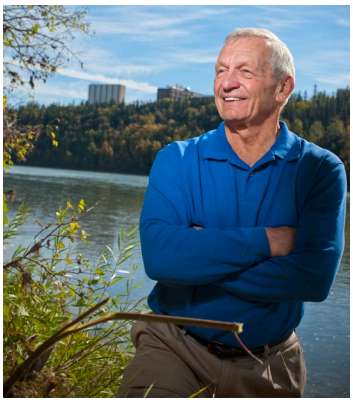
A Tribute to the Career of Dr. David William Schindler (1940-2021)

Written by Dr. Vincent St. Louis and Colleagues



It is with great sadness that the Department of Biological Sciences and Faculty of Science at the University of Alberta mourns the loss of Dr. David William Schindler, a world-renowned and universally respected scientist whose landmark research and unrelenting public and political advocacy led to better protection of freshwater ecosystems and their watersheds around the world. He had an uncanny ability to target solutions to key environmental crises, and was tireless in his education of the public and decision makers on these issues. Dr. Schindler will be eternally remembered for mentoring the new generation of Canadian aquatic scientists while tackling a diversity of emerging environmental issues, as described below.

A bit of background

Dr. Schindler began his undergraduate education in engineering physics at North Dakota State University, but after being hired for a summer research job in aquatic science, he transferred to a new study focus. He pursued his Ph.D. as a Rhodes Scholar at Oxford University from 1962-1966. He began his academic career as an assistant professor at Trent University, but in 1968 jumped at the opportunity to become the first scientific director of the Experimental Lake Area (ELA), a Department of Fisheries and Oceans Canada field station. He assembled a world-class science team and together they performed unique, whole-ecosystem experimentations that had far-reaching effects on science and policy. Located in remote NW Ontario, far from any human settlements or industrial development, 46 lakes and their boreal watersheds were set aside under the ELA for Dr. Schindler and his colleagues and students to examine how all aspects of the ecosystem—from the atmosphere to fish populations—responded to anthropogenic disturbance. These unique real-world experiments have significantly influenced governments and industries around the world, and inspired more effective environmental policies, regulations and management for protecting the health and integrity of global freshwater ecosystems. In 1989, he left his position at the Department of Fisheries Oceans to become the Killam Memorial Professor of Ecology at the University of Alberta, a position from which he further expanded his research on understanding perturbations of natural systems by human activities. Despite retirement from the University of Alberta in 2013, Dr. Schindler remained active in scientific research and advocacy until the very end.

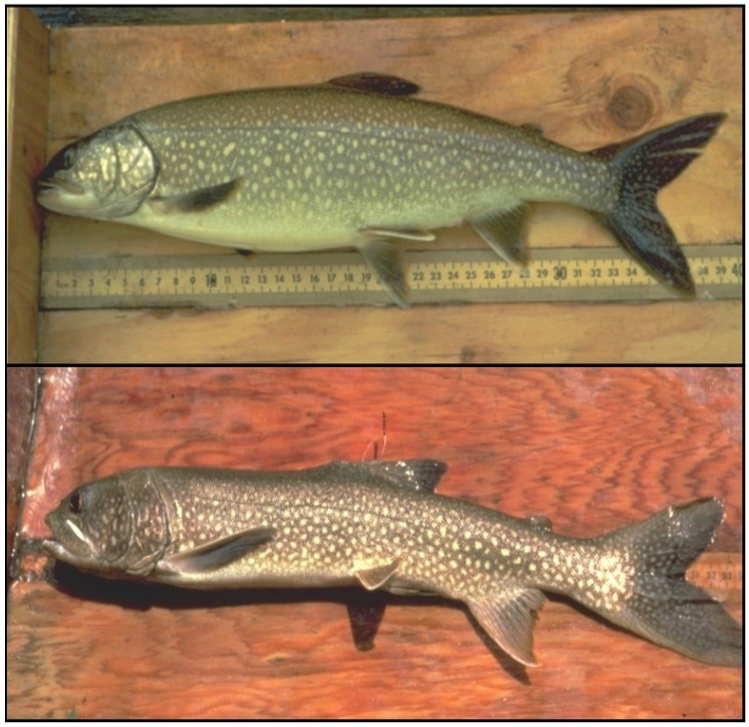
Groundbreaking, high quality, impactful science on broad issues

It is fair to assume that anyone working in the environmental sciences has heard of Dr. Schindler. Through decades of transformative experimentation on entire lake ecosystems at the ELA, Dr. Schindler generated fundamentally important knowledge of how these systems work and how human disturbance results in the impairment and loss of biodiversity and ecosystem function. Insights from his work on stressor effects on lakes and their subsequent recovery have provided guidance for effective avoidance and mitigation of environmental harm. His linkage of objective science with identifiable management options has been the basis for sound environmental policy decisions and actions around the world. His expertise, boundless energy, and experience have supported the work of numerous expert committees and task forces in Canada, the U.S. and Europe, ranging from endangered species to the oversight and regulation of the oil industry. Dr. Schindler

has also been a leader in publicly documenting and communicating the impacts of global climate change on aquatic ecosystems and their resources.

