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Arctic Justice: Addressing Persistent Organic Pollutants

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Introduction

Persistent Organic Pollutants (POPs), anthropogenic chemicals produced for or by agricultural and industrial uses, contaminate all regions of the world.[1] There are three general categories of POPs: pesticides (including insecticides, herbicides, and fungicides), industrial chemicals, and unintentionally produced byproducts of certain chemical and combustion processes.[2] The pesticide dichlorodiphenyltrichloroethane (DDT) is perhaps the most well known of the POPs.[3] It was heavily relied upon during World War II to control the spread of certain diseases and is still used to control malaria in several developing nations.[4] Another POP is a class of chemicals collectively known as polychlorinated biphenyls (PCBs), which are widely used as dielectric fluid in transformers and capacitors.[5] Dioxins are an example of unintentionally produced POPs.[6] These are chemicals released by incomplete combustion or by the manufacture of certain pesticides.[7] Although these chemicals are produced for beneficial purposes (or as a byproduct), it has become apparent

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1. UNITED NATIONS ENV'T PROGRAMME, RIDDING THE WORLD OF POPS: A GUIDE TO THE STOCKHOLM CONVENTION ON PERSISTENT ORGANIC POLLUTANTS 3 (2005), *available at* http://chm.pops.int/Portals/0/Repository/CHM-general/UNEP-POPS-CHM-GUID-RIDDING.English.PDF.

2. JACK WEINBERG, AN NGO GUIDE TO PERSISTENT ORGANIC POLLUTANTS: A FRAMEWORK FOR ACTION TO PROTECT HUMAN HEALTH AND THE ENVIRONMENT FROM PERSISTENT ORGANIC POLLUTANTS (POPS) 10 (2008), *available at* http://www.ipen.org/ipenweb/documents/ipend.html.

3. *Id.* at 9.

4. UNITED NATIONS ENV'T PROGRAMME, *supra* note 1, at 2.

5. WEINBERG, *supra* note 2, at 36.

6. *Id.* at 9.

7. *Id.* at 21.

that they cause extensive harm to the environment and to personal health.[8] Agricultural and industrial processes release these toxic chemicals into the environment where they are readily incorporated into biological systems, especially those of Arctic marine mammals.[9]

The twentieth century ushered in a chemical revolution as technological improvements and laboratory science blossomed.[10] The first mass development of synthetic chemicals occurred in the 1920s.[11] This development brought widespread chemical use into manufacturing and transformed industry.[12] The 1940s and 1950s saw the use of a wide variety of chemicals.[13] Today, traces of these chemicals are in the tissues of every living human and a staggering percentage of global wildlife.[14] In 2001, world leaders and diplomats gathered for the Stockholm Convention on POPs, where they signed an international treaty aimed at reducing and eventually eliminating POP production and use.[15]

This Article will explore the modern problems posed by POPs, recent exposure studies, the Stockholm Convention's approach, and recommendations for increased likelihood of success in eliminating POPs. Part I describes the negative global impacts associated with POPs. Part II explains the Arctic's unique vulnerability to POP accumulation. Part III discusses marine mammals as sentinels for ocean and human health. Part IV elucidates the challenges POPs present to the Arctic peoples. Part V highlights the regional problems that brought POPs into the international spotlight. Part VI outlines the goals and mechanisms of the Stockholm Convention on POPs. This Article concludes by recommending improved communication and education regarding POPs, encouraging public and private incentives to develop environmentally sound, climate-friendly technologies, and exercising caution in developing the Arctic.

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8. *Id.* at 9–10.

9. *Id.* at 11.

10. Hugo E. Weisberger, *Mining; Manufacturing; Construction*, 36 AM. ECON. REV. 438, 439 (1946) (reviewing WILLIAMS HAYNES, AMERICAN CHEMICAL INDUSTRY: A HISTORY – 1912–1922 (1945)).

11. *Id.* at 440.

12. *Id.*

13. UNITED NATIONS ENV'T PROGRAMME, *supra* note 1.

14. *Id.* at 6.

15. WEINBERG, *supra* note 2, at 16.

I. POPs Pose Risks to Health and the Environment

POPs are highly hazardous chemical pollutants that pose serious global threats. Four common features characterize all POPs.[16] First, they are highly toxic and therefore have the potential to cause harm to human health and ecosystems.[17] Second, POPs are persistent, lasting for years or even decades before degrading into less dangerous forms.[18] They "resist physical, chemical, and biological degradation."[19] Therefore, once a POP enters the body, it remains there for a long time.[20] Third, POPs are subject to long-range transport.[21] They travel long distances and cause harmful contamination at locations far from where the chemical originally entered the environment.[22] Air currents are the main vehicle for long-distance POP transportation, but water currents and migratory species also contribute to POP transportation.[23] Fourth, POPs bioaccumulate in fatty tissue.[24] They easily dissolve in fats and accumulate in these tissues in concentrations much higher than the concentrations in the surrounding environment.[25]

Their persistence and mobility make POPs globally widespread.[26] They are found in locations far from POP-using and -producing societies, most notably the Arctic.[27] Because POPs are so prevalent, most fish, birds, mammals, and other wildlife are contaminated.[28] The high body burden carried by human prey species produces contamination concentrations in our food high enough to harm us.[29]

POPs cause numerous human diseases, illnesses, and disorders.[30] As carcinogens, POPs have been shown to cause breast and pancreatic cancer, soft tissue sarcoma, non-Hodgkin lymphoma, and adult onset leukemia.[31] POPs negatively impact

16. *Id.* at 10.
17. *Id.*
18. *Id.*
19. *Id.*
20. *Id.*
21. *Id.*
22. *Id.*
23. *Id.*
24. *Id.*
25. *Id.*
26. *Id.* at 8.
27. *Id.* at 11.
28. *Id.* at 8.
29. *Id.*
30. *Id.*
31. *Id.*

the reproductive system as well, causing abnormal sperm, miscarriages, preterm deliveries, low birth weights, shortened lactation periods, and menstruation complications.[32] Neurological disorders often attributed to POPs include attention deficit disorder, behavior problems (e.g. aggression and delinquency), learning disabilities, and impaired memory.[33] POPs damage the nervous system and disrupt the endocrine system's hormone regulation.[34] These chemicals also have led to developmental dysfunctions in fetuses and infants, immune suppression, and increased incidence of Type 2 diabetes, endometriosis, hepatitis, and cirrhosis.[35]

II. The Arctic Is Extremely Vulnerable to POP Accumulation Due to POPs' Highly Effective Transport Mechanisms and the Unique Food Priorities of Arctic Mammals

POPs accumulate in northern latitudes through the global distillation process, ocean transport, rivers emptying into the Arctic, and migratory animals.[36] Global distillation is the process by which POPs migrate from warmer to colder climates.[37] This is driven by the prevailing ocean and wind currents that carry POPs into the Arctic where they are subsequently trapped by the cold climate.[38] The high volatility of POPs allows them to evaporate and travel long distances on warm air currents and dust.[39] When the temperature cools or rain falls, those airborne POPs settle back to earth.[40] If conditions later allow, POPs will re-evaporate and again hop between the air and earth.[41] The cooler the climate, the less evaporation occurs.[42] Therefore, cooler climates experience POPs settling permanently as they are less likely to be

32. *Id.*

33. *Id.*

34. *Id.* at 13.

35. *Id.* at 8.

36. SAMUEL C. BYRNE, PERSISTENT ORGANIC POLLUTANTS IN THE ARCTIC, ALASKA COMMUNITY ACTION ON TOXICS 3, *available at* http://www.ipen.org/ipenweb/documents/pop%20documents/cop4_pops_arctic.pdf.

37. *Id.*

38. Frank Wania, *Assessing the Potential of Persistent Organic Chemicals for Long-Range Transport and Accumulation in Polar Regions*, 37 ENVTL. SCI. & TECH. 1344, 1344 (2003).

39. WEINBERG, *supra* note 2, at 11.

40. *Id.*

41. Wania, *supra* note 38, at 1349.

42. WEINBERG, *supra* note 2, at 11.

able to evaporate and continue migrating.[43] Also known as the "Grasshopper Effect," global distillation explains how contaminants fall in warm climates and move to colder climates.[44] This process largely accounts for the severe POP contamination in the Arctic, far from where they are produced or used.[45]

Ocean transport is another key—albeit slow—mechanism for carrying contaminants into the Arctic ecosystem.[46] Water-soluble pollutants in the air are transferred to the water through precipitation or the air-to-sea gas exchange.[47] Ocean currents carry these chemicals across the globe, often ending in the Arctic decades after emission.[48] As rivers pass through industrial and agricultural regions, they gather contaminants.[49] When these waters meet the oceans, some of their contaminated sediments are frozen into sea ice, which then migrate north to the Arctic.[50] Migratory animals offload their body burdens into the Arctic ecosystem through waste excretion and decomposition.[51] As their bodies decompose, all of their accumulated POPs are incorporated into the Arctic ecosystem.[52] These body burdens can be very high in concentrations of POPs, particularly in marine mammals.[53] These physical transport processes, especially combined with the region's high storage capacity for POPs, create an augmenting dilemma for the Arctic environment and ecosystems.

