, a species listed as threatened or endangered cannot be killed, harmed, harassed, captured, or taken. Further, pursuant to s 33, the species' "residence" cannot be damaged or destroyed.

67 Pursuant to s 37(1) of SARA, the competent minister must prepare a recovery strategy for a species listed as threatened or endangered.

68 Pursuant to s 47 of SARA, the competent minister must prepare one or more action plans based on the recovery strategy. For Pacific species at risk, DFO has prepared only one action plan to date, and that action plan was overdue.

69 SARA, *supra*, note 10, s 42(1).

70 *Ibid*., s 43.

71 Commissioner of the Environmental and Sustainable Development, "Recovery Planning for Species at Risk" in *Report of the Commissioner of the Environment and Sustainable Development, Chapter 6* (Ottawa: Office of the Auditor General of Canada, 2013) at 10.

recovery strategies for four species several years after they were due, the Federal Court declared that the Ministers' inaction was unlawful.[72] Although the Court declined to decide whether the deadlines set out in SARA are mandatory or merely directory, all parties agreed that the competent Ministers are required to comply with them.[73]

Once created, the recovery strategy must provide a description of the species, and identify its needs and threats (including all threats identified by COSEWIC).[74] Further, the recovery strategy must identify critical habitat to the extent possible, based on the best available information.[75] Critical habitat is defined under SARA as "the habitat that is necessary for the survival or recovery of a listed wildlife species".[76] Any critical habitat that falls within federal jurisdiction is automatically protected, meaning that all marine critical habitat in Canadian waters must receive legal protection so long as it is identified in the recovery strategy. Any part of a listed aquatic species' critical habitat that is not already protected by legislation or by a conservation agreement[77] when the recovery strategy is published must receive protection via an order pursuant to SARA ss. 58(4) and (5).[78] In the event that a marine species' critical habitat is already protected, the protection must be mandatory rather than discretionary. In *Minister of Oceans v Georgia Strait Alliance*, the Federal Court of Appeal decided that since the protection of resident killer whale prey availability in the Strait of Georgia (a protected "ecosystem feature") was discretionary (pursuant to the *Fisheries Act*[79]), a mandatory protection order[80] by the Minister of Fisheries and Oceans was required.[81]

A species' action plan must also contain a description of critical habitat (to the extent possible).[82] Further, the action plan must state what actions will be taken to preserve the species' critical habitat, how the recovery strategy will be implemented, the methods used to monitor the species' recovery, and an evaluation of the socio-economic costs and benefits of the action plan.[83] The deadline for the

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72 *Western Canada Wilderness Committee v. Canada (Minister of Fisheries and Oceans)*, 2014 FC 148, 2014 CarswellNat 278, 2014 CarswellNat 279, [2014] 2 C.N.L.R. 373 at para 94, [*Western Canada Wilderness Committee*].

73 *Ibid*., at para 100.

74 *SARA*, *supra*, note 7, s 41.

75 *Ibid.*

76 *Ibid*., s 2(1).

77 See *SARA*, *supra*, note 7, ss 57(a), 11.

78 See *SARA*, *supra*, note 7.

79 See *Fisheries Act R*SC 1985, c F-14, ss 35, 36.

80 Canada Gazette, *Critical Habitats of the Northeast Pacific Northern and Southern Resident Populations of the Killer Whale (Orcinus orca) Order*, Vol 143, No 5 (March 4, 2009; Registration SOR/2009-68 February 19, 2009).

81 *Georgia Strait Alliance v. Canada (Minister of Fisheries & Oceans)*, 2012 FCA 40, 2012 CarswellNat 262, 2012 CarswellNat 2973, 427 N.R. 110, at paras 43, 109.

82 *Ibid*., s 49(1).

83 *Ibid.*

plan's completion is set at the minister's discretion in the recovery strategy,[84] but DFO has been chronically late on meeting such deadlines. While 12 Pacific species at risk currently have final recovery strategies, only Northern Abalone has an action plan (and that action plan was released after the deadline).[85]

(c) DFO Scientific and Policy Guidance

Before examining the seven final recovery strategies published by DFO under SARA for Pacific marine species at risk,[86] it will be useful to survey what guidance has been given to recovery planners by the federal government. This includes two recent scientific publications by Fisheries and Oceans Canada that study climate change and OA. Finally, this section will examine four policy frameworks released by DFO that are expressly intended to help recovery planners with the application of SARA.

Two recent DFO publications have studied the effects of increasing atmospheric CO_2 on the ocean. The first, "Canada's State of the Oceans Report 2012," discusses alterations to ocean climate and increasing acidification and hypoxia.[87] Although impacts on species at risk are not expressly considered, the report indicates that DFO is considering the implications of rising CO_2 on marine ecosystems and biodiversity generally. A next step may be to consider impacts on species at risk and their planned recovery specifically.

DFO is also conducting a multi-year research program that will follow up on the work of the Climate Change Science Initiative.[88] The Aquatic Climate Change Adaptation Services Program (ACCASP) investigates problems posed to ocean management by increasing atmospheric CO_2, and makes recommendations to policy makers regarding how these problems can be addressed. Fisheries and Oceans Canada divides its efforts into four defined Large Aquatic Basins (LABs): the Arctic, Pacific, Freshwater, and Atlantic.[89] One of the primary objectives of the AC-

84 *Ibid*., s 41(1)(g).

85 *Species at Risk Act* Action Plan Series, Action Plan for the Northern Abalone (*Haliotis kamtschatkana*) in Canada (Fisheries and Oceans Canada, 2012) at 10 [Northern Abalone Action Plan].

86 Recovery strategies for the North Pacific Humpback Whale, the Marbled Murrelet, and the Sea Otter are not examined because, at the time this article was written, the Humpback Whale was being down-listed from threatened to special concern, the Marbled Murrelet's recovery strategy had not yet been finalized, and the Sea Otter had been down-listed to special concern.

87 Department of Fisheries and Oceans, *Canada's State of the Oceans Report, 2012* (Ottawa: Communications Branch, Fisheries and Oceans Canada, 2011).

88 See Fisheries and Oceans Canada, *The Climate Change Science Initiative Final Report 2008–2012*, (Ottawa: Ecosystems and Oceans Science Sector, Oceanography and Climate Science Branch, 2012) online: <http://www.dfo-mpo.gc.ca/science/oceanography-oceanographie/ccsi-eng.html>.

89 For the Arctic, see Fisheries and Oceans Canada, *Risk-Based Assessment of Climate Change Impacts And Risks on the Biological Systems and Infrastructure Within Fisheries and Oceans Canada's Mandate — Arctic Large Aquatic Basin* (Ottawa: Canadian Science Advisory Secretariat, 2013); for the Pacific, see Fisheries and Oceans Canada,

CASP is to assess the risks that climate change poses to the delivery of DFO's mandate. Presumably, this would include the risks to the recovery of aquatic species listed under SARA.

Published as a project of the ACCASP, the "Risk-Based Assessment of Climate Change Impacts and Risks on the Biological Systems and Infrastructure within Fisheries and Oceans Canada's Mandate — Pacific Large Aquatic Basin" (published in 2013) identifies six main risks to DFO's mandate posed by climate change.[90] Impacts on species at risk are attributed to "Risk 3: Species Reorganization and Displacement." The report notes that there are "very significant gaps" and a "virtual lack of knowledge" regarding the effects of climate change in the Pacific LAB.[91]

The report states that climate change may result in more species being added to Schedule 1 of SARA, and that climate change and OA may require new management systems and recovery strategies for species at risk. This risk to DFO's mandate is captured by "Risk 7: Risk to Fisheries Management Systems."[92] Unfortunately the report does not actually investigate Risk 7 because the authors "were not prepared to undertake a complete evaluation."[93] As a result, the report does not appear to assign much urgency to evaluating the risks posed by climate change and OA to recovery planning for species at risk. So although DFO's decision to take initial steps towards investigating the policy implications of increasing atmospheric CO_2 are encouraging, it appears that species at risk management may be taking a backseat.

