10 Sustainability Champions: "We'll Keep on Fighting …"

A major goal of sustainability research is to better understand how people can intervene to actively steer complex adaptive systems toward greater sustainability. This is a significant challenge in many human-technical-environmental systems. Efforts to intervene to effect change in support of human well-being, such as those being conducted for mercury under the Minamata Convention and in other forums, often build from prior experience, where it may be possible to draw lessons from the past. Lessons can provide both motivation and ideas for change, and can help people understand causal relationships among components that will affect critical interactions within complex systems. Lessons from this book can help mercury researchers, decision-makers, and thoughtful citizens in efforts to mitigate the harms caused by mercury pollution, and thus help societies make progress on sustainability challenges.

Future mercury stories remain largely untold. Interventions on mercury go back centuries, and most of these were carried out long before the Minamata Convention entered into force in 2017. Many of the early interventions in the mercury systems that we discussed in part II helped safeguard the environment and human well-being from mercury use and pollution; however, work to address the full range of the mercury problem is far from over. Many of the necessary on-the-ground efforts to meet the objective of the Minamata Convention have only just started. The Minamata Convention and other initiatives to address mercury-related problems are also implemented in a broader context of promoting sustainability globally. The United Nations Development Programme (UNDP), as we mentioned in chapter 3, highlights linkages between its efforts to support the Minamata Convention with the seven Sustainable Development Goals on poverty,

hunger, health and well-being, energy, work, consumption and production, and life below water (UNDP 2016).

The sustainability challenge centers on a human struggle to live and thrive across generations on a finite planet. Our analysis of the mercury systems illustrates the multifaceted nature of this endeavor. Important dynamics in the mercury systems occur in different places and at different times, but share common patterns across history. Mercury miners in Almadén, Idrija, Huancavelica, and elsewhere suffered greatly from mercury poisoning. Risks from using mercury in silver and gold mining connect colonial era miners in South America with present-day artisanal and small-scale gold mining (ASGM) miners. Arctic indigenous populations and other vulnerable communities look to the Minamata Convention to address mercury emissions from across the world. Several governments see opportunities through this global treaty to expand their regulatory authority on mercury, or look to global action as a vehicle for receiving financial and technical support.

When the Minamata Convention was adopted, as we mentioned in chapter 1, the music that played during the negotiations, Freddie Mercury and Queen's "Under Pressure," switched to another of the band's songs, "We Are the Champions." That song's lyrics highlight an important goal of research on systems relevant to sustainability: informing the actions of interveners—or champions—with the goal of promoting human well-being now and in the future. Efforts toward sustainability, however, occur within a large landscape of actors who have different interests and varying levels of power and access to resources. The mercury issue involves individuals who face different challenges, and who have different goals and priorities about how to balance competing demands and tradeoffs toward protecting and enhancing human well-being. Our analysis of the mercury systems underscores the slow and deliberate process of coming to consensus as a society about matters that influence people in different places, now and in the future.

The line from "We Are the Champions" that we have used in the title of this final chapter—"We'll keep on fighting …"—is an appropriate charge for current and future champions. In this chapter, we discuss lessons for readers who support the aim of the Minamata Convention of protecting human health and the environment from mercury. The first set of lessons is addressed toward researchers in the natural and social sciences and engineering who seek to understand the properties and behavior of mercury

and related societal issues. The second set of lessons speaks to decision-makers and others, including public officials, representatives of industry or non-governmental organizations, or expert advisers, who work to craft and implement mercury-related policies and actions. The third set of lessons is relevant to thoughtful citizens who are concerned about the widespread use and dispersal of mercury and its implications.

Lessons for Researchers

Researchers from many disciplines focus on better understanding the environmental behavior of mercury, its ecological and human health impacts, and efforts and opportunities to mitigate those impacts. Many work, for example, as scientists who measure and model mercury in the environment, as health professionals who aim to prevent or treat mercury exposure, as designers of pollution control equipment or soil remediation technology, or as scholars of international treaty-making and other efforts to address mercury-related problems. Roughly a thousand participants from a wide range of fields attend the biennial conferences on mercury as a global pollutant, continuing the series of conferences that started in Gävle, Sweden, in 1990. We identify three main lessons for the diverse community of mercury researchers: (1) *consider mercury in a larger context*; (2) *work across disciplines*; and (3) *develop and communicate relevant knowledge*.