POPs' bioaccumulation and biomagnification capacities make them exceptionally harmful in the uniquely fat-based diet of Arctic mammals.[54] Bioaccumulation is the process through which POPs accumulate in an animal's fat stores because the pollutant is not easily excreted or metabolized.[55] POPs are lipid soluble, which

43. *Id.*

44. BYRNE, *supra* note 36, at 3.

45. *Id.*

46. ARCTIC MONITORING & ASSESSMENT PROGRAMME (AMAP), PERSISTENT ORGANIC POLLUTANTS IN THE ARCTIC 7 (2002), *available at* http://www.amap.no/documents/index.cfm?dirsub=%2FAMAP%20Assessment%202002%20-%20Persistent%20Organic%20Pollutants%20in%20the%20Arctic.

47. *Id.*

48. *Id.*

49. ARCTIC MONITORING & ASSESSMENT PROGRAMME (AMAP), *supra* note 46, at 14.

50. *Id.* at 7.

51. BRYNE, *supra* note 36, at 3.

52. *Id.*

53. *Id.* at 4.

54. BYRNE, *supra* note 36, at 4; *see also* Haakon Hop et al., *Food Web Magnification of Persistent Organic Pollutants in Poikilotherms and Homeotherms from the Barents Sea*, 36 ENVTL. SCI. & TECH. 2589, 2596 (2002).

55. WEINBERG, *supra* note 2, at 11.

means that they dissolve in fat instead of water.[56] Water soluble substances are easy to excrete and difficult to accumulate to a toxic amount in a living organism.[57] Lipid soluble POPs are stored in the body's fat, which is only removed from the body by expending it as energy.[58] Using the contaminated fat for energy releases the stored POPs, which then have toxic effects.[59] Unused fat stores decompose with the rest of the dead animal, releasing POPs held in those deposits into the environment.[60] Through bioaccumulation, toxins transfer to offspring during mammalian pregnancy and breastfeeding, and through the eggs of nonmammals.[61] This is especially harmful to the young as their bodies, brains, nervous systems, and immune systems are still developing and are more vulnerable.[62]

Biomagnification is a related process that works upward on the food chain.[63] When an animal eats another animal, the toxic body burden of the prey is also ingested.[64] The process of contamination increases up the food chain, beginning with micro-organisms taking in POPs from water; these microorganisms are then eaten by larger organisms, working up to fish, and eventually birds or mammals.[65] For example, if each microorganism takes in one part per million (ppm) of contaminant, predator A, who eats one hundred of these prey will ingest one hundred ppm of the contaminant. When predator B eats one hundred predator A's, predator B will ingest ten thousand ppm of the contaminant. This applies to every step of the food chain and to every animal consumed. Predatory species' POPs concentrations are on average ten times higher than the average concentration of their prey.[66] This leads to very high POPs concentrations in top predator species. In fact, an Environment Canada study showed POPs concentrations in the eggs of some fish-eating birds to be twenty-five million times the concentration of the waters where the fish live.[67] Fish, predatory birds, and mammals can have magnified

56. *Id.*
57. *Id.*
58. BRYNE, *supra* note 36, at 4.
59. *Id.*
60. *Id.* at 3.
61. WEINBERG, *supra* note 2, at 8.
62. *Id.*
63. *Id.* at 12.
64. *Id.*
65. *Id.*
66. *Id.*
67. *Id.*

toxic levels that are easily thousands of times greater than background levels.[68] These processes are especially problematic in the Arctic because organisms are dependent upon the lipid-based food web for insulation and energy stores.[69] Bioaccumulated POPs are biomagnified up the food chain as Arctic animals continually ingest and store contaminated lipids.[70] With no efficient detoxification and only contaminated food available, the Arctic fauna accrue incredibly high toxic concentrations.[71]

III. Marine Mammals Warrant Special Attention as Sentinels for Environmental and Human Health

Marine mammals serve as sentinels for coastal ecosystem and ocean health.[72] As Lars Otto Reiersen, the Executive Secretary of the Arctic Monitoring and Assessment Program, stated, "[T]he Arctic is a very important area to take the pulse of the globe."[73] Unlike controlled laboratory experiments, the study of marine mammals provides a valuable, real-world snapshot of the diverse chemical contamination affecting the marine environment. However, the various compounding variables (e.g., age, habitat, variety of pollutants), diminish the ability to draw scientific conclusions about the effects of any specific chemical.[74] Nonetheless, the study of marine mammals' exposure to complex chemical mixtures is valuable to wildlife managers and conservationists, policy makers concerned with marine food chain contamination, and professionals concerned with piscivorous human populations.[75] According to the Marine Mammal Commission, "virtually all of the threats [faced by marine mammals] are ultimately related to the size, growth rate, consumption patterns, and behavior of Earth's human popu-

68. *Id.*

69. BYRNE, *supra* note 36, at 4.

70. *Id.*

71. *Id.*

72. GREGORY D. BOSSART, MARINE MAMMALS AS SENTINELS FOR OCEANS AND HUMAN HEALTH 1 (2010), *available at* http://www.marineland.net/images/image/pdfs/Marine%20Mammals%20as%20Sentinels%20for%20Oceans%20and%20Humn.pdf.

73. Sharon Guynup, *Arctic Life Threatened by Toxic Chemicals, Groups Say*, NAT'L GEOGRAPHIC TODAY, (Oct. 8, 2002), http://news.nationalgeographic.com/news/2002/10/1008_021008_arctic.html.

74. Robert J. Letcher et al., *Exposure and Effects Assessment of Persistent Organohalogen Contaminants in Arctic Wildlife and Fish*, 408 SCI. TOTAL ENV'T 2995, 3001 (2010).

75. Peter S. Ross, *Marine Mammals as Sentinels in Ecological Risk Assessment*, 6 HUM. & ECOLOGICAL RISK ASSESSMENT 29, 30 (2000), *available at* http://www.whoi.edu/science/B/people/mhahn/Ross_weight_of_evidence.pdf.

lation."[76] Marine mammals integrate contaminant information and present realistic insight into the actual ratios of, and interactions among, marine pollutants.[77]

Six factors make marine mammals excellent sentinels of ocean and human health.[78] First, they have long life spans, so long-term effects can be studied and the effectiveness of remedies or changed circumstances can be observed.[79] Second, marine mammals are often long-term coastal residents.[80] They generally live in the same area their entire lives or continually return to the same area after each year's migration.[81] By observing and identifying the same animals over time, researchers achieve more conclusive results. Researchers more accurately identify causes and effects when they know the habits and ecosystem of their subject.[82] Third, marine mammals feed at high trophic levels,[83] just as humans do. Because of the bioaccumulation and biomagnification throughout the marine food chain, high trophic level consumers are exposed to chemical mixtures far more concentrated than the original emission.[84] Fourth, their unique fat stores serve as toxin deposits.[85] This allows a more accurate study of the effects of lipid-soluble POPs and other anthropogenic contaminants.[86]

The fifth reason why marine mammals are ideal sentinels for ocean and human health is that marine mammals are charismatic megafauna, meaning that they capture human interest.[87] The significance is twofold. The general public is more likely to express concern for the struggles suffered by or the atrocities committed on marine mammals.[88] For example, a dead seal will evoke more emotion and compassion than a sea slug having met

76. MARINE MAMMAL COMM'N, ANNUAL REPORT TO CONGRESS 71 (2004), *available at* http://www.mmc.gov/reports/annual/pdf/2004annualreport.pdf.

77. *Id.*

78. BOSSART, *supra* note 72.

79. Michelle Lynn Reddy et al., *Marine Mammals as Sentinels of Ocean Health*, *in* CRC HANDBOOK OF MARINE MAMMAL MEDICINE 2, 3–13 (2001).

80. BOSSART, *supra* note 72.

81. *Id.*

82. Ross, *supra* note 75, at 29.

83. *See* Reddy et al., *supra* note 79.

84. Letcher et al., *supra* note 74, at 3032.

85. BOSSART, *supra* note 72.

86. *See* Randall S. Wells et al., *Bottlenose Dolphins as Marine Ecosystem Sentinels: Developing a Health Monitoring System*, 1 ECOHEALTH 246, 246–54 (2004).

87. *See* Gregory D. Bossart, *The Florida Manatee: On the Verge of Extinction?*, 214 J. AM. VETERINARY MED. ASS'N 1178, 1178–83 (1999).

88. Reddy et al., *supra* note 79, at 4.

the same fate. Additionally, casual observers are more likely to pay attention to charismatic megafauna and note problems.[89] For example, tourists clamor to swim with dolphins or go on whale-watching tours.[90] Sixth, Peter Ross, a marine mammal toxicologist with the Canadian Department of Fisheries and Oceans, points out that POPs interact with a cell structure common to all mammal endocrine systems.[91] A given pollutant will have the same effect in mice, orcas, and humans, although to varying degrees.[92]

POPs amplify challenges faced by Arctic marine mammals, whose likelihood of survival is already attenuated by climate change, accumulation of toxic trace metals, radioactive contamination, and development largely associated with oil operations.[93] POPs heighten the risks of already vulnerable marine mammals.[94] These contaminants act as endocrine disruptors that inhibit species' abilities to cope with threats induced by climate change and ecosystem instability.[95] In addition to creating struggles at the species level, POPs inflict harm on individual animals, such as lessening an animal's ability to fight infection.[96] Furthermore, these endocrine-disrupting pollutants lessen animals' abilities to cope with the rapidly changing landscape.[97]

POP concentrations in marine mammals follow a general contamination hierarchy.[98] However, certain regional populations

89. *Id.*

90. *See, e.g.*, *Ask Shamu*, ANIMALS, http://www.seaworld.org/ask-shamu/faq.htm#seaworld (last visited Dec. 7, 2011) (explaining that each year, twenty-one million guests visit SeaWorld's nine parks, including SeaWorld San Diego's Dolphin Interaction Program).