In 2005, DFO published "A Framework for Developing Science Advice on Recovery Targets for Aquatic Species in the Context of the *Species At Risk Act*."[94] The report lists a number of factors that should be considered when developing recovery targets, but does not mention climate change or OA. Although these omis-

Risk-Based Assessment of Climate Change Impacts And Risks on the Biological Systems and Infrastructure Within Fisheries and Oceans Canada's Mandate — Pacific Large Aquatic Basin (Ottawa: Canadian Science Advisory Secretariat, 2013); for freshwater, see Fisheries and Oceans Canada, *Risk-Based Assessment of Climate Change Impacts And Risks on the Biological Systems and Infrastructure Within Fisheries and Oceans Canada's Mandate — Freshwater Large Aquatic Basin* (Ottawa: Canadian Science Advisory Secretariat, 2013); for the Atlantic, see Fisheries and Oceans Canada, *Risk-Based Assessment of Climate Change Impacts And Risks on the Biological Systems and Infrastructure Within Fisheries and Oceans Canada's Mandate — Atlantic Large Aquatic Basin* (Ottawa: Canadian Science Advisory Secretariat, 2013).

90 Fisheries and Oceans Canada, *Risk-Based Assessment of Climate Change Impacts And Risks on the Biological Systems and Infrastructure Within Fisheries and Oceans Canada's Mandate — Pacific Large Aquatic Basin* (Ottawa: Canadian Science Advisory Secretariat, 2013) at 1 [Pacific LAB Climate Change Assessment].

91 *Ibid*., at 6 and 14.

92 *Ibid*., at 8.

93 *Ibid*., at 8.

94 Canadian Science Advisory Secretariat, *A Framework for Developing Science Advice on Recovery Targets for Aquatic Species in the Context of the Species At Risk Act*, Science Advisory Report 2005/054 (DFO: Ottawa, 2005).

sions would be worse if made in a framework for developing recovery *strategies*, the report's silence on climate change and OA is still troubling.

In 2007, DFO released a "Revised Protocol for Conducting Recovery Potential Assessments."[95] Recovery Potential Assessments (RPAs) are conducted after DFO receives COSEWIC's assessment of a species, and before the MFO advises the GIC on the species' appropriate legal designation under SARA. RPAs are therefore critical to the determination of whether a species is listed, and also play a role in the recovery planning stage by informing (along with COSEWIC's status assessment) the recovery strategy. The report mentions the importance of modeling that explores the potential consequences of alternative management scenarios, and instructs that information gained from modeling should inform listing decisions and recovery planning.[96] However, climate and OA modeling — specifically, projections of different climate and OA scenarios — are not mentioned.

In 2011, DFO published "A Complement to the 2005 Framework for Developing Science Advice on Recovery Targets in the Context of the *Species At Risk Act*."[97] This report aimed to revisit the issue of setting population and distribution objectives for species listed under SARA. While the authors had the opportunity to amend the 2005 framework to include a requirement to incorporate climate and OA information, they did not take it.

IV. RECOVERY STRATEGIES FOR PACIFIC MARINE SPECIES AT RISK

DFO's lack of guidance on how climate change and OA should be incorporated into recovery planning under SARA has had a noticeable effect on recovery strategies created via SARA's statutory framework. This section examine the seven recovery strategies that have been released for Pacific species at risk, and evaluates the strategies in terms of how well they incorporate climate change and OA information. First, recovery strategies for five Pacific cetacean species will be examined since they share some common risks posed by climate change and OA.[98] Next, the Basking Shark, Leatherback Sea Turtle and the Northern Abalone are considered. The recovery strategies examined are expansive documents that cover everything from fisheries impacts to bioaccumulation of persistent toxins. This section focuses exclusively on how well the strategies address climate change and ocean acidification, and therefore ignores much of the other important work that goes into planning the recovery of imperiled species. Further, many of the studies on climate change and OA that are not mentioned in this section were published after the strategies were released. This underscores the need to reconsider climate change and OA as action plans and new recovery strategies are developed.

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95 Canadian Science Advisory Secretariat, *Revised protocol for conducting recovery potential assessments*, Science Advisory Report 2007/039 (DFO: Ottawa, 2007).

96 *Ibid*., at 4.

97 Fisheries and Oceans Canada, "A Complement to the 2005 Framework for Developing Science Advice on Recovery Targets in the Context of the *Species At Risk Act*", Science Advisory Report 2010/061 (Ottawa: 2011).

98 Cetacean is a term that includes whales, dolphins and porpoises.

(a) Recovery Strategies for Pacific Whale Species at Risk

Climate change and OA will have important consequences for whale species. For example, it is predicted that the ranges of 88% of cetaceans may be affected by changes in water temperature,[99] and that migratory whales are especially vulnerable to alterations in climate since temperature changes can affect them in any part of their migratory pathway.[100] It has also been discovered that as the ocean's pH decreases, underwater noise attenuates less effectively.[101] This could impact social interactions between whales, and make it harder for certain species to locate and hunt prey. Further, the abundance and distribution of plankton will change as oceans warm[102] and acidify.[103] This could have cascading implications for marine food webs, and will affect baleen whales directly (who prey on plankton).

For these reasons and others examined below, it is critical that recovery efforts directed at Pacific cetaceans adequately consider how climate change and OA may affect these species. Commentators have suggested that 21st century whale recovery planning must react more quickly to emerging developments, be more precautionary, and take the concept of resilience seriously.[104] This article examines four DFO recovery strategies for Pacific whale species at risk, and evaluates each in terms of how well it incorporates the expected and current effects of climate change and OA. The strategies usually mention climate change, but do not take the next step of considering how it may actually affect the species. Further, they generally do not mention OA.

(i) Recovery Strategy for the Blue, Fin and Sei Whales

The Blue Whale was listed as special concern when SARA was proclaimed in 2003, and was then uplisted two years later to endangered.[105] The Fin Whale was also listed as special concern at SARA's proclamation, and was then uplisted three years later to threatened.[106] The Sei Whale was not listed until 2005, at which time

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99 Colin D Macleod, "Global Climate Change, Range Changes and Potential Implications for the Conservation of Marine Cetaceans: A Review and Synthesis" (2009) 7 Endangered Species Research 125, [McLeod].

100 MP Simmonds & SJ Isaac, "The Impacts of Climate Change on Marine Mammals: Early Signs of Significant Problems" (2007) 41:1 Oryx 19.

101 Hildebrand, *supra*, note 50.

102 Andrew S Brierley & Michael J Kingsford, "Impacts of Climate Change on Marine Organisms and Ecosystems" (2009) 19 Current Biology 602.

103 IPCC Chapter 6, *supra*, note 5.

104 For example, see MP Simmonds & WJ Elliot, "Climate Change and Cetaceans: Concerns and Recent Developments" (2009) 89:1 Journal of the Marine Biological Association of the United Kingdom 203.

105 *SARA*, *supra*, note 7 as it appeared in 2003 and Canada Gazette Part I, *Order Amending Schedules 1 to 3 to the Species at Risk Act*, Vol 138, No 43 (October 23, 2004) at 2918.

106 *SARA*, *supra*, note 7 as it appeared in 2003 and Canada Gazette Part II, *Order Amending Schedules 1 to 3 to the Species at Risk Act*, Vol 140, No 18 (September 6, 2006) at 1082.

it was designated endangered.[107] Published in 2006, the recovery strategy for blue, fin, and sei whales (or balaenopterids) considers these three species collectively because of their similar distribution and shared threats.[108] An action plan was due in 2008 but had not been released at the time this article was written.[109] The recovery strategy considers ship strikes and anthropogenic noise to be the most serious threats to balaenopterids, with pollution, fishing interactions, and habitat alterations from medium and long-term shifts in ocean climate also posing threats.[110]

A. The Effects of Climate Change

The strategy argues that it will be difficult to distinguish natural variations in ocean temperature (caused, for instance, by El Nino events and by the Pacific Decadal Oscillation) from anthropogenic variations (caused by increasing GHG emissions).[111] Further, the authors point out that recovery efforts should "focus on human actions and activities that can be directly managed" rather than activities that cannot be directly managed (such as those that contribute to shifts in ocean climate).[112] So while the recovery strategy seems to consider climate change, it also does work to explain why these effects fall outside of the strategy's purview.