Consider Mercury in a Larger Context

Much early research on mercury had a singular focus on specific aspects of the behavior of this one element, but it is now well established that mercury use, discharges, transport, and exposure take place in a larger environmental and societal context. The scientific community as a result increasingly addresses connections between mercury and other sustainability issues. The mercury systems that we analyzed in this book furthermore illustrate just how closely the element mercury is linked to a broad range of other components of human, technological, and environmental systems. A recent synthesis of the state of mercury science drew attention to the fact that human-influenced environmental processes, such as climate and land-use changes, are increasingly affecting the cycling of previously discharged mercury from environmental storage in land and oceans (Chen et al. 2018). As a result, researchers will not fully understand many important aspects

of the mercury problem unless they consider it together with other factors including drivers of local and global change.

The range of examples of how mercury is connected to other sustainability challenges across part II illustrates some of the challenges in studying linked mercury-related issues. Technologies to control mercury emissions from point sources often overlap with, and interact with, those that address other air pollutants such as sulfur dioxide and particulates. This highlights for the engineering community the importance of designing effective multi-pollutant control technologies. The formation and accumulation of methylmercury in food webs depend on ecosystem characteristics and structure. As a result, ecological factors sometimes determine where and when this highly toxic form of mercury will reach its highest concentrations. Health impacts of methylmercury are shaped not only by exposure to the substance through dietary intake, but also by genetic factors that vary among individuals, as well as cultural traditions around food. Further analyzing these interconnected issues requires a comprehensive approach.

Scientists in different fields have greatly advanced research on mercury, but there remain important knowledge gaps about mercury's environmental cycling. This creates a need for more sampling of mercury in air, water, soil, and biota to further study its environmental behavior. Mercury could be increasingly measured together with other pollutants, rather than through separate monitoring networks, and it is important to design new techniques that make it possible to measure mercury without using expensive equipment. Modeling efforts could focus on further development of a spectrum of models to address the full complexity of how mercury moves and transforms in the environment and society. These different kinds of mercury-related studies could be better integrated as a part of larger global change research efforts. In addition, mercury researchers should come from a broad range of fields and geographical areas, and not just a few well-known mercury-focused research groups in a small number of mainly industrialized countries.

Work Across Disciplines

The complex and interacting environmental and societal dimensions of the mercury issue underscore the need to reach across disciplinary boundaries in the natural sciences, social sciences, and engineering to better examine system interactions and interventions from a sustainability perspective. Analysis of the biogeochemical and societal cycling of mercury requires

understanding how mercury flows through environmental and technical components as well as humans. Analyses of mercury pollution and its consequences should consider the importance of economic and technological factors that influence coal-fired power plants and industrial production, as well as the local and long-range atmospheric transport of mercury. It is also important to compile other kinds of information, such as on the costs and effectiveness of pollution controls. Studies of the impacts of mercury use in ASGM should look at a wide range of factors, including the role of poverty, the influence of mining laws, technology use during the extraction process, and mercury and gold market forces.

One important argument in favor of more interdisciplinary research is that researchers, including those who study different aspects of the mercury issue, may reach incomplete or even incorrect conclusions relevant to sustainability if analyses are conducted within one discipline in isolation. Those scientists who are interested in the atmospheric transport of mercury may be able to better capture how political and economic forces affect the operation and distribution of point sources if working with colleagues in the social sciences. Mercury-capture technologies for use in ASGM designed by engineers working alone are less likely to be effective if behavioral aspects of ASGM production are not accounted for in the design process. Governance scholars drawing lessons from institutional efforts to control air pollutants may make inappropriate conclusions about the match—or fit—between the scope of these institutions and the environmental processes they are designed to govern if they do not consider technological factors and the long-term environmental dynamics of mercury and other substances.