91. Ross, *supra* note75.

92. *See* Letcher et al., *supra* note 74, at 3017.

93. *See* ARCTIC MONITORING & ASSESSMENT PROGRAMME, ARCTIC POLLUTION 2002: PERSISTENT ORGANIC POLLUTANTS, HEAVY METALS, RADIOACTIVITY, HUMAN HEALTH, CHANGING PATHWAYS 111 (2002) [hereinafter ARCTIC POLLUTION 2002].

94. *Id.*

95. *See* Bjørn Munro Jenssen, *Endocrine-Disrupting Chemicals and Climate Change: A Worst Case Combination for Arctic Marine Mammals and Seabirds?*, 114 ENVTL. HEALTH PERSP. (SUPP. 1) 76, 76 (2006).

96. ARCTIC POLLUTION 2002, *supra* note 93, at 26.

97. *See* Gwynne Lyons, *Viewpoint: Policy Requirements for Protecting Wildlife from Endocrine Disruptors*, 114 ENVTL. HEALTH PERSP. (SUPP. 1) 142, 146 (2006).

98. Letcher et al., *supra* note 74, at 3001. The general hierarchy is: PCB > chlordane compounds ≈ DDT ≈ PFSA > CBz ≈ HCH ≈ toxaphene ≈ PFCA > PBDE > HBCD. The above abbreviations are: PCB—polychlorinated biphenyl congeners (originally listed by the Stockholm Convention); chlordane compounds (originally listed by the Convention); DDT—dichlorodiphenyldichloroethylene and dichlorodiphenyldichloroethane (originally listed by the Convention); PFSA—perfluor-

of species may be more affected by a dominant chemical related to their geographic location than other populations of the same species inhabiting a different Arctic region.[99] For example, Alaskan and Norwegian orca populations had "extremely high levels" of DDT relative to other Arctic orca populations.[100] Many of the most recent pollutant exposure studies have been conducted on the bowhead whale, beluga whale, harbor porpoise, and ringed seal.[101] These species lend themselves to such research due to their circumpolar distribution, potential to be models for other species, available POP data, physiological and pathological data in pollution and ecology contexts, and subsistence use by indigenous communities.[102] Bowhead whales provide a model for mysticetes (filter-feeding whales), belugas, odontocetes (toothed whales), ringed seals, and other ice seals.[103] Pathological data, such as endocrinology and lesions, can be evaluated in the context of the animal's exposure to pollutants to sharpen the understanding of biological effects of ecological factors, such as biomagnification and trophodynamics.[104]

The bowhead whale provides a valuable study subject because it provides food and material subsistence to Russian, Canadian, and Alaskan indigenous communities; is nearly circumpolar; is endangered; and researchers can easily access and

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inated sulfonates (added to the Convention by the Convention of the Parties: Fourth Meeting (COP4) amendment); CBz—poly-chlorinated benzenes (some of which were added to the Convention by the COP4 amendment); HCH—hexachlorocyclohexane isomers, lindane-related isomers (added to the Convention by the COP4 amendment); toxaphene (originally listed by the Convention); PFCA—perfluorinated carboxylates (not yet addressed by the Convention); PBDE—polybrominated diphenyl ether congeners (some of which were added to the Convention by the COP4 amendment); HBCD—hexabromocyclododecanes isomers (currently under review for inclusion in the Convention). Stockholm Convention on Persistent Organic Pollutants, Annex A, May 22, 2001, 2256 U.N.T.S. 119, 237–41 [hereinafter Stockholm Convention], *available at* http://chm.pops.int/Convention/ConventionText/tabid/2232/Default.aspx; Conference of the Parties of the Stockholm Convention on Persistent Organic Pollutants: Fourth Meeting, Geneva, May 4–8, 2009, *Draft Text for Amendments to Annexes A, B, and/or C to the Stockholm Convention*, U.N. Doc. UNEP/POPS/COP.4/18 (Feb. 4, 2009); *see also* Secretariat of the Stockholm Convention, *What are POPs?* STOCKHOLM CONVENTION, http://chm.pops.int/Convention/ThePOPs/tabid/673/Default.aspx (last visited Dec. 7, 2011) (listing the POPs included in the Convention and its amendments).

99. Letcher et al., *supra* note 74.

100. *Id.*

101. *Id.* at 2999.

102. *Id.* at 2998.

103. *Id.*

104. *Id.* Trophodynamics is the dynamics of nutrition or metabolism. *Definition: 'Trophodynamics'*, MEDILEXICON, http://www.medilexicon.com/medicaldictionary.php?t=94187 (last visited Dec. 7, 2011).

identify them.[105] Interestingly, bowheads occupy a relatively low trophic position in the food chain as they are baleen whales.[106] Instead of preying on fish, birds, or smaller marine mammals, bowhead whales filter plankton and small crustaceans out of the water with their baleen plates.[107] Due to their diet, bowheads have very low pollutant contamination levels because only limited bioaccumulation has occurred in their prey.[108] According to one study, the Bering and Beaufort Seas serve as important feeding regions for the bowhead whale.[109] This research team found accumulating yet low concentrations of eight forms of PCB in bowhead blubber and liver.[110] However, the bowheads' metabolites show that the whales are responding to POP exposure.[111] In a subsequent study, the same research team investigated metabolites further and found that certain PCB concentrations in blubber were lower than those in other marine mammals.[112] This shows that certain biotransformation and accumulation processes are occurring in bowhead whales even though the whales are not yet exhibiting adverse health effects like other marine mammals.[113]

Beluga whales and harbor porpoises provide excellent study subjects that allow inferences to be drawn about the effects of POPs on human health. Belugas are toothed whales that feed at the upper trophic levels in the Arctic and industrially polluted waters, most famously Quebec's Saint Lawrence River Estuary.[114] For nearly two decades, researchers have studied the Saint Lawrence River Estuary beluga population, finding that those whales have pollutant contamination levels ten times higher than other Arctic beluga populations.[115] High POP levels have been linked to alarming physical consequences such as lethal lesions,

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105. *Id.* at 3015.

106. P.F. Hoekstra et al., *Trophic Ecology of Bowhead Whales (*Balaena mysticetus*) Compared to Other Arctic Marine Biota as Interpreted from Carbon-, Nitrogen-, and Sulfur-Isotope Signatures,* 80 CAN. J. ZOOLOGY 223, 227 (2002).

107. *Id.* at 224.

108. Letcher et al., *supra* note 74, at 3015.

109. *Id.*

110. *Id.*

111. *Id.*

112. *Id.*

113. *Id.*

114. *Id.* at 3016.

115. G. Andersen et al., *Concentrations and Patterns of Organochlorine Contaminants in White Whales (*Delphinapterus leucas*) from Svalbard, Norway,* 264 SCI. TOTAL ENV'T 267, 276 (2001).

infections, and higher rates of abnormal cell proliferation.[116] Significantly higher cancer rates in Saint Lawrence River Estuary belugas may be attributed to the POP contamination from local aluminum smelters.[117] Similarly, high POP and other pollutant exposure strongly correlate with lymphocyte and spleen depletion and thymus atrophy in harbor porpoises.[118] PCBs lead to immunosuppression and high nematode (parasitic worm) burdens in these species.[119]

The ringed seal, which preys on fish and crustaceans, suffers predominately from PCBs, chlordanes, DDT, and toxaphene contamination.[120] As the most populous of the Arctic seals, the ringed seal serves as an important food source for humans and other Arctic predators.[121] As a testament to its importance, the Arctic Monitoring and Assessment Programme recommends using the ringed seal as an indicator species for the environmental monitoring program in the Arctic.[122] Many recent studies reveal POP contamination in ringed seal blubber across the Arctic, including in Norway, Greenland, Canada, Alaska, the White Sea, and the Baltic Sea.[123]

An excellent sentinel species, the ringed seal is not the only ice seal to suffer the negative effects of POP exposure. Researchers such as Robert J. Letcher of the National Wildlife Research Centre at Ottawa's Carleton University blamed pollutants for the decline of Baltic Sea seal populations in the 1950s after observing "reproductive impairment and symptoms suggesting immune dysfunction, pathology of bone tissue, proliferation of gastrointestinal parasites and lesions."[124] More

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116. Letcher et al., *supra* note 74, at 3016.

117. Daniel Martineau et al., *Cancer in Wildlife, a Case Study: Beluga from the St. Lawrence Estuary, Quebec, Canada*, 110 ENVTL. HEALTH PERSP. 285, 289 (2002).

118. Letcher et al., *supra* note 74, at 3018.

119. *See* Paul D. Jepson et al., *Investigating Potential Associations Between Chronic Exposure to Polychlorinated Biphenyls and Infectious Disease Mortality in Harbor Porpoises from England and Wales*, 243 SCI. TOTAL ENV'T 339, 345 (1999); *cf.* Paul D. Jepson et al., *Relationships Between Polychlorinated Biphenyls and Health Status in Harbor Porpoises (*Phocoena phocoena*) Stranded in the United Kingdom*, 24 ENVTL. TOXICOLOGY CHEMISTRY 238, 240 (2005) (finding parasitic infestations to be a common cause of harbor porpoise mortality).