Although ship strikes and noise may pose a greater threat in the short run than changes in ocean climate, climate change is still worthy of a more complete consideration. The fact that climate change is not caused by human activity that can be directly managed by recovery planners should not preclude its consideration. The strategy mentions that changes in ocean climate can displace balaenopterid habitat or alter marine trophic structures,[113] but does not go on to consider how these changes may actually affect whale populations. Since water temperature is arguably the single most important physical factor affecting the range of cetaceans,[114] any whale recovery strategy that does not consider the effects of temperature change is incomplete. For instance, anticipating how blue, fin and sei whales will respond to changes in their environment may be a very important element of adequately designating their critical habitat and projecting future population numbers (since as range size changes, population size also changes).

B. The Effects of Ocean Acidification

107 Canada Gazette Part I, *Order Amending Schedules 1 to 3 to the Species at Risk Act*, Vol 138, No 43 (October 23, 2004) at 2918.

108 *Species At Risk Act* Recovery Strategy Series, Recovery Strategy for Blue, Fin, and Sei Whales (*Balaenoptera musculus, B. physalus, and B. borealis*) in Pacific Canadian Waters (Fisheries and Oceans Canada, 2006) at iv.

109 *Ibid*., at 36.

110 *Ibid*., at 17.

111 *Ibid*., at 23.

112 *Ibid*., at 30.

113 *Ibid*., at 23.

114 McLeod, *supra*, note 99.

1. Decreasing pH and Ambient Noise

The strategy considers increasing ocean noise to be an important threat to balaenopterids, but does not consider the effects that OA will have on sound attenuation. Since balaenopterids rely on sound for social communication and sensing their environment, any increase in anthropogenic ambient sound in the ocean has the potential to negatively affect individuals. This is becoming particularly important as anthropogenic noise generation increases, having already increased an average of 15 dB in the latter half of the 20th century.[115] In Canada's Pacific waters currently, it is estimated that typical noise levels reduce fin whale habitat by 1% while noisy conditions reduce habitat by 30%.[116]

OA may be exacerbating the effects of anthropogenic oceanic noise on cetaceans. As pH decreases, so too does water's ability to attenuate sound. For instance, a drop in pH of only 0.3 reduces the intrinsic sound absorption coefficient (dB km^{-1}) by 40%.[117] This effect is particularly strong in frequency ranges of ~100Hz to ~1kHz. At low frequencies (below 100 Hz) OA has a negligent effect on attenuation. The same is true for very high frequencies, where sound attenuates rapidly regardless of acidity. Commercial shipping has increased ambient noise 10- to 100-fold in the 20-200Hz band, the same band used by balaenopterids for some of their communication signals.[118] Since OA will cause sounds in this band to travel greater distances, shipping noise may have a greater masking effect on the calls of balaenopterids than it would have had in the absence of OA. Since ambient noise is a qualitatively similar stressor to habitat loss,[119] decreasing ocean pH may have important implications for the recovery of Pacific whale species. As the oceans become noisier and more acidic, effective recovery planning must incorporate the fact that quiet marine habitat optimal for whale species is shrinking.

2. Calcifying Plankton and Marine Food Webs

The recovery strategy for blue, fin and sei whales also does not consider the effects that decreasing ocean pH could have on calcifying plankton and marine food webs. While the strategy mentions that the ocean's trophic structure may be altered by a changing ocean climate, it does not discuss how OA could also alter trophic structures. For instance, subpolar pteropods — a kind of sea snail which form part of the diet of north Pacific baleen whales — may either disappear altogether or transition to warmer, carbonate-rich waters at lower latitudes.[120] This

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115 National Research Council, *Ocean Noise and Marine Mammals* (Washington, DC: National Academies Press, 2003).

116 R Williams et al, "Acoustic Quality of Critical Habitats for Three Threatened Whale Populations" (2014) 17 Animal Conservation 174, [Williams].

117 Peter G Brewer & Keith Hester, "Ocean Acidification and the Increasing Transparency of the Ocean to Low-Frequency Sound" (2009) 22:4 Oceanography 86.

118 Peter L Tyack, "Implications for Marine Mammals of Large-Scale Changes in the Marine Acoustic Environment" (2008) 89:3 Journal of Mammalogy 549.

119 Williams, *supra*, note 116.

120 IPCC Chapter 6, *supra*, note 5; Richardson, *supra*, note 27.

could affect balaenopterids both indirectly and directly by altering marine food webs and by removing an important source of prey.[121]

(ii) Recovery Strategy for the North Pacific Right Whale

The North Pacific Right Whale was listed as endangered in 2006,[122] and a recovery strategy was released five years later in 2011.[123] An action plan is due in 2016. The recovery strategy states that current threats cannot be determined due to a lack of information, but that potential threats include ship strikes and marine traffic, entanglement in fishing gear, noise and pollution. Climate change and OA are not considered potential threats.

A. Effects of Climate Change

Although the strategy does not consider climate change to be a threat to North Pacific Right Whales, it does consider it to be a "limiting factor." The authors point out that climate change could affect the Right Whale's food supply by impacting copepod populations (the right whales' primary source of prey).[124] Under cold, well-mixed conditions the ocean's surface waters are replete with nutrients, and planktonic communities are dominated by large phytoplankton species and crustaceans such as large copepods.[125] But as surface waters warm making the ocean more stratified, nutrient supply decreases, plankton communities shift toward smaller phytoplankton species and recycled production, and less energy will be available for transfer up the food chain via copepods.[126] Therefore, cooler, less stratified surface conditions better suit copepods and right whales. Further, changing surface temperatures may create a range contraction for right whales that results from warmer waters shifting the species' range northward.[127] So while climate change may not pose as acute a risk as ship strikes, entanglement or noise, it still warrants serious consideration.

B. Effects of Ocean Acidification

The recovery strategy does not mention OA. This means that recovery planning for the North Pacific Right Whale will not incorporate the increased masking effect of anthropogenic noise caused by decreasing ocean pH, unless it is incorporated into the action plan. Right whales communicate in the 50Hz-2kHz band,[128] which overlaps with shipping noise and contains the band most affected by the

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121 IPCC Chapter 6, *supra*, note 5.

122 Canada Gazette Part I, *Order Amending Schedules 1 to 3 to the Species at Risk Act*, Vol 138, No 43 (October 23, 2004) at 2927.

123 *Species At Risk Act* Recovery Strategy Series, Recovery Strategy for the North Pacific Right Whale (*Eubalaena japonica*) in Pacific Canadian Waters (Fisheries and Oceans Canada, 2011), [Right Whale Recovery Strategy]

124 *Ibid*., at 13.

125 Richardson, *supra*, note 27.

126 *Ibid.*

127 Macleod, *supra*, note 107.

128 Right Whale Recovery Strategy, *supra*, note 131 at 17

reduction of sound attenuation by boric acid.[129] This would seem to suggest that OA could have a larger impact on right whales than on other whale species that use higher frequency calls.

The strategy also fails to consider the effect that OA will have on copepods, the right whale's primary food source. Copepods are thought to be less vulnerable to OA than other calcifying zooplankton because of their mostly chitonous exoskeleton.[130] However, studies have documented reduced reproductive and larval growth rates in response to increasing ocean acidity.[131] Further, increased mortality of copepods in both shallow and deep subarctic and subtropical water has been observed as pCO_2 exposure time increases.[132] Finally, it has been suggested that OA-induced stress might favour smaller brood sizes, females and later maturing females, which could profoundly destabilize marine trophodynamics.[133] Effective recovery planning for the North Pacific Right Whale should consider and compensate for shifting copepod abundance and distribution resulting from OA.