Many reports and studies call for more interdisciplinary research (Brewer and Lövgren 1999; National Academy of Sciences et al. 2005; Repko 2008; Shaman et al. 2013). Such calls often specifically note the need to reach across traditional disciplines in addressing sustainability challenges. The continuing difficulties of achieving interdisciplinary collaborations are already well known (Rhoten and Parker 2004). Much research is still organized based on traditional disciplines, and conventional reward structures for promotion in academia do not typically value interdisciplinary work (Spangenberg 2011). We do not purport to have new solutions from our examination of the mercury systems to the more general challenge of how to better support and reward interdisciplinary collaborations, but researchers may draw on examples from this book to argue that interdisciplinary

collaborations hold much promise in generating more nuanced and societally relevant results.

Develop and Communicate Usable Knowledge

It is often critical for researchers to develop and share new and usable knowledge in support of interventions. This involves applying transdisciplinary approaches that engage those outside of academia (Brandt et al. 2013). Researchers in the past few decades have been increasingly called on to pay more attention to crafting usable knowledge, including by working with stakeholders (Clark et al. 2016). Examples from the mercury systems show how such usable knowledge has been influential. The diffusion of knowledge about how to make mercury-free goods and how to design mercury-free manufacturing processes helped phase out much intentional mercury use. Dietary guidelines related to methylmercury levels in food must be tailored based on how people in different locations interpret them, to ensure people keep gaining the benefits of other nutrients in seafood. ASGM miners are more likely to adopt new extraction and amalgamation techniques when these techniques fit local needs and take into account behavioral and cultural factors.

Contemporary mercury debates illustrate the continued importance for scientists to generate and diffuse authoritative information in partnership with non-experts. Two of these debates concern the use of mercury amalgam in dentistry and the use of thimerosal in vaccines. The longer-term goal is to phase out both of these areas of mercury use, but doing so prematurely is likely to cause more harm than good to human health. Mercury amalgam sometimes remains the best alternative for repairing teeth, as recommended by the World Health Organization (WHO). The surge of an anti-vaccine movement in North America, Europe, and elsewhere poses a serious public health problem. Efforts by the WHO, the GAVI Alliance, and others during the Minamata Convention negotiations helped communicate science-based knowledge on the health benefits of using thimerosal-containing vaccines. Researchers can learn from this experience in thinking critically about benefits and harms, including unintended effects and perceived risks, in partnership with stakeholders.

Producing usable knowledge, even with the participation of stakeholders, may not by itself be sufficient to lead to change. Knowledge about mercury is not always evenly shared and distributed. There are many historical

examples of how knowledge about the dangers of specific forms of mercury were documented in some places and largely unknown or contested in others. Some European medical associations already warned against the use of mercury in medicine in the sixteenth century, but doctors prescribed many different mercury-based treatments well into the twentieth century. Those who treated early patients of the "strange disease" in Minamata did not know of the experience of Hunter-Russell syndrome and associated knowledge of organic mercury poisoning. Knowledge can also be suppressed: the Chisso Corporation knew it was releasing dangerous quantities of methylmercury into Minamata Bay, but it did not publicly share this information. Understanding how information is generated and disseminated, including aspects of power and influence, is thus critical.

Lessons for Decision-Makers

The negotiations and early implementation of the Minamata Convention helped to elevate the political awareness and perceived importance of mercury abatement globally. Decision-makers and public authorities in different countries, however, have taken action on mercury for much longer, with more modern controls on mercury use and discharges dating back to the 1960s. As we mentioned in the introduction to this chapter, the implementation of the Minamata Convention has only just begun, and much more action by decision-makers will be needed to meet the treaty's objective of protecting human health and the environment from mercury. We believe that decision-makers taking actions in support of this goal are well advised to consider three important points: (1) *intervene in different ways and at multiple scales*; (2) *focus on high-impact interventions*; and (3) *consider long-term impacts*.

Intervene in Different Ways and at Multiple Scales

Many interventions that are needed to comprehensively address the mercury issue must be taken by decision-makers across global, regional, national, and local forums. Mercury is a multi-scale problem in which several factors interact simultaneously, and cross-scale actions are needed to mitigate the various ways that mercury harms human well-being. The protection of people in all regions of the world from mercury's health effects depends on concomitant local-to-global policy action mandating stricter pollution controls on large point sources. Reducing mercury use in consumer products

and production processes requires sharing knowledge about mercury-free alternatives across national borders. Greater formalization of artisanal and small-scale mining is an important step toward addressing ASGM-related problems, but it needs to be combined with local interventions addressing mercury use, exposure, and discharges as well as efforts that target mercury trade and gold supply chains.