120. Paul D. Jepson et al., *supra* note 119.

121. J. Van Oostdam et al., *Human Health Implications of Environmental Contaminants in Arctic Canada: A Review*, 351–52 SCI. TOTAL ENV'T 165, 173 (2005).

122. Letcher et al., *supra* note 71, at 3001.

123. *Id.*

124. *Id.* at 2998.

recently, pollutants have been linked to renal lesions, decreased fecundity, and reproductive organ abnormalities in ringed and grey seals.[125] In 1976, ringed seal pregnancies dropped sixty percent in Bothnian Bay, which was highly contaminated with PCBs.[126] Studies in the 1980s showed negative health effects and population declines in ringed, grey, and harbor seals.[127] High POP concentrations increase harbor seals' susceptibility to infection[128] and frequency of reproductive disorders,[129] suppress the immune system,[130] and disrupt the endocrine system.[131] A series of studies in which harbor seals were fed contaminated fish demonstrated exposure effects on antibody response and cell-mediated immunity.[132] A similar study on grey seal pups linked PCB

125. *Id.*

126. *Id.* at 3017.

127. *Id.*

128. *See* Peter J. H. Reijnders et al., *Population Development of Harbor Seals* Phoca Vitulina *in the Wadden Sea After the 1988 Virus Epizootic*, 38 J. SEA RES. 161, 165 (1997); H. Van Loveren et al., *Contaminant-Induced Immunosuppression and Mass Mortalities Among Harbor Seals*, 112–13 TOXICOLOGY LETTERS 319, 320 (2000) (noting that a class of chemicals, including PCBs, harms the immune system).

129. Peter J. H. Reijnders, *Organochlorine and Heavy Metal Residues in Harbor Seals from the Wadden Sea and Their Possible Effects on Reproduction*, 14 NETH. J. SEA RES. 30, 46 (1980); *see also Report of the Workshop on Chemical Pollutants and Cetaceans*, *in* JOURNAL OF CETACEAN RESEARCH & MANAGEMENT: SPECIAL ISSUE 1: CHEMICAL POLLUTANTS AND CETACEANS 1, 10 (Peter J. H. Reijnders et al. eds., 1999) (noting that scientists found endocrine-disrupting chemicals in marine mammals whenever searching for them); Reijnders, *supra* note 128, at 166; Peter J. H. Reijnders, *Reproductive Failure in Common Seals Feeding on Fish from Polluted Coastal Waters*, 324 NATURE 456, 457 (1986) (concluding in one study that "the reproductive success of the seals receiving the diet with the highest level of pollutants was significantly decreased"); Peter J. H. Reijnders, *Toxicokinetics of Chlorobiphenyls and Associated Physiological Responses in Marine Mammals, with Particular Reference to Their Potential for Ecotoxicological Risk Assessment*, 154 SCI. TOTAL ENV'T 229, 230 (1994) (noting that endocrine disruptors are correlated with "both reproductive and immunological disorders").

130. Chiahru Mori et al., *Immunomodulatory Effects of In Vitro Exposure to Organochlorines on T-Cell Proliferation in Marine Mammals and Mice*, 69 J. TOXICOLOGY ENVTL. HEALTH, PT. A 283, 284 (2006); *see* Milton Levin et al., *PCBs and TCDD, Alone and in Mixtures, Modulate Marine Mammal but not B6c3F1 Mouse Leukocyte Phagocytosis*, 68 J. TOXICOLOGY ENVTL. HEALTH, PT. A 635, 653 (2005); Jennifer C. C. Neale et al., *PAH- and PCB-Induced Alterations of Protein Tyrosine Kinase and Cytokine Gene Transcription in Harbour Seal (*Phoca Vitulina*) PBMC*, 12 CLINICAL DEVELOPMENTAL IMMUNOLOGY 91, 95–96 (2005); Peter S. Ross et al., *PCBs Are a Health Risk for Humans and Wildlife*, 289 SCI. 1878, 1879 (2000).

131. Reijnders, *supra* note 128.

132. Peter S. Ross et al., *Contaminant Related Suppression of Delayed-Type Hypersensitivity and Antibody Responses in Harbor Seals Fed Herring from the Baltic Sea*, 103 ENVTL. HEALTH PERSP. 162, 166 (1995); *see also* R. L. De Swart et al., *Impaired Immunity in Harbor Seals [*Phoca Vitulina*] Fed Environmentally Contaminated Herring*, VETERINARY Q., Oct. 1996, at S127, S128 (finding that

contamination to significantly suppressed immunosuppressive responses.[133] First-born pups of northern fur seals, exposed to higher pollutant concentrations in milk than pups born in later litters, displayed more immune suppression than their younger siblings.[134]

Orcas have also fallen victim to anthropogenic pollutants. Norwegian Polar Institute toxicologist Hans Wolkers performed blubber sampling on Northern Norway orcas, finding those whales to be among the most highly contaminated Arctic animals.[135] Research on free-ranging Alaskan orca populations found that concentrations of POPs, including PCBs and DDT, in transient whale blubber far exceeded those in resident whales.[136] Transient whales feed on marine mammals while the residents of the Alaskan Kenai Fjords and Prince William Sound primarily eat fish.[137]

IV. POP Contamination Causes Acute Health and Cultural Challenges to the Indigenous Peoples of the Arctic

Arctic peoples face significant health, cultural, and food security challenges. The health of native Arctic people is integrally tied to their traditional food sources.[138] Called "country food" in Arctic Canada, this traditional food consists of locally harvested mammals, fish, plants, and birds.[139] Most Arctic people consume these foods regularly.[140] Subsistence hunting of walruses, whales, seals, and other marine mammals is commonplace.[141] Arctic processes of harvesting country food, similar across the

contaminants "accumulated through the Baltic Sea food chain ha[ve] led to an impairment of immune function" in some seals).

133. Eugen Gravningen Sørmo et al., *Immunotoxicity of Polychlorinated Biphenyls (PCB) in Free-Ranging Gray Seal Pups with Special Emphasis on Dioxin-Like Congeners*, 72 J. TOXICOLOGY & ENVTL. HEALTH, PT. A 266, 275 (2009).

134. *See* Kimberlee B. Beckmen et al., *Organochlorine Contaminant Exposure and Associations with Hematological and Humoral Immune Functional Assays with Dam Age as a Factor in Free-Ranging Northern Fur Seal Pups (*Callorhinus Ursinus*)*, 46 MARINE POLLUTION BULL. 594, 595–96 (2003).

135. Letcher et al., *supra* note 74, at 3015.

136. *Id.*

137. Gina M. Ylitalo et al., *Influence of Life-History Parameters on Organochlorine Concentrations in Free-Ranging Killer Whales (*Orcinus Orca*) from Prince William Sound, AK*, 281 SCI. TOTAL ENV'T 183, 184 (2001).

138. *See* Van Oostdam et al., *supra* note 121, at 170.

139. *Id.*

140. Harriet V. Kuhnlein & H. M. Chan, *Environment and Contaminants in Traditional Food Systems of Northern Indigenous Peoples*, 20 ANN. REV. NUTRITION 595, 598 (2000).

141. *Id.*

region, are of social, nutritional, spiritual, psychological, economic, and cultural importance.[142] For example, the Inuit people of Sanikiluaq believe that eating seal allows them to generate heat and strength in a manner that imported foods cannot.[143] The Inuit belief system maintains that one's *tiimiut* (physical body) and *tarneq* (emotions and soul) must be nourished and at peace in order to achieve health.[144] This can be done largely by the consumption of seal meat and oil, which confer warmth and well-being, both considered to be "health."[145] This health, in turn, "allows one to fulfill personal needs, the family's needs, and social needs and results in a feeling of control and contentment which in turn generates high self-esteem."[146] The complex social and cultural regimes governing the exchange of food within the Inuit and other native Arctic peoples reflect their societal structure and organization.[147] In fact, in an interview study of over seventeen hundred Arctic Canadians, ninety percent of the respondents said family harvest and use of traditional foods confer numerous social, cultural, spiritual, economic, and nutritional benefits.[148]

Country foods provide numerous health benefits, including nutritional intake and good physical health associated with harvesting.[149] Marine mammal blubber is a significant source of omega-3 fatty acids for Arctic people, including the Canadian Inuit.[150] Aside from its cultural and nutritional benefits, country food is more economical for Arctic communities than imported foods.[151] In a 2006 Canadian study, the cost of a week's worth of food in remote northern communities was roughly double the cost of the same food in southern markets.[152] People reported skipping meals because food was too expensive.[153] The cash economies in these remote regions are often tenuous[154] and opportunities for

142. S. G. Donaldson et al., *Environmental Contaminants and Human Health in the Canadian Arctic*, 408 SCI. TOTAL ENV'T 5165, 5168 (2010).

143. Van Oostdam et al., *supra* note 121, at 170.

144. Kristen Borré, *The Healing Power of the Seal: The Meaning of Inuit Health Practice and Belief*, 31 ARCTIC ANTHROPOLOGY 1, 5 (1994).

145. *Id.*

146. *Id.*

147. Van Oostdam et al., *supra* note 121, at 170.

148. *Id.* at 221.