(iii) Recovery Strategy for the Transient Killer Whale

The Northeast Pacific Transient Killer Whale population has been listed as threatened since 2003 when SARA was proclaimed. Published four years later, the recovery strategy considers chemical contaminants and acoustical disturbance to be the most pressing threats to the species.[134] An action plan was due in 2009, but had not been completed at the time this article was written.[135] The recovery strategy indicates that the effect of climate change on transient killer whales and their prey is a knowledge gap, and raises the positive relationship between disease and warmer ocean temperatures as a potential concern.[136]

A. Effects of Climate Change

With regards to climate change, the recovery strategy focuses on the effect that warmer ocean temperatures may have on pathogen outbreaks amongst marine

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129 Hildebrand, *supra*, note 50 at 17.

130 Ceri N Lewis et al, "Sensitivity to Ocean Acidification Parallels Natural pCO2 Gradients Experiences by Arctic Copepods Under Winter Sea Ice" (2013) PNAS E4960 [Lewis].

131 Haruko Kurihara, Shinji Shimode & Yoshihisa Shirayama, "Effects of Raised CO2 Concentration on the Egg Production Rate and Early Development of Two Marine Copepods" (2004) 41 Marine Pollution Bulletin 721; Victoria J. Fabry et al, "Impacts of Ocean Acidification on Marine Fauna and Ecosystem Processes" (2008) 65 ICES Journal of Marine Science 414.

132 Yuji Watanabe et al, "Lethality of Increasing CO2 Levels on Deep-Sea Copepods in the Western North Pacific" (2006) 62 Journal of Oceanography 185.

133 Susan C Fitzera et al, "Copepod Naupliar Production with Possible Conflict for Reproductive Resource Allocation" (2012) 418-419 Journal of Experimental Marine Biology and Ecology 30.

134 *Species At Risk Act* Recovery Strategy Series, Recovery Strategy for the Transient Killer Whale (*Orcinus* orca) in Canada (Fisheries and Oceans Canada, 2007) at v.

135 *Ibid.*, at 32.

136 *Ibid.*, at 22.

mammals.[137] This is of particular concern for transient killer whales because they are heavily chemically contaminated and likely immuno-compromised. Further, a pathogen outbreak — similar to the one that occurred in northwestern Europe in 1988 — could cause a mass mortality of harbour seals, an important prey source for transients.[138]

B. Effects of Ocean Acidification

The strategy lists acoustic disturbance as a major threat to transients, but does not consider the effect that OA will have on sound attenuation. As a recovery goal, the strategy mentions that a more comprehensive understanding of the impacts of noise must be developed.[139] Added to this goal might be an appreciation of how an increasingly acidic Pacific Ocean may make anthropogenic noise even worse.

(iv) Recovery Strategy for the Northern and Southern Resident Killer Whales

The northeast Pacific Northern and Southern Resident Killer Whale populations were listed as threatened and endangered, respectively, when SARA was proclaimed in 2003.[140] Published eight years later in 2011, the recovery strategy for northern and southern residents is one of the latest examined in this article.[141] The action plan was due in 2013, but had not been completed at the time of writing. Threats to the species identified in the strategy include reduced prey availability, environmental contaminants, disturbance and the degradation of critical habitat.[142]

A. Effects of Climate Change

The authors argue that in order to survive, killer whales will have to adapt to changes in their prey base caused by climate change.[143] Surprisingly, the strategy then fails to discuss climate change in a substantive way again. It does recommend as an "additional measure" that salmon availability be evaluated under different climate scenarios (because Chinook salmon are an important prey for resident killer whales),[144] and also identifies the effect of climate change on killer whales as a knowledge gap.[145] Finally, the strategy mentions the same concern discussed in the transient killer whale recovery strategy, that climate change might make pathogen outbreaks more frequent.[146]

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137 *Ibid*., at 14.

138 *Ibid*., at 8.

139 *Ibid*., at v.

140 *SARA*, *supra*, note 7 as it appeared in 2003.

141 *Species At Risk Act* Recovery Strategy Series, Recovery Strategy for the Northern and Southern Resident Killer Whales (*Orcinus* orca) in Canada (Fisheries and Oceans Canada, 2011) [Resident Killer Whale Recovery Strategy].

142 *Ibid*., at 48.

143 *Ibid*., at 17.

144 *Ibid*., at 45.

145 *Ibid*., at 46.

146 *Ibid*., at 20.

Although the direct effect of ocean warming on killer whales has not been widely studied, it is clear that climate change will have a negative impact on resident killer whale prey. The decline of Chinook salmon caused by climate change — together with increased marine traffic and biomagnifying contaminants — may lead to extirpation of the species from BC waters if no action is taken.[147] The decline of Pacific salmon is partially due to impacts to their thermal habitat, which is forecast to decrease in the North Pacific by a staggering 86% during summer.[148]

Chinook salmon are considered to be one of the most estuarine-dependent Pacific salmon species,[149] and so will suffer more acutely than other salmon from the degradation of these important ecosystems. In the Skagit Delta in Washington State, it is estimated that sea level rise of 45- and 80-centimeters could affect estuarine systems by reducing rearing capacity by 211,000 and 530,000 fish, respectively (as estuaries become inundated, beach habitats that are suitable for rearing juvenile Chinook salmon are converted to less suitable open water or tidal flats).[150] In a different study, climate change is predicted to also have a negative impact on Chinook salmon in the Snohomish River Basin in Washington State.[151] The authors conclude that increased peak river flows, higher water temperatures and lower spawning flows will make recovery targets more difficult to achieve. A 20% decrease in Snohomish Chinook salmon populations is predicted by 2050 under an optimistic emissions scenario, and the authors warn that this prediction may be too conservative since it does not take into account rising sea levels or ocean warming. Although these studies did not take place in BC, they nevertheless provide a snapshot of the estuarine decline potentially faced by many Pacific Northwest Chinook salmon as climate change progresses.

B. Effects of Ocean Acidification

The recovery strategy contains an extensive section on the effects of anthropogenic noise, but does not consider how OA will make impacts on killer whales worse by decreasing sound attenuation.[152] The effect of reduced sound attenuation may be worse for residents than transients since the former communicate more fre-

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147 SC Johannessen & RW Macdonald, "Effects of Local and Global Change on an Inland Sea: The Strait of Georgia, British Columbia" (2009) 40 Climate Research 1.

148 Omar I Abdul-Aziz, Nathan J Mantua & Katherine W Myers, "Potential Climate Change Impacts on Thermal Habitats of Pacific Salmon in the North Pacific Ocean and Adjacent Basins" (2011) 68 Canadian Journal of Fisheries and Aquatic Sciences 1660.

149 US White Paper prepared by Gregory D Williams and Ronald M Thom, "Marine and Estuarine Shoreline Modification Issues", (submitted to Washington Department of Fish and Wildlife, Washington Department of Ecology, Washington Department of Transportation: 2001).

150 WG Hood, "Sea Level Rise in the Skagit Delta" (2005) Skagit River Tidings. Skagit Watershed Council, Mount Vernon, Washington.

151 James Battin et al, "Projected Impacts of Climate Change on Salmon Habitat Restoration" (2007) 104:16 PNAS 6720.

152 Resident Killer Whale Recovery Strategy, *supra*, note 141 at 27.

quently. While transients prey on marine mammals that have sensitive underwater hearing, residents prey on poor-hearing salmon and so do not require stealth.[153]

(c) Recovery Strategy for the Pacific Basking Shark

The Pacific Basking Shark was listed as endangered in 2010[154] and its recovery strategy was released one year later.[155] The species' action plan is due in 2016. Four classes of threats are listed in the recovery strategy: entanglement, vessel collision, harassment from marine based activities, and prey availability.[156] Climate change is considered a sub-threat of prey availability but is not examined at any length. OA is not mentioned.