Global-to-local scale governance efforts to address the human health impacts of mercury are greatly affected by the underlying dynamics of power and influence that shape the differential impacts of mercury use, exposure, and environmental distribution. This creates a need for decision-makers to pay close attention to the situations of populations vulnerable to mercury exposure, including future generations. For example, people in many indigenous communities in the Arctic and elsewhere feel that they are unfairly harmed because of risks from the methylmercury in their traditional diets of fish and marine mammals. Lamenting that some traditional foods consumed for centuries or more are no longer safe to eat, a representative of indigenous peoples during the final negotiation session of the Minamata Convention quoted a line from the song "Under Pressure": "it's the terror of knowing what this world is about" (Earth Negotiations Bulletin 2013b).

Because mercury is linked to other sustainability issues, there is potential for interventions that have multiple and simultaneous benefits for the environment and human well-being. Efforts to reduce the negative environmental impacts of industrial production and wastes can focus on mercury discharges together with other pollutants. Linkages between mercury and climate change mean that addressing mercury can also require actions by decision-makers that at first glance may not seem related to the mercury issue. For example, avoiding deforestation may be an effective way to reduce methylmercury production (Hsu-Kim et al. 2018). Research is still developing on the impact of climate change on the environmental cycling of mercury, but preventing the remobilization of mercury from long-term storage by mitigating climate change could at the same time lessen future human health damages from the consumption of seafood contaminated with methylmercury.

Focus on High-Impact Interventions

Decision-makers operate under resource constraints. Money spent on problems involving mercury is finite, and funding for mercury-related issues competes with the resources needed to address other pressing sustainability

challenges, in both developing and industrialized countries. It is therefore important for decision-makers to consider the relative impact, feasibility, and costs of potential interventions on mercury. Some high-impact interventions may be long-term in scope. For example, initiatives that contribute to increased economic opportunities for miners in regions where ASGM takes place would help address the harms from mining and associated mercury use and exposure. Similarly, phasing out fossil fuel use including coal burning in favor of low-carbon energy sources would have a major impact on mercury emissions. Reducing fossil fuel use would also dovetail with efforts to reduce air pollution and mitigate climate change, and could link to efforts to address economic inequality.

The highest-impact interventions, however, are not always the ones that are the most ambitious. Idealized solutions—such as addressing pollution sources far upstream, including by phasing out coal burning—may not always be politically and practically feasible. Addressing the root causes of the mercury problem would have both shorter-term and longer-term benefits for the environment and human health, but it is important that a focus on such transformative change does not detract from the introduction of more incremental or downstream interventions that would benefit current and future generations. For example, local actions to mitigate human exposure—such as the formulation of dietary advice to vulnerable populations—can occur at the same time as efforts to prevent future discharges to the environment. Simultaneous adaptation and mitigation efforts on mercury, like those on climate change, are necessary to support human well-being where changes are irreversible on human-relevant timescales (N. E. Selin 2014).

Decision-makers should be conscious of tradeoffs in trying to identify high-impact interventions. Moving away from the use of coal would have substantial benefits for the mercury problem, but the Minamata Convention would likely not be in force today had national delegates and policy advocates focused on pushing this most ambitious solution. This would have left mercury emissions from coal burning as well as other aspects of the mercury issue unregulated globally. The ability to respond to changing knowledge is also important. Lessons from the mercury systems suggest that efforts to intervene ought to be conducted with recognition of the extent to which our understanding of both environmental and societal dynamics of the mercury issue have changed over time, and may change

again in the future. A first step is to consider the current state of knowledge. Decision-makers can also help researchers design scientific assessments to provide information that both is relevant to their needs and accounts for the perspectives of stakeholders (Cash et al. 2003).