149. Donaldson et al., *supra* note 142, at 5169.

150. Harriet V. Kuhnlein et al., *Lipid Components of Traditional Inuit Foods and Diets of Baffin Island*, 4 J. FOOD COMPOSITION & ANALYSIS 227, 231 (1991).

151. Donaldson et al., *supra* note 142, at 5170.

152. *Id.*

153. *Id.*

154. *Cf.* Van Oostdam et al., *supra* note 121, at 171.

local employment are scarce.[155] With such a restrictive local economy, few people can afford to rely on market-bought food.[156] Even if imported food was economically feasible, the consumption of these foods has negative health and cultural impacts.[157] Unfortunately, these traditional foods that are so integrally tied to native society are also vectors of contaminant exposure; for example, the common country food of mammalian organ meat is high in PCBs.[158]

Contamination forces indigenous peoples to replace traditional diets with imported foods. This brings negative effects on health, community, culture, and local economies.[159] When native people who traditionally eat country food change their diet to imported or manufactured food, their health often deteriorates.[160] For example, consumption of total fat, saturated fat, and sucrose increases; intake of vitamins A, D, E, B6, and riboflavin decreases; and intake of vital minerals like iron, zinc, copper, magnesium, manganese, phosphorus, potassium, and selenium also decreases.[161] Shifting to imported food is associated with increased rates of obesity, diabetes, anemia, and dental problems; it is also connected to decreased physical activity and lowered infection resistance.[162] Additionally, changing to imported food negatively impacts the native community and culture.[163] Eliminating communal harvesting and sharing traditions undermines the vitality of their spiritual and cultural identities.[164] This inhibits community interdependence and self-reliance.[165] Local economies suffer as well because consumers must stretch

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155. BYRNE, *supra* note 36, at 11.

156. Van Oostdam et al., *supra* note 121, at 171.

157. *Id.* at 220.

158. Harriet V. Kuhnlein et al., *Arctic Indigenous Women Consume Greater than Acceptable Levels of Organochlorines*, 125 J. NUTRITION 2501, 2506 (1995).

159. Van Oostdam et al., *supra* note 121, at 220.

160. *Id.*

161. *Id.*; O. Receveur & Harriet V. Kunhlein, *Health Benefits of Consuming Arctic Traditional Food*, WORKSHOP ON PERSISTENT ORGANIC POLLUTANTS (POPS) IN THE ARCTIC: HUMAN HEALTH AND ENVIRONMENTAL CONCERNS 26–27 (2000), www.amap.no/documents/index.cfm?action=getfile&dirsub=&FileName=wsphh-rep.pdf.

162. E. J. E. Szathmary et al., *Dietary Change and Plasma Glucose Levels in an Amerindian Population Undergoing Cultural Transition*, 24 SOC. SCI. MED. 791, 791 (1987); J. P. Thouez et al., *The Other Face of Development: Native Population, Health Status, and Indicators of Malnutrition—The Case of the Cree and Inuit of Northern Québec*, 29 SOC. SCI. MED. 965, 973 (1989).

163. BYRNE, *supra* note 36, at 11.

164. *Id.*

165. *Id.*

their budgets to afford the expensive market food.[166] Even where imported foods are available, they are often not economically feasible.[167]

V. Elevated Contamination and Regional Problems Around the World Capture International Attention

In the 1960s, public concerns about new chemicals, specifically DDT, PCBs, and dioxin, began to surface.[168] In her 1962 book titled *Silent Spring*, Rachel Carson discusses the effects of DDT use: destruction of bird populations, ecosystem disruption, and human illness.[169] In 1964, a Swedish researcher found PCBs in human blood while trying to study DDT, discovering that PCB levels in the blood were so high they were masking the DDT.[170] Further studies found DDT and PCBs in wildlife and human tissue.[171] In the following two decades, many countries, especially highly industrialized countries, banned the continued production and sale of these chemicals.[172] Dioxin came into the public eye in the 1970s when unexpectedly high rates of rare cancers and other illnesses were documented in U.S. Airmen and the Vietnamese.[173] Although the U.S. military initially denied it, these dioxin illnesses were eventually linked to the more than 20,341,000 gallons of Agent Orange sprayed on Vietnam as a defoliation method used against the Viet Cong.[174]

Growing regional concerns resulted in POP contamination becoming a global issue. Researchers in the North Sea, Baltic Sea, Great Lakes, and the Arctic seas noted repeated environmental health concerns throughout the 1980s and 1990s.[175] These areas suffered severe disruptions in aquatic ecosystems, which were linked to POPs.[176] Sharp declines in fish and wildlife populations threatened species while simultaneously weakening the surviving individuals' reproductive abilities, causing tumors and birth defects, and leading to problems for the remnant populations, such

166. *Id.* at 12.
167. *Id.*
168. WEINBERG, *supra* note 2, at 9.
169. RACHEL CARSON, SILENT SPRING (1962).
170. WEINBERG, *supra* note 2, at 9.
171. *Id.*
172. *Id.*
173. *Id.*
174. *Id.*
175. *Id.* at 10.
176. *Id.*

as an inability to feed their young.[177] As a result, the health of human populations reliant on these animals also suffered.[178] Central and Eastern Europe and the former Soviet Union also saw common regional problems.[179] These areas continued using POPs after other highly industrialized regions banned or restricted such use.[180] This practice contributed to the region's serious dioxin problem, which was also spurred on by their poorly controlled combustion processes, lack of proper process implementation, and the many poorly controlled stockpiles of POPs and contaminated wastes.[181] In Latin America, Asia, and Africa, agricultural and pesticide issues focused attention on the dangers of POP pesticides.[182] Non-governmental organizations (NGOs) were the first to take note of the POP problem. In the late 1980s through the 1990s, Greenpeace led campaigns in developing countries against incinerators and open waste burning, emphasizing the hazards of dioxin released during these processes.[183] The World Wildlife Foundation also contributed to raising POP awareness in these developing regions.[184]

These growing regional concerns led to a global recognition of the hazards of POPs and the need for a global solution.[185] POPs are too volatile for any country to protect its people and environment from them.[186] Any efforts taken by a particular country or even region would be continually frustrated by the pollution from other countries not attempting to curb or stop POP production and use.[187] A 1995 United Nations Environment Programme (UNEP) resolution recognized this problem and identified POPs as a major and increasing threat to human health and the environment.[188] UNEP's resolution postulated that a global and binding agreement is required to control and eliminate POPs, and listed the twelve POPs to be handled first: the Dirty Dozen.[189] The following year, an ad hoc POPs working group

177. *Id.* at 11.
178. *Id.*
179. *Id.* at 13.
180. *Id.*
181. *Id.* at 13–14.
182. *Id.* at 14.
183. *Id.*
184. *Id.*
185. *Id.* at 15.
186. *Id.*
187. *Id.*
188. *Id.*
189. *Id.*

considered global strategies to approach POPs.[190] They concluded that only a binding international agreement could reduce the health and environmental risks of the Dirty Dozen.[191] Treaty negotiations began in 1998 with the POPs Intergovernmental Negotiating Committee in Montreal.[192] Almost one hundred governments attended, in addition to many NGOs.[193] The NGOs adopted the POPs Elimination Platform and founded the International POPs Elimination Network (IPEN).[194] The Platform contained global policies and articulated concerns of global society.[195] IPEN united NGOs in their global campaign to support the Platform and coordinate efforts to aid the treaty negotiations.[196] In 2000, negotiations ended with a consensus agreement on the text of the treaty.[197] The following year, Stockholm hosted the Diplomatic Conference, where heads of state and ambassadors formally adopted the Stockholm Convention on POPs, which seeks to restrict and ultimately eliminate the production, use, release, and storage of POPs.[198] The treaty entered into force in May 2004.[199]

VI. The Stockholm Convention on POPs Outlines Five Distinct Goals and Provides Mechanisms for Their Achievement

The Convention has five core goals.[200] First, the treaty seeks to eliminate POPs through concerted global efforts, beginning with the Dirty Dozen.[201] Second, it strives to foster the transition from POPs to safer alternatives.[202] Third, the Convention stipulates how to qualify other pollutants as POPs and provides the required process by which additional action may be mandated for those "unacceptably hazardous" chemicals.[203] Fourth, the Convention seeks to channel resources to sterilize stockpiles and old

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190. *Id.*
191. *Id.*
192. *Id.* at 16.
193. *Id.*
194. *Id.*
195. *Id.*
196. *Id.*
197. *Id.*
198. *Id.*
199. *Id.*
200. UNITED NATIONS ENV'T PROGRAMME, *supra* note 1, at 4.
201. *Id.* at 5.
202. *Id.* at 8.
203. *Id.* at 11.

equipment that contain POPs.[204] Fifth, the Convention suggests ways to continue the global effort to a POP-free future.[205]

The Convention's first goal is to eliminate the Dirty Dozen through international efforts.[206] It begins its global eradication of POPs by listing and categorizing the twelve worst into three Annexes.[207] Annex A lists nine POPs that are to be restricted and eliminated; Annex B explains DDT use and production; and Annex C explains unintentionally produced POPs.[208]