A. Effects of Climate Change

The strategy mentions that sea surface temperature (SST) has been correlated with basking shark sightings in the northeast Atlantic, and that SST is also thought to influence prey abundance and distribution.[157] Climate change is considered a "low" level concern, which may explain why it is not explored further. In a study conducted off southwest Britain, it was discovered that Basking Sharks follow climate-driven thermal habitat.[158] This is likely because the species travel with zooplankton populations, which may be closely affected by changes in SST. This preliminary study supports the hypothesis that basking sharks (including Pacific populations) exhibit behavioural responses at small scales in response to large-scale changes in ocean climate.[159]

B. Effects of Ocean Acidification

The strategy does not mention OA, and there likewise appears to be little discussion of OA in the scientific literature on basking sharks. But since the primary prey of the basking shark — the calanoid copepod — may have a negative response to increasing acidity, we will visit OA briefly. As explained above, impacts of OA on copepods may include increased energetic costs of maintaining homeostasis of

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153 Volker B Deecke, John KB Ford & Peter JB Slater, "The Vocal Behaviour of Mammal-Eating Killer Whales: Communicating with Costly Calls" (2005) 69:2 Animal Behaviour 395.

154 Canada Gazette Part II, *Order Amending Schedules 1 to 3 to the Species at Risk Act*, Vol 144, No 6 (October 23, 2004) at 268.

155 Species At Risk Act Recovery Strategy Series, Recovery Strategy for the Pacific Basking Shark (*Cetorhinus maximus*) in Canadian Pacific Waters (Fisheries and Oceans Canada, 2011) [Basking Shark Recovery Strategy].

156 *Ibid*., at 4.

157 *Ibid*., at 8.

158 Peter A Cotton et al, "The Effects of Climate Variability on Zooplankton and Basking Shark (*Cetorhinus maximus*) Relative Abundance Off Southwest Britain" (2005) 14:2 Fisheries Oceanography 151.

159 David W Sims, "Sieving a Living: A Review of the Biology, Ecology and Conservation Status of the Plankton-Feeding Basking Shark *Cetorhinus Maximus*" (2008) 54 Advances in Marine Biology 171.

physiological processes (e.g. acid-base balance[160]), resulting in changes in growth, fecundity, and survival.[161] The effect of these impacts on basking sharks may become increasingly important as we move through the 21st century and acidification increases.[162] Since the recovery strategy for the Pacific Basking Shark is long-term in scope,[163] the fact that OA is projected to increase is particularly relevant.

(d) Recovery Strategy for the Pacific Leatherback Sea Turtle

The Leatherback Sea Turtle has been listed as endangered since SARA was proclaimed in 2003.[164] Published in 2006, the recovery strategy identifies accidental capture or entanglement, vessel collisions and ingestion of debris as major threats to the species.[165] The strategy emphasizes that concerted international efforts will be required to recover Leatherback populations, meaning that threats occurring outside of Canada cannot be ignored.[166] But confusingly, the strategy goes on to ignore threats posed by climate change (many of which occur outside of Canada), and does not appear to appreciate that as the Pacific continues to warm, Leatherbacks are expected to extend their range north (making Canadian recovery efforts more important for the species).[167] COSEWIC's reassessment of Leatherbacks, released in 2009, does consider climate change.[168] COSEWIC identifies sea level rise, temperature-dependent sex ratio determination, changes in species abundance and distribution, increased storm activity and egg and hatchling mortality to be climate change risks.

A. Effects of Climate Change

The strategy argues that threats present in Leatherback nesting environments may outweigh those in BC waters, and that stewardship for a species that migrates 15,000 kilometres can know no international boundaries.[169] Yet climate change, which mainly poses a threat to Leatherbacks outside of Canadian waters (and par-

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160 Stephen Widdicombe & John I Spicer, "Predicting the Impact of Ocean Acidification on Benthic Biodiversity: What Can Animal Physiology Tell Us?" (2008) 366:1-2 Journal of Experimental Marine Biology and Ecology 187.

161 Lewis, *supra*, note 130 at E4960.

162 IPCC Chapter 6, *supra*, note 5.

163 Basking Shark Recovery Strategy, *supra*, note 155 at 16.

164 *SARA*, *supra*, note 7 as it appeared in 2003.

165 *Species At Risk Act* Recovery Strategy Series, Recovery Strategy for Leatherback Turtles (*Dermochelys coriacea*) in Pacific Canadian Waters (Fisheries and Oceans Canada, 2006) at 14, 15 [Leatherback Recovery Strategy].

166 *Ibid*., at 13.

167 Robinson, *supra*, note 22 at 95; Clive R McMahon & Graeme C Hays, "Thermal Niche, Large-Scale Movements and Implications of Climate Change for a Critically Endangered Marine Vertebrate (2006) 12 Global Change Biology 1330.

168 COSEWIC, Assessment and Status Report on the Leatherback Sea Turtle *Demochelys coriacea* Atlantic Population Pacific Population in Canada (Ottawa: COSEWIC, 2009).

169 Leatherback Recovery Strategy, *supra*, note 165 at 17, 21.

ticularly in nesting grounds), is ignored completely. This is particularly striking because temperature is of such profound importance to marine turtles.[170]

While air temperature affects hatchling sex ratios,[171] water temperature affects individuals' growth rates and largely determines the distribution of adult turtles.[172]

Further, one study suggests that an increase in El Nino events — which is possibly associated with anthropogenic climate change — is making it more difficult for eastern Pacific Leatherbacks to recover from human caused mortality by lowering net primary production (NPP) in post-nesting female migration and foraging areas.[173] Although Leatherbacks that spend time in Pacific Canadian waters are thought to originate in western Pacific waters, it is reasonable to expect that a decrease in Pacific NPP will result in fewer suitable foraging areas for all Pacific Leatherback populations.

Climate change also poses a major threat to Leatherback nesting grounds. As the ocean warms and expands and as ice once present over land melts, some sea turtle nesting grounds may become inundated by rising seas.[174] Further, climate change is expected to generate stronger and more frequent storm activity, which — in addition to creating large-scale problems for human societies — may erode important beaches currently used by Leatherbacks as nesting grounds.[175]

B. Effects of Ocean Acidification

The recovery strategy does not mention OA, and OA is also rarely mentioned in the scientific literature on Leatherbacks. Although it has been suggested that OA could have a positive impact on jellyfish (the prey of Leatherbacks) by opening up ecological space previously occupied by calcifying plankton,[176] another study has shown that there is no significant relationship between jellyfish abundance and pH.[177] At present it is hard to predict whether the impact of OA on prey abundance will help or hinder the recovery of Pacific Leatherback Turtles.

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170 Lucy A Hawkes et al, "Climate Change and Marine Turtles" (2009) 7 Endangered Species Research 137 [Hawkes].

171 John Davenport, "Temperature and Life-History Strategies of Sea Turtles" (1997) 22:6 Journal of Thermal Biology 479; NJ Mitchell & FJ Janzen, "Temperature-Dependent Sex Determination and Contemporary Climate Change" (2010) 4 Sexual Development 129.

172 Clive R McMahon & Graeme C Hays, "Thermal Niche, Large-Scale Movements and Implications of Climate Change for a Critically Endangered Marine Vertebrate (2006) 12 Global Change Biology 1330.

173 *Ibid.*

174 *Ibid.*

175 Hawkes, *supra*, note 170.

176 Martin J Attrill, Jade Wright & Martin Edwards, "Climate-Related Increases in Jellyfish Frequency Suggest a More Gelatinous Future for the North Sea" (2007) 52:1 Limnology and Oceanography 36.

177 Anthony J Richardson & Mark J Gibbons, "Are Jellyfish Increasing in Response to Ocean Acidification" (2008) 53:5 Limnology and Oceanography 29.

(d) Recovery Strategy and Action Plan for the Northern Abalone

The Northern Abalone was listed as threatened when SARA was proclaimed in 2003, and was uplisted to endangered in 2011.[178] Published in 2007, the recovery strategy identifies illegal harvest, low recruitment, coastal and underwater development and sea otter predation as threats to the species.[179] There is no mention of climate change or OA. However, the COSEWIC reassessment conducted in 2009 did list climate change as an "additional consideration," but did not consider OA.[180] The action plan for Northern Abalone, published in 2012, considers climate change but concludes that individuals in BC will not be affected for several years since they are well within the species' global range.[181] The plan does not mention OA. While all of these documents make omissions that could have important implications for the recovery of Northern Abalone, the 2009 COSEWIC assessment reflects the best understanding of the importance of climate change risks to the species. Notably, all of the reports omit OA completely.