Over the past ~55 years, Dr. Schindler has investigated many aquatic problems related to physical, chemical and biological changes, and has had exceptional productivity and impact, as evidenced by his ~ 350 publications (> 30 in the most prestigious of scientific journals, such as *Nature, Science* and *Proceedings of the National Academy of Sciences*). He is legendary for his high standards in science and demands for accuracy in how data are created, interpreted, published, presented and used. In particular, his science has had the greatest international or national impact in 4 key areas: ***eutrophication*** (the overfertilization of lakes with nutrients, usually from sewage and agricultural runoff); the impacts on lakes of ***acid rain*** that results from emissions to the atmosphere of oxides of sulfur and nitrogen; ***climate change*** stresses on freshwater resources; and the downstream and watershed ***effects of oil sands development***.

Dr. Schindler's work has shown clearly that the eutrophication of freshwater can be reversed or prevented by controlling inputs of a single element, phosphorus. His work, using a number of small lakes at the ELA as natural experimental vessels, has inspired countries throughout the world to develop policies to control phosphorus inputs to lakes. He generated the single-most powerful image in the history of limnology with the photo of Lake 226 showing that phosphorous added to one half of the lake caused algal blooms (*Science*, 184: 897-899). This image has been reproduced hundreds of times in ecology and limnology textbooks around the world, and resolved a highly controversial debate over the nutrients responsible for algal blooms. This image, the very strong supporting science, and many hours in government offices and congressional hearings persuaded policy-makers in numerous countries to remove phosphates from detergents and improve sewage treatment. As a result of Dr. Schindler's research at the ELA, new detergents were formulated and new technologies were quickly developed to remove phosphates from wastewater effluents, which had a profound impact on water quality throughout the world. As a result of this research, hundreds of lakes have recovered from eutrophication, and the problem has been prevented in many more. His 2008 book on eutrophication with J.R. Vallentyne, *"The Algal Bowl: Overfertilization of the World's Freshwaters and Estuaries"*, was deliberately written in jargon-free language understandable to non-scientific readers, in hopes that private citizens will continue to act to prevent water pollution with nutrients.



Dr. Schindler quickly transitioned from working on eutrophication at the ELA to investigating the effects of acid rain on lakes, and was the first to show that atmospheric inputs of sulfuric and nitric acids caused losses of biodiversity, fisheries, and ecosystem function. Experimental acidification of Lake 223 at the ELA showed that damage to algal and invertebrate communities and biogeochemical cycles began much earlier than had been previously believed (*Science*, 228: 1395-1401). This was the first demonstration that acidification's disruption of the aquatic foodweb has severe, indirect effects on fish, long before fisheries would otherwise collapse from direct toxicity. Lake trout, previously thought to be physiologically resistant to the direct toxic effects of acidification, were essentially starved by the changes taking place in the underlying food web. Dr. Schindler and his colleagues also showed that once inputs of acid to lakes ceased, microbial processes such as sulfate reduction and denitrification would assist lakes in recovering chemically, whereas previously it had been thought that they would remain acidic over the long term. However, they also demonstrated that biological recovery requires much longer, with the possibility of permanent impairment. Similar to his study of eutrophication, he was tireless in his communication of this research to decision-makers and the public alike and, as a result, in 1990 changes were introduced to the Clean Air Act to reduce emissions from smokestacks and acid rain, followed quickly by the Acid Rain Treaty between Canada and the USA in 1991. He deeply believed that the legislation at that time was not protective enough and did everything in his power, including facing considerable political, industrial, and public opposition, to ensure that effective legislation was implemented.