Consider Long-Term Impacts

Mercury's persistence in both the environment and society shows the need for decision-makers to take a long-term perspective. Mercury is an element, and as such it will not go away. Many of the problems that are caused by mercury pollution today come from the activities of the past. Similarly, today's mercury discharges become tomorrow's legacy pollution. A sustainability perspective means that there is a need to consider both present and future generations in decision-making. Stakeholders from future generations (by definition) are not physically present in negotiations about present-day policies, but decision-makers have a moral obligation to pay attention to the long-term impacts of their decisions (to intervene or not to intervene). Governments and others can better account for the perspectives of future generations in decision-making. Making assumptions more explicit, for example in discount-rate analysis of the costs and benefits of pollution controls, could help to better highlight impacts on future generations.

Considerations of the long-term impacts of interventions can be hampered by a lack of scientific knowledge. Many early efforts to address mercury use, exposure, and discharge were based on the dominating perception that mercury was a local problem that could be addressed by local action. This view persisted for centuries. Until the late twentieth century, scientists did not understand that mercury transports long distances through the atmosphere, and cycles between the atmosphere, land, and oceans for generations. There is still scientific uncertainty about the timescales of mercury cycling through the environment and the speed at which concentrations of mercury in the atmosphere and ocean (and methylmercury in different organisms) will respond to changing discharges. This suggests that decision-makers should recognize that decisions today may need to be revisited with further scientific and technical information. Monitoring and evaluation will continue to be necessary to understand both the short-term and long-term impacts of interventions.

Evaluations of the effectiveness of interventions can help to better assess their impact over time. Additional measurements of mercury in the

environment would assist in these efforts. Decision-makers should support the establishment of more monitoring programs and stations in all regions of the world, but especially outside North America and Europe. It is critical, however, that environmental data are supplemented with other policy-relevant information. The Minamata Convention effectiveness evaluation process presents a particularly useful opportunity for periodic assessments to explore whether policy actions taken under the treaty are contributing to its objective of protecting human health and the environment from mercury. This involves using outcome and process indicators that couple environmental monitoring data with other types of information about the domestic measures that parties have taken in support of treaty implementation (Selin et al. 2018; Selin 2018).

Lessons for Thoughtful Citizens

Many people across the world are harmed by mercury alongside other stresses that also affect their lives and well-being. Some people are part of societal groups that are highly exposed or particularly vulnerable to mercury exposure and other hazards, such as indigenous peoples, ASGM miners and other community members, and pregnant women and small children. Others are not disproportionately affected by mercury pollution, but may nevertheless be concerned and motivated to take action on addressing a substance that has worldwide impacts. The mercury systems draw attention to the potential influence that thoughtful citizens can have on addressing sustainability challenges, including those involving mercury pollution. For individuals concerned about mercury and its impacts, we suggest three lessons: (1) *consider consumption choices*; (2) *organize to push for change*; and (3) *share sustainability stories*.

Consider Consumption Choices

Many individual behavioral choices involving mercury are related to consumption habits. Everyone, but especially those who are highly exposed or particularly vulnerable to the impacts of methylmercury, should pay attention to dietary guidelines and eat low-mercury seafood. People who consume self-caught fish should be attentive to warnings about mercury and other pollutants specific to local bodies of water. The introduction of mercury-free alternatives makes it easier for consumers to avoid buying

mercury-added products, but some products and other consumer goods still contain mercury. People can help minimize future mercury pollution by purchasing mercury-free products where available, and by ensuring that mercury-containing products, such as old thermometers or compact fluorescent bulbs, are disposed of according to local regulations. Using less energy reduces mercury emissions and other forms of pollution and climate change when energy is produced using fossil fuels.

There is an ongoing debate about individual ability to address sustainability issues versus the need for more systemic change. The mercury issue shows that individual consumer choices matter. The effects of certification schemes are debated, but consumers who buy certified mercury-free gold not only send an important market-based signal but also contribute to efforts that look to phase out mercury use in ASGM and improve living conditions in mining communities. Consumers who install solar panels on their homes or buy their electricity from renewable sources help to address mercury emissions as well as other air pollutants and climate change by reducing coal burning. At the same time, systemic change is critical. Much of the demand for gold that drives ASGM comes from large jewelry companies, central banks, and large investment firms. Decisions in many electricity and energy markets are dominated by the fossil fuel industry, which receives much government support. Yet, individual choices can be a catalyst for systemic change, pushing innovation, shifting public opinion, and driving policy development.