Annex A calls for the restriction and ultimate elimination of nine listed POPs that are intentionally produced.[209] These include seven pesticides (endrin, toxaphene, aldrin, dieldrin, heptachlor, chlordane, and mirex) and two industrial chemicals (hexachlorobenzene (HCB) and PCBs).[210] Parties to the Convention must severely limit or prohibit the production and use of these seven pesticides.[211] The Convention immediately bans endrin and toxaphene in ratifying countries.[212] Parties must cease production of aldrin, dieldrin, and heptachlor or register for exemptions.[213] The production and use of chlordane, mirex, and hexachlorobenzene are similarly limited to restrictively defined purposes and to countries granted an exemption.[214] Exemptions are public, reviewed periodically, and only permit the grantees to use the specified pesticide for prescribed purposes and for a limited time.[215] PCB production is immediately banned in party nations; however, the Convention allows the continued use of PCB-containing equipment subject to phasing out this old gear and machinery.[216] The transition must be completed by 2025 and the recovered PCBs properly disposed of by 2028.[217]

Annex B addresses the use and production of the pesticide DDT.[218] The Convention allows acceptable uses of DDT if four

204. *Id.* at 13.
205. *Id.* at 15.
206. *Id.* at 5.
207. Stockholm Convention, *supra* note 98, at 237–49.
208. *Id.*
209. *Id.*
210. *Id.*
211. UNITED NATIONS ENV'T PROGRAMME, *supra* note 1, at 7.
212. *Id.*
213. *Id.*
214. *Id.*
215. *Id.*
216. *Id.*
217. *Id.*
218. Stockholm Convention, *supra* note 98, at Annex B.

criteria are met.[219] First, the DDT must be used exclusively for disease vector control, such as mosquitoes.[220] Second, all World Health Organization guidelines for DDT use must be followed.[221] Third, DDT may only be used where it is locally safe and effective.[222] Fourth, there must not be any other affordable alternatives available.[223] If any of these criteria are not met, DDT production and use must be eliminated in party countries.[224] The Convention asks that capable parties promote research and development into safe alternatives to DDT.[225]

Annex C addresses unintentionally produced POPs, including dioxins, furans, unintentional PCBs, and unintentional HCBs.[226] These chemicals are produced as byproducts during combustion and during some chemical processes.[227] Unintentionally produced POPs also arise from waste incinerators, cement kilns firing hazardous waste, production of wood pulp that uses chlorine bleach, and certain metallurgical thermal processes.[228] Dioxins and furans have no commercial use and are the most potent carcinogenic chemicals known.[229] Parties are required to develop and implement plans to minimize and eliminate these chemicals where feasible and also promote the use of best available techniques and environmental practices.[230]

Additionally, parties must prohibit importation and exportation of intentionally produced POPs (Annex A's pesticides and industrial chemicals, and Annex B's DDT).[231] However, an exception allows the shipment of these pesticides through party countries for environmentally proper disposal in accordance with Convention provisions.[232] If any potential party seeks an exemption[233] to these rules at the time of becoming a party, the

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219. *Id.* at Annex B, pt. I.
220. *Id.* at Annex B, pt. II.
221. *Id.*
222. *Id.*
223. *Id.*
224. *Id.*
225. *Id.* at Annex B, pt. II, ¶ 5(b).
226. *Id.* at Annex C.
227. *Id.* at Annex C, pt. II.
228. *Id.*
229. UNITED NATIONS ENV'T PROGRAMME, *supra* note 1, at 12.
230. Stockholm Convention, *supra* note 98, at art. 5 (d)–(e).
231. *Id.* at art. 3, ¶¶ 1(a)(ii), 2–3.
232. *Id.* at art. 6.
233. The Secretariat maintains the Convention's register of specific exemptions. *See Register of Specific Exemptions*, UNITED NATIONS ENV'T PROGRAMME, http://www.pops.int/documents/registers/specexempt.htm (last visited Dec. 8, 2011).

Convention will grant an exemption that expires in five years or less.[234] Finally, the Convention requires that within two years of ratification, parties develop national plans for implementing the requirements.[235]

For its second goal, the Convention provides mechanisms to channel resources and help parties find viable, safe alternatives.[236] With those considerations, the Convention seeks to balance environmental and human health concerns against other regional concerns that are more pressing to the local population.[237] For example, DDT is a hazardous pesticide that permeates the soil, bioaccumulates in animals, and causes human illness and cancer.[238] However, it is highly effective at warding off malaria-carrying mosquitoes.[239] In regions highly susceptible to malaria, the positive benefit of fighting the prevalence of malaria are thought to outweigh the risk of environmental harm or other health hazards that take longer to manifest.[240] The Convention seeks to balance these concerns by spurring the development of alternatives while allowing DDT to be used for malaria vector control where the appropriate criteria are met.[241] Every three years, if not more frequently, the need for DDT to control malaria will be reevaluated.[242] Ideally, this international scrutiny will improve the efficiency and safety of DDT use.

As national and regional concerns grew, even before the treaty was considered, many countries recognized the health hazards posed by various POPs and took the initiative to ban or limit them.[243] Those countries developed alternatives to the POPs that they were concerned about years or even decades ago.[244] As a result, some of the Dirty Dozen were nearly eliminated even before the Convention.[245] However, there are still abandoned stockpiles of the banned POPs and equipment containing them.[246] Even countries that proactively limited their use decades before the

234. Stockholm Convention, *supra* note 98, at art. 4, ¶¶ 3–4.
235. UNITED NATIONS ENV'T PROGRAMME, *supra* note 1, at 7.
236. *Id.* at 8.
237. *Id.*
238. *Id.* at 9, 12.
239. *Id.* at 8.
240. *Id.*
241. Stockholm Convention, *supra* note 98, at Annex B, pt. I.
242. *Id.* at Annex B, pt. II, ¶ 4.
243. UNITED NATIONS ENV'T PROGRAMME, *supra* note 1, at 8.
244. *Id.*
245. *Id.*
246. *Id.*

Convention still have the problem of dangerous, leaking stockpiles.[247] The cleanup process will take time, money, and expertise, resources that many of the party nations do not have.[248] In countries that did not proactively restrict POPs before the Convention, stockpiles not only still exist but are still being used.[249] These nations' efforts to dispose of the stocks and transition to safer alternatives will need to be subsidized as they cannot afford these measures themselves.[250]

The Convention also calls for the phasing out and eventual elimination of PCBs, which will require more developed technologies and more financing.[251] PCB-containing equipment is widespread, especially along electric power grids where PCBs are a key element in transformers and capacitators.[252] Because requiring the immediate replacement of this equipment is impractical and expensive, the Convention gives parties until 2025 to phase out the old technology and replace it with safer alternatives.[253] However, the old equipment must be maintained to prevent contamination while still in use and throughout the replacement and disposal processes, which must be complete by 2028.[254] Transportation, containment, and disposal of PCBs require specialized technologies that current facilities cannot support.[255] With these current limitations, the Convention sets the challenging requirement that within two years of entering into force, each party develop action plans that promote the best available technologies and best environmental practices.[256] The Convention hopes to "reconcile eventual elimination with immediate human needs. By signaling to governments and industry that certain chemicals have no future and at the same time respecting their legitimate short-term concerns, the Convention will stimulate the discovery of new, cheap and effective alternatives to the world's most dangerous POPs."[257]

The third goal of the Convention is to allow additional chemicals, whose dangers warrant the Convention's attention, to

247. *Id.* at 13.
248. *Id.* at 9.
249. *Id.*
250. *Id.*
251. *Id.*
252. *Id.*
253. Stockholm Convention, *supra* note 98, at Annex A, pt. II, ¶ (a).
254. *Id.* at Annex A, pt. II, ¶ (e).
255. UNITED NATIONS ENV'T PROGRAMME, *supra* note 1, at 9.
256. *Id.*
257. *Id.* at 12.

be officially listed as POPs.[258] Scientific uncertainty plagues environmental law, including the efforts to curb and eliminate POPs.[259] To avoid waiting for conclusive evidence linking unlisted POPs to environmental harms and health hazards, the Convention calls for precautionary action against those POPs with the potential to be listed.[260] This precautionary approach prevents scientific uncertainty from blocking the appropriate measures needed to protect global and environmental health.[261] The Convention establishes a Review Committee[262] and a strict evaluation process by which it considers listing additional POPs.[263] Any government that has consented to be bound by the Convention can nominate a particular chemical of concern.[264] If the Committee determines that the chemical is appropriate to be listed in the Convention and the parties agree to its listing, then an amendment to the Convention is drafted and left to the parties for ratification.[265]

The fourth goal of the Convention is to clean up stockpiles and old equipment that contain POPs by channeling resources among parties.[266] Although little can be done to remove the trace amounts of POPs that are pervasive throughout the world, identifiable stockpiles, waste sites, and related equipment can be managed and cleaned up in an environmentally responsible manner.[267] Because this task requires expertise, advanced technologies, and capital to prevent further contamination, the Convention requires parties to develop identification strategies and then handle stockpiles safely.[268] This includes the collection, storage, and transportation of wastes containing POPs.[269] Accordingly, "recovery, recycling, reclamation, direct reuse or alternative uses of POPs" are prohibited.[270] Additionally, the Convention pools parties' resources to aid developing countries in their efforts to meet these requirements.[271]

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258. *Id.* at 11.
259. *Id.* at 12.
260. *Id.*
261. *Id.*
262. Stockholm Convention, *supra* note 98, at art. 8., ¶ 2.
263. *Id.* at art. 8.
264. *Id.* at arts. 6, 15.
265. UNITED NATIONS ENV'T PROGRAMME, *supra* note 1, at 12.
266. *Id.* at 13.
267. *Id.*
268. *Id.* at 14.
269. *Id.*
270. *Id.*
271. *Id.*