A. Effects of Climate Change

The COSEWIC assessment points out that although Northern Abalone have considerable temperature tolerance and are not expected to be directly affected by ocean warming in BC anytime soon, their food supply — namely kelp — may not be so fortunate.[182] The concern is that as SST rises and surface waters become nutrient depleted, kelp growth will decline.[183] But this threat is ignored in both the recovery strategy (published before the COSEWIC reassessment) and in the action plan (published after the 2009 reassessment).

B. Effects of Ocean Acidification

While OA is not mentioned in any of the three documents, it does appear in the scientific literature. An eight-year trend of declining pH along the Northeast Pacific coast was correlated with shifts in community structure where shelled species were outcompeted by fleshy algae and barnacles.[184] Further, in a study examining the effects of elevated CO_2 on Northern Abalone specifically, it was found

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178 *SARA*, *supra*, note 7 as it appeared in 2003; Canada Gazette Part II, *Order Amending Schedules 1 to 3 to the Species at Risk Act*, Vol 145, No 14 (July 6, 2011) at 1227.

179 Species At Risk Act Recovery Strategy Series, Recovery Strategy for Northern Abalone (*Haliotis kamtschatkana*) in Canada (Fisheries and Oceans Canada, 2007) at 7.

180 COSEWIC, Assessment and Update Status Report on the Northern Abalone *Haliotis kamtschatkana* in Canada (Ottawa: COSEWIC, 2009).

181 Northern Abalone Action Plan, *supra*, note 90 at 10.

182 *Ibid*., at 29.

183 Mia J Tegner et al, "Is There Evidence for Long-Term Climatic Change in Southern California Kelp Forests?" (1996) 37 California Cooperative Oceanic Fisheries Investigations 111; L Ignacio Vilchis et al, "Ocean Warming Effects on Growth, Reproduction, and Survivorship of Southern California Abalone" (2005) 15:2 Ecological Applications 469.

184 J Timothy Wootton, Catherine A Pfister & James D Forester, "Dynamic Patterns and Ecological Impacts of Declining Ocean pH in a High-Resolution Multi-Year Dataset"

that projected ocean acidification will likely pose a significant additional threat to the species.[185] At an atmospheric CO_2 concentration of 800 ppm — which may occur by the end of this century[186] — larval recruitment dropped from 65% to 40%.[187] Further, while larvae reared at current CO_2 levels almost all developed normal shells, only 60% of larvae reared at 800 ppm were able to develop normal shells.[188] In a study that examined Pacific Abalone, it was found that increased acidity prolonged the hatching process and hindered embryonic development.[189] Lower pH was also correlated with an increased rate of malformations and a decreased rate of hatchling success.[190]

The shallow coastal region of the Northeast Pacific (i.e. Northern Abalone habitat) experiences upwelling of deep, old and more acidic water. In general seasonal fluctuations and long-term trends in pH are much more pronounced in coastal waters than one would expect based on observations in open ocean waters. An 11-year record of high-resolution pH measurements[191] from Tatoosh Island (Washington State) shows typical daily variations of 0.24 pH units; in other words, pH changes within 24 hours by more than twice the change that has occurred from preindustrial to present in the surface open ocean. The seasonal pH fluctuations are more extreme; for example, in 2007 pH changed by more than 1 pH unit; this is more than twice the estimated pH change between preindustrial and year 2100 conditions in the surface open ocean. Superimposed on these signals is a long-term decline of pH that is much faster than that observed for the open ocean. The sporadic and localized acidification events are already affecting shellfish growers.[192]

(2008) 105:48 Proceedings of the National Academy of Sciences of the United States of America 18848.

185 Ryan N Crima, Jennifer M Sunday & Christopher DG Harley, "Elevated Seawater CO_2 Concentrations Impair Larval Development and Reduce Survival in Endangered Northern Abalone (*Haliotis kamtschatkana*)" (2011) 400:1-2 Global Change in Marine Ecosystems 272 [Crima].

186 IPCC Chapter 6, *supra*, note 5 at 7.

187 Crima, *supra*, note 185 at 274.

188 *Ibid.*

189 Jiaqi Li et al, "Detrimental Effects of Reduced Seawater pH on the Early Development of the Pacific Abalone" (2013) 74:1 Marine Pollution Bulletin 320.

190 *Ibid.*

191 JT Wootton, CA Pfister & JD Forester "Dynamical Patterns and Ecological Impacts of Changing Ocean pH in a High-Resolution Multiyear Dataset" (2008) 105 Proceedings of the National Academy of Sciences 18848; JT Wootton & CA Pfister, "Carbon System Measurements and Potential Climatic Drivers at a Site of Rapidly Declining Ocean pH" (2012) 7:12 *PLoS ONE* e53396.

192 Whitman Miller et al, "Influence of Acidification on Oyster Larvae Calcification and Growth in Estuaries" (2009) 4:5 PLoS ONE e5661; Daiju Narita, Katrin Rehdanz & Richard SJ Tol, "Economic Costs of Ocean Acidification: A Look into the Impacts on Global Shellfish Production" (2012) 113 Climate Change 1049; Stephanie C Talmage & Christopher J Gobler, "Effects of Past, Present, and Future Ocean Carbon Dioxide Concentrations on the Growth and Survival of Larval Shellfish" (2010) 107:40 PNAS 17246; Alan Barton et al, "The Pacific Oyster, *Crassostrea gigas*, Shows Negative

V. A NEW ERA FOR PACIFIC RECOVERY PLANNING: FUTURE COURSES

Climate change and ocean acidification will complicate management regimes and increase the vulnerability of marine ecosystems.[193] Traditional ecosystem management strategies and recovery planning for species at risk that do not adequately consider the effects of climate change and OA, or the "shifting baseline," will not be effective.[194] For instance, warming surface temperatures may shift the ranges of some marine species at risk outside the protected areas set aside to conserve their most important feeding grounds.[195]

Modern recovery planning must consider and adjust for predicted changes in ocean temperature and acidity.[196] While the effects of increasing atmospheric CO_2 will be more severe for some species than others, recovery planning that ignores or pays mere lip service to climate change and OA risks missing important impacts that could jeopardize the recovery of a given species. A precautionary yet bold approach is advocated where the interactions between rising CO_2 and other anthropogenic stressors are evaluated in concert. It must also be acknowledged that planning for climate change and OA will necessarily be challenged by some degree of uncertainty. Rather than allowing uncertainty to preclude action, planning should incorporate the reasonably expected worst-case scenario and take corresponding management actions.

Further, the goal of ecosystem resilience should be supported.[197] Due to anthropogenic CO_2 already present in the atmosphere, marine species face inevitable changes in their ranges, migratory patterns, prey abundances and distributions, and habitat structure. These changes will make it impossible to sustain previous ecosystem structures.[198] Therefore recovery efforts must be flexible and adaptive rather than rigid. Resilience thinking acknowledges that ecosystem baselines are changing in non-linear and unprecedented ways, and that attempting to restore a marine ecosystem to its pre-industrial state is neither practicable nor helpful. A better approach focuses on determining what population size is necessary to maintain sufficient genetic diversity to allow for adaptation, while anticipating how a species may adapt to future anthropogenic changes.[199]

Currently, DFO recovery strategies for Pacific species at risk generally mention climate change, but do not project how it will actually affect species' recovery.

Correlation to Naturally Elevated Carbon Dioxide Levels: Implications for Near-Term Ocean Acidification Effects" (2012) 57:3 Limnology and Oceanography 698.

193 IPCC Chapter 6, *supra*, note 5.

194 SJ Hawkins, "Marine Conservation in a Rapidly Changing World" (2012) 22 Aquatic Conservation: Marine and Freshwater Ecosystems 281.

195 Christina G Soto, "The Potential Impacts of Global Climate Change on Marine Protected Areas" (2002) 11 Reviews in Fish Biology and Fisheries 181.