With amazingly unprecedented foresight, upon creation of the ELA Dr. Schindler initiated collection of what would become the world's greatest dataset on the impacts of climate change on lakes and their watersheds. In 1968, he began monitoring unperturbed lakes and their watersheds at the ELA as reference systems to those that were being experimentally manipulated, most of which are still being closely monitored today through the IISD-ELA organization that now manages the ELA. Since the ELA began operation, air temperature increased ~0.5ºC/decade, the ice-free season increased ~4 days/decade, and the amount of annual precipitation deposited as snow has decreased while that deposited as rain has increased. The impacts of these climate changes on water quality, biological productivity and watershed runoff have all been recorded in the reference systems during this period, and Dr. Schindler initially published some of these findings in *Science*, 250: 967-970. There, he showed that higher evaporation and lower precipitation decreased rates of water renewal in lakes. As a consequence of decreased water renewal and increased intensity and frequency of forest fires in their watersheds, concentrations of most chemicals increased in both lakes and streams. He also showed that increased wind velocities, increased transparency, and increased

exposure of lakes to wind in burned catchments caused thermoclines to deepen, resulting in decreases in summer habitats and refugia for cold-loving organisms like lake trout. Since then, Dr. Schindler used meta-data to publish numerous predictive models for the impacts of climate change on freshwater resources, while also doing numerous smaller-scale experiments on climate warming impacts in lakes. He also co-authored a seminal paper highlighting the interactive and cumulative effects of climate warming, droughts and mismanagement of water (including water removal for oil sands extraction processes) on river systems that have seen major declines in water flow over much of the 20th century (*Proc. Natl. Acad. Sci. USA* 103: 7210-7216).

His most recent studies have shown that the mining of oil sands in northern Alberta is releasing organic (*Proc. Natl. Acad. Sci. U.S.A. 106: 22346-22351*) and metal contaminants (*Proc. Natl. Acad. Sci. U.S.A. 107: 16178-16183*) to the Athabasca River and the watersheds of its tributaries, ecosystems that are important to the subsistence and existence of Indigenous people downstream of the development. Initially this work generated considerable controversy and was denounced by the economic entities (including the Government of Alberta) that benefited from this development. However, reviews of the work by two eminent scientific panels upheld Dr. Schindler's and his colleagues' conclusions and assertions that existing industry-led monitoring programs needed replacement. As a result of Dr. Schindler's studies, both the federal and provincial oil sands monitoring programs were redesigned to legitimately assess the impact of the oil sands industry on these river systems and the downstream Peace-Athabasca Delta. Dr. Schindler's summary of oil sands water quality monitoring in the 25 November 2010 issue of *Nature* prompted an editorial in *Nature* praising his courageous opposition to political propaganda that had been based on bad science: "Where such issues (pollution of water by the oil sands industry) justify pressure for action, it is crucial that scientists such as David Schindler highlight them." The story of the influence of Dr. Schindler's study and the potential impacts of oil sands development on Indigenous health was the subject of a two-hour documentary *"Tipping Point,"* on the Canadian Broadcasting Corporation's science program, The Nature of Things.

Although Dr. Schindler has made many other contributions to freshwater and environmental sciences, on topics such as the effects of radioactive materials fallout, persistent organic pollutants, ultraviolet radiation, and invasive species, the four areas just mentioned are where his contributions have been greatest. While many have studied these issues, Dr. Schindler's successes at effecting policy changes can be attributed to his superior ability to identify the emerging issues and jump to fill critical scientific gaps, and his skill in communicating science in simple terms and in language that non-experts can understand and appreciate. His dogged determination to educate the public and legislators alike is evident from his many, many hours spent communicating and working with media, Indigenous organizations, and resource managers. Without a doubt, he demonstrated over and over again his willingness and ability to be a voice driving significant real-world change, even in the face of political or public controversy.

Dr. Schindler was both a pioneer and leader, and his many awards and appointments for both science and public communication highlight how influential he was in Canada and internationally. As examples, he was a Fellow of the Royal Society of Canada, a Distinguished Member of the International Water Academy, a Fellow of the Royal Society (UK), and a Member of the U.S. National Academy of Sciences. Scientific society recognition includes the first Frank Rigler Award from the Canadian Society of Limnologists, the Outstanding Achievement Award of the American

Institute of Fisheries Research Biologists, and the G.E. Hutchinson Medal, Ruth Patrick Award, and A.C. Redfield Lifetime Achievement Award from the Association for the Sciences of Limnology and Oceanography. He was recognized with Canada's highest honor in Science and Engineering, the Gerhard Herzberg Gold Medal, and was appointed an officer in the Order of Canada, the country's highest civilian honor. In addition, Dr. Schindler received the Manning Distinguished Achievement Award, the First Romanowski Medal from the Royal Society of Canada, a Lifetime Achievement Award from the Canadian Institute for Environmental Law and Policy, and the Canadian Nature Federation's Douglas Pimlott Award for Conservation. His international recognitions included being selected as the inaugural winner of the Stockholm Water Prize from the Royal Swedish Academy of Sciences (created by the Swedish government as the equivalent of a "Nobel Prize" in aquatic sciences), the Volvo Environment Prize, and most recently, the Rachel Carson Award from the Society for Environmental Toxicology and Chemistry.