Organize to Push for Change

There are many examples in the mercury systems demonstrating that champions, individually and collectively, can have an impact on making people's lives better by organizing and pushing for change. Early advocates for better working conditions in factories, including Alice Hamilton, helped push worker protection efforts on mercury and other hazardous substances. Ornithologists in Sweden alerted the public and the authorities about the dangers caused by the extensive use of mercury pesticides in farming. Advocates in Minamata pressed authorities to remediate the damage to Minamata Bay and helped victims of Minamata disease to get certified and gain compensation. Serious poisoning incidents are not just a thing of the past. Mercury continues to pose human health risks in Grassy Narrows and Kodaikanal, impacting the well-being of community members in complex

ways. High levels of mercury exposure and other pressing socio-economic problems in ASGM create further needs for advocacy and local-level community engagement.

Individuals also have power to make a difference on other aspects of the mercury problem. Communities that are concerned about air pollution and "hot spots" can be important sources of advocacy for public authorities to mandate the use of pollution-abatement technology that reduces mercury emissions from industrial point sources. Advocates can continue to raise awareness about the health dangers of using mercury-added products in their communities, for example in places where mercury is still used in cosmetics and skin-lightening creams or religious ceremonies. Individuals can thus help bridge the gap between global-scale interventions such as the Minamata Convention and local action. In addition, concerned citizens can support advocacy and community-based organizations by offering their financial support, participating in collective actions, or providing information (such as joining citizen science projects that aim to collect information on mercury).

Share Sustainability Stories

The Minamata storytellers, by publicly sharing their own and their family members' experiences with Minamata disease, helped raise awareness of the dangers of mercury. Their message resonated with many other people in Japan as well as all over the world. Their stories have also touched others who are affected by mercury pollution, such as the indigenous communities in Grassy Narrows. Their words have echoed at the highest levels of global governance, from the 1972 Conference on the Human Environment in Stockholm to the 2017 meeting of the Minamata Convention Conference of the Parties (COP) in Geneva. Although researchers, experts, and decision-makers have a role to play, the stories of individual people who seek better lives for themselves and for future generations are central to advancing sustainability.

In October 2006, on the fiftieth anniversary of the first official recognition of Minamata disease, a committee of local citizens wrote "Minamata's Pledge" to draw attention to the lessons of the past half century when looking forward to the next 50 years (Minamata-Juku Committee 2006). The pledge acknowledges that Minamata has learned through the failures of history how difficult it is to restore "both a polluted natural environment

and a confused social environment." It commits to reconsidering citizens' relationships with nature, ways of living, industrial activities, and community, and creating "spiritually abundant and satisfied lives." This pledge was handed out to delegates at the ceremonial signing of the Minamata Convention in 2013, with a request to translate it into as many different languages as possible; in this way, the story of Minamata and its lessons can continue to reach people worldwide and inspire them to act.

We have done our best in this book to highlight some of the stories of people affected by mercury. People concerned about mercury can share these stories further. They can communicate information about healthy fish consumption during pregnancy, and help others better understand the life-saving benefits of vaccination. By giving voice to those who may not have been listened to in the past, individuals can help make efforts toward sustainability more inclusive for all. Telling stories and hearing the perspectives of others is a critical prerequisite toward building coalitions and advocating for change. Every individual has a story to tell about their experiences, what they value, and what they hope for, for themselves and for future generations. Sharing these stories is a vital part of working toward sustainability.

The urgent need for moving toward greater sustainability underscores the importance of continued actions by champions. Our analysis of the mercury systems highlights the basic challenge for sustainability: to steer often highly complex systems to maintain and enhance the well-being of both present and future generations. With respect to mercury, this requires continued attention to the stories of the most vulnerable, and interventions that weigh the implications of short-term actions alongside their long-term effects. Human activities continue to dominate the Earth in surprising and often damaging ways, and meeting the challenges of sustainability is more than ever dependent on the efforts of people acting alone and in groups to inform and manage a transition toward a more just and sustainable future. As Freddie Mercury sang decades ago—in words that resonate with those who are seeking to address the sustainability challenges of today and the future—we, indeed, are the champions of the world.

Mercury Stories

Understanding Sustainability through a Volatile Element

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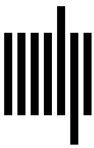

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