The Convention's fifth goal is to continue the global effort to achieve a POP-free future.[272] POPs provide a perfect model for the tragedy of the commons: their volatility and mobility create global contamination that no single country can combat alone.[273] No country has the incentive to reduce contamination if others do not do the same.[274] However, the environmental health of the world depends on international consensus and efforts to stop the use and proliferation of POPs.[275]

In the decades since the international community began to understand the dangers of POPs, governments have yet to determine the full extent of devastation caused by POPs.[276] As nations better understand the problem, they are more willing to work together as it has become clear that the only viable solution requires maximum participation.[277] To that end, UNEP lists voluntary projects that over a hundred nations have initiated in order to add to the concerted efforts.[278] The Convention provides for information sharing and the development of action plans to "increase public awareness of the dangers of POPs, provide up-to-date information on these pollutants, launch educational programs, train specialists, and develop and disseminate alternative chemicals and solutions."[279] Parties are required to regularly report on the effectiveness of implemented efforts and to further research POPs and their effects.[280]

In 2009, the fourth meeting of the Conference of the Parties (COP4) decided to add nine new POPs to the Convention's Annexes.[281] COP4 amended Annex A to call for the elimination of four new POPs (α-hexachlorocyclohexane, β-hexachlorocyclohexane,[282] chlordecone,[283] and hexabromobiphenyl[284]) without any

272. *Id.* at 15.

273. *See id.* (explaining how collaboration and consensus are essential so that governments have an incentive to work together to resolve the problem rather than relying on others to make sacrifices).

274. *Id.*

275. *Id.*

276. *See* UNITED NATIONS ENV'T PROGRAMME, *supra* note 1, at 12.

277. *Id.* at 15.

278. *Id.* at 16, n.5.

279. *Id.*

280. *Id.*

281. Press Release, Stockholm Convention Secretariat Office, Amendments to Global Treaty Launched To Eliminate Nine Toxic Chemicals (Aug. 26, 2010), *available at* http://chm.pops.int/Convention/Media/Pressreleases/Amendmentsentry intoforceGeneva26August2010/tabid/809/language/en-US/Default.aspx.

282. Conference of the Parties of the Stockholm Convention on Persistent Organic Pollutants: Fourth Meeting, Geneva, May 4–8, 2009, *Report of the Conference of the Parties of the Stockholm Convention on Persistent Organic*

exemptions allowed. Exceptions will be granted for certain environmentally sound uses of hexabromodiphenyl ether,[285] heptabromodiphenyl ether,[286] tetrabromodiphenyl ether,[287] pentabromodiphenyl ether,[288] and lindane,[289] but otherwise such chemicals must be eliminated. Pentachlorobenzene was added to Annexes A and C, calling for complete elimination of intentional and unintentional production.[290] Finally, the COP4 calls for the restriction of perfluorooctanesulfonic acid[291] (PFOS) and perfluorooctanesulfonyl fluoride[292] (PFOSF) to Annex B, with explicit exceptions.[293]

VII. Recommendations

An effective, global, long-term POP response can occur with adequate legal and financial support, combined with coordination among entities addressing Arctic monitoring and a worldwide transition to best practices. Diffusion of the best available practices requires sharing information, raising awareness, and building capacity to realize the benefits from climate mitigation and the reduction of POPs.

Arctic governance can inform effective, equitable, and reasonable decision making.[294] Forums bring together stakeholders and enhance Arctic good governance by sharing information and making sensible decisions regarding sustainable development.[295] Despite the distinct geopolitical sensitivity in the Arctic, heightening cooperation among all levels and sectors will

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Pollutants on the Work of its Fourth Meeting, U.N. Doc. UNEP/POPS/COP.4/38, at 63 (May 8, 2009).

283. *Id.* at 64.

284. *Id.*

285. *Id.*

286. *Id.*

287. *Id.* at 69.

288. *Id.*

289. *Id.* at 65–66.

290. *Id.* at 66.

291. *Id.* at 67.

292. *Id.*

293. *Id.* at 68.

294. *See* Elizabeth Burleson & Diana Pei Wu, *Collaborative Community-Based Natural Resource Management*, 21 FORDHAM ENVTL. L. REV. 193, 201 (2010); Elizabeth Burleson, *Equitable and Reasonable Use of Water in the Euphrates-Tigris River Basin*, 35 ENVTL. L. REP. NEWS & ANALYSIS 10041, 10049 (2005) (describing the role of local governments in coming to a consensus on water use).

295. Elizabeth Burleson, *The Polar Regions and Environmental Law*, *in* ROUTLEDGE HANDBOOK OF INTERNATIONAL ENVIRONMENTAL LAW (Alam et al. eds., 2012) (forthcoming 2012).

strengthen good governance.[296] Additionally, further cooperation through scientific and sustainable development coordination can help avert environmental collective action problems.[297] The POP collective action problem can be addressed by building upon UNEP's voluntary projects and following its precautionary approach to achieving a robust legal regime that fosters the development and diffusion of best available practices.[298] Greater efforts and funding should support coordinating responses among new POP multilateral developments and the more established environmental regimes.[299]

The international community's commitment to finding a shared vision to address climate destabilization provides an opportunity to implement sustainable development based on transfer of environmentally sound technologies and resilience strategies.[300] This can be done within the existing United Nations Framework Convention on Climate Change (UNFCCC), but with a differentiated responsibilities framework.[301] These commitments should be fleshed out in a participatory, transparent, and accountable manner. The UNFCCC highlights both the precautionary principle and intergenerational equity—two key norms that can combine to further human rights protections.[302] Decisions informed by an understanding of climate justice can bring together dialogue from development, human rights, environment, trade, and business communities.[303] Energy, food, and climate security can all be discussed as a single interwoven crisis that threatens humanity, rather than as unrelated dilemmas. Indigenous and other frontline communities are struggling to keep pollution generally, and climate change in particular, from impacting their human rights.[304] Inclusive decisionmaking can empower these

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296. *Id.*

297. *Id.*

298. *See* UNITED NATIONS ENV'T PROGRAMME, *supra* note 1.

299. *Id.*

300. *See, e.g.*, United Nations Framework Convention on Climate Change art. 4, May 9, 1992, 1771 U.N.T.S. 107 (entered into force Mar. 21, 1994) [hereinafter UNFCCC], *available at* http://unfccc.int/resource/docs/convkp/conveng.pdf ("All parties, taking into account their common but differentiated responsibility . . . shall . . . [p]romote and cooperate in the development, application and diffusion, including transfer, of technolgies, practices and process . . . .").

301. *Id.*; *see also* U.N. Rep. of the Human Rights Council, 10th session, at 5 U.N. Doc. A/HRC/10/61 (Jan. 15, 2001), *available at* http://www2.ohchr.org/english/bodies/hrcouncil/10session/reports.htm ("Giving operational meaning to the 'equity principle' is a key challenge in ongoing climate change negotiations.").

302. UNFCCC, *supra* note 300.

303. Burleson, *supra* note 295, at 18.

304. *See* Guynup, *supra* note 73.

communities.[305] Global collaboration can achieve sustainable development of pathways encompassing climate mitigation and adaptation.

Beyond the Arctic, improved communication should be fostered regarding all aspects of the fight against POPs. Education about the dangers and consequences of POP use will not only heighten awareness, but will also bring more creative ideas to the discussion. The scientists, governments, policy makers, technicians, and developers who are already involved must improve communications. The appropriate research must be connected to the best policy.

As Arctic development pressures mount, stakeholders seek stronger environmental governance to augment existing international environmental law, multilateral environmental agreements, and domestic measures.[306] Enhancing multilateral agreements and increasing the Arctic Council's authority and funding would tighten the Arctic governance regime to meet the burgeoning environment and development challenges. A good starting point would be to form public-private initiatives to minimize negative impacts to the Arctic by implementing environmentally sound technology transfers. To that end, there are valuable, untapped resources within the private sector of the Unites States, a conspicuous nonparty to the Stockholm Convention.[307] Leaving the political reasons for the United States' noninvolvement aside, an incentive program should be developed through which private citizens, corporations, or research teams in the United States and other highly developed countries can profit

305. Burleson, *supra* note 295, at 5.

306. POLAR LAW TEXTBOOK 120 (Natalia Loukacheva ed., 2010).

> In the case of the oil and gas industry the risks include the noise effects of seismic and drilling operations on marine mammals; disposal of drilling and other oilfield waste; the risk of blowouts and subsequent hydrocarbon contamination; hydro-carbon contamination from leaks and seeps during production and from pipelines and associated facilities; disposal of produced water; gas emissions during production and as part of processing; and habitat fragmentation as a result of seismic lines and access roads. In the case of the mining industry the environmental risks include those arising from acid mine drainage (where background rocks contain sulphides); tailings ponds and their potential breach; sedimentation as a result of milling and other disturbance activities; chemicals used in mineral processing activities such as cyanide used in leaching; groundwater effects as a result of contamination or pumping to lower groundwater levels; fugitive dust emissions from mining activities; and reclamation activities. Uranium mining poses distinctive challenges because of the risks of radioactive contamination.

Id.