196 Ruhl, *supra*, note 9.

197 See Melinda Harm Benson & Robin Kundis Craig, "The End of Sustainability" (2014) 27:7 Society & Natural Resources: An International Journal 777.

198 *Ibid.*

199 Robert L Pressey et al, "Conservation Planning in a Changing World" (2007) 22:11 TRENDS in Ecology and Evolution 583.

OA is generally not mentioned. These two themes, combined with recovery strategies' tendency to rate CO_2-related threats as either of low concern or no threat at all, may indicate that DFO is under prioritizing climate change and OA.[200] Notably, DFO's Risk-Based Assessment of Climate Change Impacts for the Pacific LAB also appears to under prioritize increasing atmospheric CO_2-related concerns. The report does not investigate threats posed by climate change to the management of species at risk because participants in the study were not prepared to undertake a complete evaluation at that time.[201]

Recovery planning relating to the Canadian Pacific might be strengthened through two future courses. First, administrative measures might be taken including the creation of a national climate adaptation strategy with a specific commitment to conduct climate and OA modeling and monitoring.[202] Second is a legal course, where SARA might be amended or regulations made that mandate recovery planners to include climate change and OA information.

(a) Administrative Courses

While Fisheries and Oceans Canada has been developing adaptation tools to take account of climate change, this has occurred in a rather fragmented and incomplete manner. As mentioned earlier, DFO has received $16.5m to implement the Aquatic Climate Change Adaptation Services Program. One component of the program is the development of "Adaptation Tools" and strategies to incorporate climate change information into the delivery of DFO's mandate. The program has produced 13 published tools since 2011, one of which is designed to help marine protected area network planners incorporate climate change information.[203] The other 12 tools, although employing leading edge science, do not appear to be useful to recovery planners (but are rather aimed at fisheries management).[204]

A key administrative way forward to strengthen recovery planning would be the development of a central strategy document, rather than an array of decentralized "Adaptation Tools." This would allow the Canadian government to take a more concerted, planned approach to adapting to climate change and OA in the

200 For example, see *Species At Risk Act* Recovery Strategy Series, Recovery Strategy for the Pacific Basking Shark (*Cetorhinus maximus*) in Canadian Pacific Waters (Fisheries and Oceans Canada, 2011) at 5; *Species At Risk Act* Recovery Strategy Series, Recovery Strategy for the North Pacific Right Whale (*Eubalaena japonica*) in Pacific Canadian Waters (Fisheries and Oceans Canada, 2011) at 13.

201 Pacific LAB Climate Change Assessment, *supra*, note 90.

202 Anthony Povilitis & Kieran Suckling, "Addressing Climate Change Threats to Endangered Species in U.S. Recovery Plans" (2010) 24:2 Conservation Biology 372.

203 The ACCASP project called "Incorporating Climate Change into Marine Protected Area Network Planning" eventually led to an article published in PLOS ONE. See Nancy Shackell, Daniel Ricard & Christine Stortini, "Thermal Habitat Index of Many Northwest Atlantic Temperate Species Stays Neutral under Warming Projected for 2030 but Changes Radically by 2060" (2014) 9:3 PLOS ONE e90662.

204 See the Adaptation Tools webpage online: <http://www.dfo-mpo.gc.ca/science/oceanography-oceanographie/accasp/projects/type-eng.asp?type=Adaptation>.

species at risk context. A climate change adaptation strategy should consider SARA expressly and include plans for the creation of climate and OA projections and a framework of "standard operating procedures" for integrating climate and OA information into recovery planning.

Guidance for such an approach may be drawn from practice in the United States. The U.S. Fish and Wildlife Service (USFWS) has already created a climate change adaptation strategy that includes plans to consider projected climate change impacts before making decisions under the *Endangered Species Act* (ESA).[205] "Rising to the Urgent Challenge: Strategic Plan for Responding to Accelerating Climate Change" establishes a framework and action plan that the USFWS will follow in order to adapt to and to mitigate climate change. To this end, the Service plans to engage in "strategic habitat conservation," where habitat adequate for the maintenance of target populations and ecological functions is preserved. In order to adapt strategic habitat conservation to the challenges presented by climate change, the USFWS will provide guidance to its various programs by creating decision-making frameworks, predictive modeling and structured monitoring systems. Further, the USFWS plans to support the efforts of various State and Tribal management planners to incorporate climate change considerations, and to review the Service's laws, regulations and policies to find opportunities to better support responses to climate change.

A climate change adaptation strategy in the Canadian context might also include a plan to create climate and OA projections and to conduct monitoring that observes how increasing atmospheric CO_2 is affecting Canadian waters, again following the lead of the United States.[206] In the U.S., the National Oceanic and Atmospheric Association (NOAA) has recognized that climate change projections are required to properly inform recovery planning under the *Endangered Species Act*.[207] The NOAA also plans to develop standard operating procedures for incorporating climate science into recovery planning, a tool that could also be developed in the Canadian context as part of a framework that provides guidance to recovery planners.[208]

Another administrative course to ensuring that more climate change and OA information is incorporated into recovery planning might make use of SARA's built-in reporting provisions.[209] Section 126 requires that the Minister of the Environment prepare an annual report on the administration of the act. The report must include COSEWIC's assessments and the Minister's corresponding responses, enforcement and compliance actions taken and the preparation and implementation of

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205 US Fish and Wildlife Service, "Rising to the Urgent Challenge: Strategic Plan for Responding to Accelerating Climate Change" (2010).

206 John A Wiens & Dominique Bachelet, "Matching the Multiple Scales of Conservation with the Multiple Scales of Climate Change" (2010) 24:1 Conservation Biology 51.

207 National Oceanic and Atmospheric Administration, "Incorporating Climate Change into NOAA's Stewardship Responsibilities for Living Marine Resources and Coastal Ecosystems: A Strategy for Progress", NOAA Technical Memorandum NMFS-F/SPO-95 by RB Griffis et al (Silver Spring, Maryland: NOAA, NMFS, 2008) at 20.

208 *Ibid*., at 26.

209 *SARA*, *supra*, note 7, ss 126 and 128.

recovery strategies and action plans. The latest annual report, published in 2013, examines how SARA was administered in 2012.[210] Climate change is mentioned once in passing, a similar treatment to the one given to the effects of increasing atmospheric CO_2 in the 2011 report.[211]

Section 128 requires that a report be published every five years on the status of wildlife species. So far only one report has been created (for the years 2003–2008), and it does not appear to engage critically with efforts taken under SARA to date. Rather, it merely outlines the listing and recovery process, what has been accomplished under SARA so far and suggests some possible ways forward. Unfortunately, an increased incorporation of climate change or OA information is not suggested in the ways forward section.

While SARA's internal reporting mechanisms have promise, much discretion is granted to the Minister of the Environment. In light of the growing public profile of climate change and ocean acidification threats, the Minister might expand future reporting to provide details on how the threats are being addressed and related scientific challenges. Specifically, an added requirement that scientific management challenges — such as climate change and OA — be addressed might be helpful. This would underscore emerging challenges faced by recovery planners, which could assist in effectively allocating departmental resources and research efforts.

A final administrative course might make use of the fact that action plans have not yet been produced for 11 of the 12 Pacific marine species listed under SARA. This creates an opportunity to integrate more climate and OA information into recovery planning efforts without amending existing recovery strategies. This course is limited by a lack of properly scaled climate and OA projections, but could at least make use of the scientific studies mentioned in this article.

(b) Legal Courses

While administrative measures might equip recovery planners with the tools needed to incorporate up-to-date climate and OA information, additional legal measures might ensure that these tools are consistently utilized. As suggested by an earlier article,[212] regulations might be made that create additional recovery strategy requirements.[213] These might include that the latest available climate and OA information must be considered, or that climate and OA projections must be incorporated where relevant. In the alternative, an amendment could be made to the Act that captures the importance of climate change and OA information at the recovery planning stage as well as during the listing process.