A desire to help others understand aquatic stressors, and contributions to public education

In addition to his talents as a scientist, Dr. Schindler worked hard to educate policy-makers and the public about the necessity to protect freshwater ecosystems. He gave from 50 to 100 invited lectures a year, to academic and public audiences, as well as to policy-makers. About half of those presentations were to non-scientific audiences, and he aimed to write an equal number of scientific and popular articles each year. For example, in 1999 and 2000, he co-organized two *"Ecosummits"* in the Canadian Parliament building, one on air pollution and the other on water pollution. At the Ecosummits, Members of Parliament were briefed on air and water pollution by recognized experts, most of them Fellows of the Royal Society. Dr. Schindler was renowned for his ability to translate complicated science into plain language easily understood by all, and gave countless media interviews. As a result of these and his many other contributions to public education, he received the Royal Canadian Institute's Sandford Fleming Medal for public communication of science, an unusual achievement for a scientist. These achievements spoke to his high commitment to ensuring that aquatic science and its value were understood by non-experts, publicly communicated, and used for the protection of lakes, rivers and their watersheds.

In addition to his many contributions to public education, Dr. Schindler was also frequently invited to speak to the Canadian Senate and House of Commons committees on a wide variety of policy issues. He was also consulted by senior policy-makers in the U.S., U.K. and Europe, and a featured speaker in three Royal Colloquia sponsored by King Carl Gustav V of Sweden. In many years, he was the most quoted Canadian academic in the media in all disciplines, a measure of his public standing.

Dr. Schindler was an advocate for Indigenous Canadians because he understood and respected their spiritual attachment to aquatic ecosystems, their concerns when water was contaminated or lakes, rivers and wetlands were disturbed, and their reliance on these systems for gathering plants and animals as part of their traditional practices and subsistence. He chaired the Board of Directors of the Safe Drinking Water Foundation, a small not-for-profit foundation that specialized in providing educational material about water to school children and ensuring safe drinking water for Indigenous communities. He was the keynote speaker at the 2011 Treaty 8 gathering, where several hundred Indigenous people and over 50 Cree and Chipewyan Chiefs from across western Canada gather annually to celebrate the signing of the 1899 treaty. This is a rare honor for a non-Indigenous person. He was also invited to address an assembly of Treaty 8 Chiefs on the topic of water in October 2012.

He worked tirelessly and passionately to improve the lives of Indigenous peoples through the protection of their aquatic resources in Canada and throughout the world.

A lasting legacy through the people he trained, collaborated with and influenced

Since his passing, countless tributes have been posted on social media feeds such as Twitter. They all began with the same basic message: "*Dr. Schindler greatly influenced my career….”*

This is because Dr. Schindler demonstrated exceptional abilities as a mentor for young scientists. For his own students, he always provided the opportunity for them to develop their aptitude for original thought and fueled their desire to continue in science. He was an exceptional intellectual resource, taught students to collaborate and think broadly, introduced them to the critical value of objective and vigorous scientific critique, and was always enthusiastic about discussing science, results, or ideas with young scientists. As a result, many young scientists who passed through his lab had success in acquiring prestigious scholarships, fellowships and research chairs, and many have continued into their own research careers in Canada, the U.S., and elsewhere in the world, and now mentor their own students.

It was always an honour to collaborate with Dr. Schindler on research projects. He brought fresh perspectives and a breadth of knowledge and depth of understanding to all of the scientific endeavors to which he contributed, while always challenging his collaborators to be precise in the design and interpretation of their scientific work. And that intellectual transparency - his obvious commitment to ensuring his own science was as critically robust as the science of others that he was contributing to or reviewing - not only improved his and others' science, but also provided an exceptional example of a scientific ethos to follow. As a result, he contributed immensely to our understanding of the cumulative ecological impacts of multiple environmental stressors on ecosystems, perhaps reflecting his earlier education as a doctoral student under the supervision of one of the premier ecologists of the 20th century Dr. Charles Elton. In addition to his clear scientific strength, he also revealed a much lighter side to those lucky enough to get to know him and the sense of humour that he brought to almost everything.

Dr. Schindler set the highest of standards for all contemporary and future generations of aquatic scientists and ecologists, and for that the world owes him a debt of gratitude. Dr. Schindler was a giant and will be sorely missed. But his scientific and public legacy remains for us to build on and to be inspired by.