307. *See* Stockholm Convention, *supra* note 98, at 120–21.

from developing useful and viable technological alternatives. The incentives should benefit the many party nations that do not have the finances, infrastructure, or human resources to follow the Convention's demands for such new technologies.

Best practices must include technology transfers of environmentally sound POP-reduction and -elimination measures. Technology transfer requires enhanced awareness raising and capacity building to broaden technical responsiveness, legal assistance, and financial support. The new technology mechanism under the UNFCCC[308] should lead this technology transfer, starting with efficiency improvements that lower fuel consumption per unit of power generated. An international database housing green technologies and best practices enhances implementation of technology transfer and such enabling activities as technical training, capacity building, and research and development cooperation.[309] The technology mechanism should facilitate cooperation by sharing best practices and best available technologies, both current and emerging.[310] It should also facilitate environmentally sound technology transfer to all relevant sectors.[311] International cooperation should facilitate transitioning to cleaner processes and materials for industrial and agricultural uses. Cooperation should also sustain ongoing monitoring and research on emissions and effects because just as DDT was once believed to be innocuous to humans,[312] new emissions may present unforeseen health and environmental consequences.

The Technology Executive Committee of the UNFCCC should recommend actions to address barriers to technology transfer and catalyze development of technology action plans. The technology

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308. *See* UNFCCC, *supra* note 300, at 166, 170.

> The developed country Parties and other developed Parties included in Annex II shall take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties, to enable them to implement the provisions of the Convention. In this process, the developed country Parties shall support the development and enhancement of endogenous capacities and technologies of developing country Parties. Other Parties and organizations in a position to do so may also assist in facilitating the transfer of such technologies.

Id.

309. *See id.* at art. 5.

310. *Id.*

311. *Id.*

312. *See, e.g.*, DDT DELOUSING PICTURES (TYPHUS), http://www.whale.to/b/typhus_pic.html; DDT SPRAYING PICTURES, http://www.whale.to/vaccines/ddt_spraying.html (demonstrating widespread use of DDT during the 1940s).

mechanism should help shape policy and program priorities by providing a focal point for collaboration among governments, NGOs, and academic and research communities. Technology transfer can be combined with capacity building support via communication, outreach, training, and stakeholder participation.

Some improvements do not require complicated technological research and development. For instance, leaded gasoline should be phased out globally. This does not require new innovations to be discovered. Nevertheless, the best available technologies should be an upwardly moving target. Breakthrough technologies should be fostered while existing best available technologies continue to be diffused broadly.

Coordinated decisionmaking on POPs and climate change can increase the likelihood of effectively responding to ecosystem integrity in the face of the dual stressors they present. Climate change can increase individual and ecosystem vulnerability to POPs. UNEP explains:

> Mitigation actions to reduce GHG emissions and short-lived climate forcers (e.g., black carbon or soot) are expected in most cases to result in simultaneous reductions in emissions of unintentionally formed POPs and other contaminants of concern. These reductions may be expected for emissions from major anthropogenic sources of CO2, including stationary combustion of fuels, incineration of wastes, and transportation. In some cases, however, where there is an increase in the use of biomass as fuel for heating and cooking, unintentional POPs emissions may increase.
>
> Technological and non-technological options for climate change mitigation can be considered when discussing co-benefits for reductions of unintentional POPs. Major technological options include switching fuels, improving combustion efficiency, improving heat recovery and better recycling, and changing combustion technologies. Non-technological measures contributing to co-benefits include measures such as introduction and enforcement of regulations.[313]

Coordinated public-private initiatives should diffuse environmentally optimal technologies and practices across power production, transportation, incineration, paper production, and other sectors contributing to POPs production and climate change.

Progress to reduce POPs under the Stockholm Convention will likely be undermined by climate change as communities

313. UNEP/AMAP EXPERT GRP., CLIMATE CHANGE AND POPS: PREDICTING THE IMPACTS 48, ¶ 7.7 (2011), *available at* http://chm.pops.int/Implementation/GlobalMonitoringPlan/ClimateChangeandPOPsPredictingtheImpacts/tabid/1580/Default.aspx.

respond to higher temperatures by using the insecticide DDT.[314] Higher temperatures and increased precipitation may also facilitate the transport of POPs to the Arctic. Efficiency measures, combined with optimizing high combustion temperatures, ensure complete combustion, which can minimize the formation of POPs and maximize energy recovery.

Within the Arctic Council, the Arctic Monitoring and Assessment Programme has been engaged in integrated POPs and climate research that coordinates circumpolar assessment. The Arctic Council, Intergovernmental Panel on Climate Change, and IPEN could enhance efforts to understand and implement the co-benefits of responding to POPs and climate change in an integrated manner. IPEN is composed of seven hundred public interest NGOs in one hundred countries that support a common platform for the global elimination of POPs.[315] IPEN has gathered analytical data in developing and emerging economies and has helped build capacity for environmentally sound management of chemicals.[316] Gap-filling studies are already under way and would benefit from intensified coordination of government, international institutions, and civil society collaboration.[317]

Enhanced collaborative learning and best climate practices require stakeholders to cooperate in developing and implementing co-benefits strategies at all scales of government and civil society. Countries should enhance inclusive gatherings and networks with civil society to fully implement the Stockholm Convention—minimizing the release of both legacy POPs and new POPs through robust and up-to-date national implementation plans. Global cooperation should expand to find replacement technologies and chemicals that are not POPs. This ongoing process should identify and integrate the ways in which responding to climate change impacts the management of POPs.

Conclusion

Chemical pollution plagues the entire globe, most acutely in the Arctic.[318] The Arctic deserves special attention due to its

314. Transitioning from DDT to less persistent yet effective methods such as pyrethroids and nonchemical pest management can enhance public health. *See supra* note 241 and accompanying text.

315. IPEN, IPEN: WORKING TOGETHER FOR A TOXICS FREE FUTURE: 2009 IPEN ANNUAL REPORT 2 (2009), *available at* ipen.org/ipenweb/documents/ipen%10documents/2009%20IPEN%20Annual%20Report%20final.pdf.

316. *See id.* at 7.

317. *See id.*

318. *See supra* Part II.

extreme susceptibility and high capacity for POP storage. This region's unique characteristics create the perfect storm for a serious contamination disaster.[319] POPs accumulate in cold climates and fat.[320] Animals require thicker layers of fat for natural insulation.[321] Indigenous diets are heavy in fatty foods, to which there are few or no alternatives.[322] Once POPs enter the Arctic, they are readily incorporated and retained in biological systems.[323]

Aside from contamination, an ethical dilemma must be carefully considered before industry charges into the frozen north. The manifest destiny or colonization mentality has spelled doom for natives throughout history—from conquistador-borne diseases bringing the fall of the Aztecs, to the extermination campaign of Pygmies by other African nationalities,[324] to the forced displacement of North American natives from across the continent into reservations. But even a "lesser intrusion" on the human rights of the Arctic indigenous should not be allowed. Even if the Arctic Indigenous welcome development, developed nations must approach Arctic expansion with restraint. Arctic industrial development would not only harm the environment, it would further separate the indigenous people from their rich cultural, nutritional, and spiritual history. Even without the conquistador-like invasion, developed nations have already sickened Arctic peoples. Even without a campaign against Arctic natives, oil operations and other developments have already brought higher crime[325] and alcoholism.[326] And even without forcing indigenous peoples off their land, development has already imposed managerial schemes that interfere with the native way of life.[327]

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319. *See supra* Part II.

320. *See supra* Part II.

321. *See supra* Part III.

322. *See supra* Part IV.

323. *See supra* Part II.

324. *See* Nicholas D. Kristof, *As the World Intrudes, Pygmies Feel Endangered*, N.Y. TIMES, June 16, 1997.

325. Terry Lynn Karl, *Oil-Led Development: Social, Political, and Economic Consequences*, *in* 4 ENCYCLOPEDIA OF ENERGY 669 (2004).

326. *See* Press Release, Nat'l Acad. of Sci., Effects of Oil and Gas Development Are Accumulating on Northern Alaska's Environment and Native Cultures (March 5, 2003), *available at* http://www8.nationalacademies.org/onpinews/newsitem.aspx?recordid=10639.

327. *See* THE ENERGY & BIODIVERSITY INITIATIVE, NEGATIVE SECONDARY IMPACTS FROM OIL AND GAS DEVELOPMENT (2003), *available at* http://www.theebi.org/pdfs/impacts.pdf; Rune S. Fjellheim & John B. Henriksen, *Oil and Gas Exploitation on Arctic Indigenous Peoples' Territories: Human Rights,*

Chemical pollutants such as POPs pose an immediate and global threat to all populations and ecosystems, but none more than those of the Arctic. Marine mammal research provides valuable observations into the devastating consequences of high POP exposure. Enhanced understanding of the diseases and abnormalities suffered by marine mammals will augment our ability to protect ourselves and our environment from future chemical contamination. However, communication among researchers, policymakers, and industry must improve to efficiently and effectively manage the dangers of POPs and other chemical pollutants. By improving communication regarding POPs, establishing incentives to develop technologies that capture POPs, and exercising caution in Arctic development, we can more adequately address and eliminate the chemical pollutants plaguing our world.

International Law and Corporate Social Responsibility, J. INDIGENOUS PEOPLES RTS., Apr. 2006, *available at* http://www.galdu.org/govat/doc/oilengelsk2.pdf.