Drawbacks of a legal approach include inflexibility (how relevant must climate and OA impacts be to a specific species to warrant their mandated inclusion?) and low enforceability. Requiring that climate and OA information merely be considered solves the inflexibility problem, but could also have little impact on business as usual. Adding a regulation or amendment that requires that climate and OA information be included only where relevant raises the difficult line drawing exer-

210 Environment Canada, *Species at Risk Act* Annual Report for 2012 (EC, 2013) at 36.

211 Environment Canada, *Species at Risk Act* Annual Report for 2011 (EC, 2012) at 37.

212 See Lemkow, *supra*, note 2.

213 *SARA*, *supra*, note 7, ss 41(4) and 41(1)(e).

cise alluded to earlier. However, the latter amendment would at least allow for challenges to be made in court if relevant impacts are missed by a recovery strategy or by a listing decision.

The low enforceability challenge presented by a legal approach is illustrated by the Federal Court's decision in *Vancouver Island Peace Society v Canada*.[214] In response to an application to quash Orders in Council that would allow US and UK nuclear vessels to visit a Canadian port, Justice Strayer made it clear that the judiciary is not to act as an "academy of science" by arbitrating conflicting scientific opinions. The courts' historic reluctance to resolve matters of science might suggest that law suits challenging the scientific content of recovery strategies are unlikely to succeed. While suits challenging the federal government's failure to complete required recovery strategies have succeeded,[215] it may be more difficult to enforce amendments to SARA that require that adequate consideration of climate change and OA be taken.

VI. CONCLUSION

Recovery strategies for Pacific species at risk currently do not consider the threats posed by climate change or OA in any depth. While climate change is often mentioned without incorporating climate modeling or projections of future ocean conditions, OA is generally not mentioned. The latter point should come as no surprise since the science on OA is still relatively young. Ocean acidification is only now entering the international political radar screen, as underscored by its recent inclusion into proposed UN sustainable development goals.[216]

So while recovery strategies published to date may appear out of touch with some modern scientific issues, it is not too late to take action. Since action plans for most Pacific species at risk have not yet been developed, there is still an opportunity to integrate some of the threats raised for each species by this article. In addition to addressing the specific climate and OA threats suggested by this article, DFO and the Canadian federal government could follow the American example by producing a climate change and OA strategy and committing to modeling and monitoring climate change and OA. Further, a framework is needed that instructs recovery planners on how to incorporate climate and OA information into future recovery strategies and actions plans.

While future climate and OA projections will never be certain, it is important that this uncertainty does not paralyze progress. As long as the direction of changes in climate and OA are known, uncertainty in the exact magnitude of change should not preclude proactive management action.[217] Where uncertainty exists, multiple models may be used in order to discover the range of possible outcomes. A precau-

214 *Vancouver Island Peace Society v. Canada*, 1992 CarswellNat 108, 1992 CarswellNat 108F, [1992] 3 F.C. 42, [1992] F.C.J. No. 324, at para 12.

215 *Western Canada Wilderness Committee*, *supra*, note 72.

216 *Outcome Document — Proposal of the Open Working Group on Sustainable Development Goals*, UN DESA and UNDP, 2014.

217 Michelle M McClure et al, "Incorporating Climate Science in Application of the US *Endangered Species Act* for Aquatic Species" (2013) 27:6 Conservation Biology 1222 at 1227.

tionary yet bold approach is advocated that accepts the reasonably expected worst-case scenario of these models and takes corresponding management actions. Taking adequate precaution means that uncertainty should result in bolder action than would otherwise be taken.[218]

Current DFO efforts in understanding and engaging with risks posed by climate change are encouraging. It is hoped that this article and others like it will spur DFO recovery planning to better incorporate the effects that increasing atmospheric CO_2 will have on marine species at risk.[219] By adjusting for the "no-analog" future and taking into consideration how ecological, biological and physical baselines present moving targets for traditional recovery planning, 21st century species at risk management has the potential to become more flexible, adaptive and effective.

However, adaptive management may not be the ultimate solution to some problems posed by climate change and OA. For instance, large-scale shifts in marine communities resulting from increasing temperature cannot be remedied through adaptation.[220] Instead, mitigation will be needed in order to keep temperature within bounds that extant marine species can handle through evolution and adaptation.

Currently, Canada is lagging behind international efforts to combat climate change. In 2011, the federal government formally withdrew from its Kyoto accord obligations, citing actions taken by the previous government and looming penalties as reasons.[221] More recently, Environment Canada projects that emissions reductions will be only half of the target agreed to by the federal government by 2020 under the Copenhagen Accord.[222] Although Canada has not been very successful in meeting its past international obligations, the 2015 United Nations Climate Change Conference (UNFCC) in Paris presents a critical second chance.[223] The goal of the conference is to create a legally binding international agreement that includes all

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218 For more on the precautionary principle, see David VanderZwaag, "The Precautionary Principle and Marine Environmental Protection: Slippery Shores, Rough Seas, and Rising Normative Tides" (2002) 33 Ocean Devel and Int'l L 165 and also see James Cameron & Juli Abouchar, "The Precautionary Principle: A Fundamental Principle of Law and Policy for the Protection of the Global Environment" (1991) 14:1 BC Int'l & Comp L Rev 1.

219 See Aaron Lemkow & David VanderZwaag, "Recovery Planning under Canada's *Species at Risk Act* in a Changing Ocean: Gauging the Tides, Charting Future Coordinates," (2014) 26:2 J Envtl L & Prac 121.

220 Robinson, *supra*, note 22 at 95.

221 "Canada Pulls Out of Kyoto Protocol", CBC News, (12 December 2011), online: <www.cbc.ca/news>.

222 Environment Canada, "The 2012 Progress Report of the Federal Sustainable Development Strategy" (EC, 2013) at 12.

223 For reviews of the difficult negotiations leading up to the Conference, see Michael Bothe, "Doha and Warsaw: Reflections on Climate Law and Policy" (2014) 4 Climate Law 5 and Steinar Andresen "The Climate Regime: A Few Achievements, but Many Challenges" (2014) 4 Climate Law 21.

major emitters,[224] a deal that has not been reached in over 20 years of UN negotiations.[225]

The need to factor ocean acidification into international negotiations on climate change mitigation remains a particular challenge. To date, negotiations have largely focused on controlling global temperature increases, and ocean impacts have received marginal attention.[226] The suggestion by various authors for the establishment of a global target for limiting pH decreases in the ocean has yet to be followed but the idea certainly warrants further consideration and debate.[227]

In light of the serious threats posed to Canada's oceans by climate change and ocean acidification, the time is due for Canada to become a leader in global adaptation and mitigation efforts. The recently released 2014 Fall Report of the Commissioner of the Environment and Sustainable Development concludes that while "the Government of Canada has recognized the need to urgently combat climate change, its planning has been ineffective and the action it has taken has been slow and not well coordinated."[228] Strengthening adaptive measures, including recovery planning under SARA, is an important course towards the realization of a diverse and resilient future for all Canadians.

224 Negotiations are expected to conclude in 2015 with an agreed outcome with entry into force and implementation in 2020. Decision 1/CP.17, Establishment of an Ad Hoc Working Group on the Durban Platform for Enhanced Action (2011).

225 France Diplomatie, *Issues and Reasons Behind the French Offer to Host the 21st Conference of the Parties on Climate Change 2015* (Updated 22 May 2013).

226 Grantly Galland, Ellycia Harrould-Kolieb & Dorothee Herr, "The Ocean and Climate Change Policy" (2012) 12 Climate Pol'y 764.

227 See e.g., Ellycia R Harrould-Kolieb & Dorothee Herr, "Ocean acidification and climate change: synergies and challenges of addressing both under the UNFCCC" (2012) 12 Climate Pol'y 378; and Meredith Simmons & Tim Stephens, "Ocean Acidification: Addressing the other CO_2 Problem" (2009) 12 Asia Pacific J Envtl L 1.

228 *Report of the Commissioner of the Environment and Sustainable Development*, Chapter 1: Mitigating Climate Change (Ottawa: Public Works and Government Services Canada, 2014) at 32.