IGNORANCE IS RISK: SCIENTIFIC UNCERTAINTY, HYDROPOWER & MERCURY

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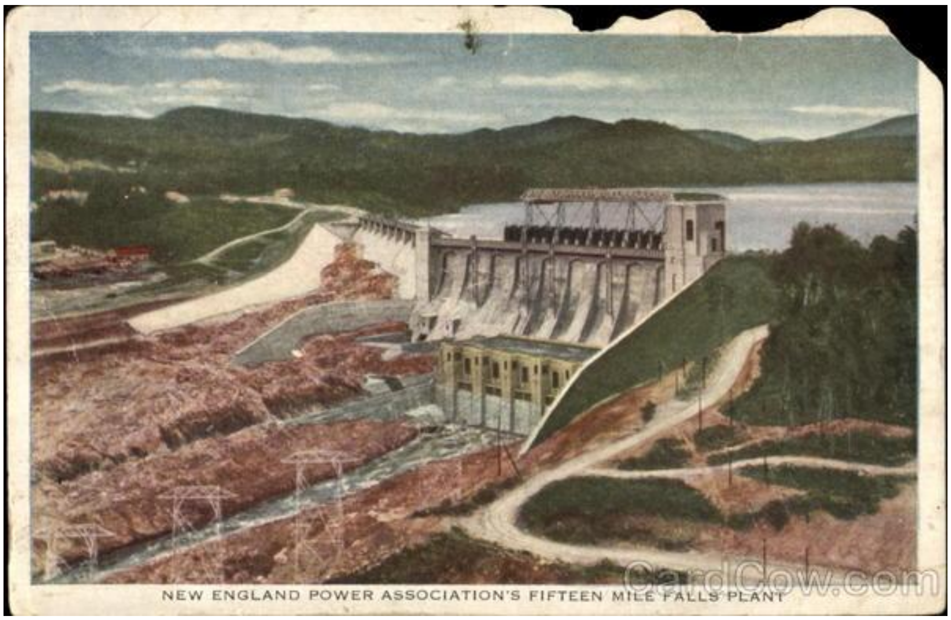

Figure 1: A postcard depicting one of the Fifteen Mile Falls Hydroelectric Complex's massive dams. New England Power Association's Fifteen Mile Falls Plant, CARD COW VINTAGE POSTCARDS & COLLECTIBLES, http://www.cardcow.com/162684/new-england-power-associations-fifteen-mile-falls-plant-monroe-hampshire/ (last visited Feb. 1, 2012).

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ABSTRACT

Although hydroelectricity has many environmental benefits, it has accompanying environmental costs. One such cost that is particularly understudied and overlooked is hydropower's contributions to mercury pollution. This paper examines how mercury pollution occurs and assesses how mercury is regulated, using the Fifteen Mile Falls hydroelectric generation project in New England as a case study. This research reveals that current regulations are clouded by scientific uncertainty, which offers regulatory authorities an excuse to wait and see what happens rather than imposing precautionary restrictions. As a result, no restrictions are currently placed on hydropower for mercury pollution. This paper recommends certain studies that, once conducted, will reduce this scientific uncertainty. In the meantime, this paper suggests legal reform and the institution of precautionary measures. This paper concludes that until hydropower's contributions to the mercury problem are properly acknowledged, owners will continue to develop and regulators will allow projects to go forward—all blindly contributing to a problem without sight of the risks.

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INTRODUCTION

Fish contaminated with elevated levels of mercury are a widespread problem in the United States. In 2007, 44 states had fish consumption advisories for mercury contamination.[1] Between 2006 and 2008, both the number of lake acres and the number of river miles under advisory steadily increased.[2] By 2008, all 50 states had issued advisories warning citizens to limit their consumption of certain types of fish due to mercury contamination.[3] Meanwhile, federal and state health departments—the same agencies that issue fish consumption advisories—encourage people to consume fish for health benefits, since fish provide an excellent source of lean protein and omega-3 fatty acids without containing high saturated fats.[4]

In an effort to curb mercury contamination, the U.S. Environmental Protection Agency ("EPA") proposed national standards for mercury and other toxic air pollution from power plants for the first time in March 2011.[5]

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[1] Charles T. Driscoll, Young-Ji Han, Celia Y. Chen, David C. Evers, Kathleen Fallon Lambert, Thomas M. Holsen, Neil C. Kamman & Ronald K. Munson, *Biological Mercury Hotspots in Northeastern United States and Southeastern Canada*, 57 BIOSCIENCE 17, 29 (2007).

[2] *Mercury Contamination in Fish*, NATURAL RESOURCES DEFENSE COUNCIL, http://www.nrdc.org/health/effects/mercury/sources.asp.

[3] *Id.*

[4] *See Mercury in Fish*, VT. DEP'T OF ENVTL. SERVICES, http://www.mercvt.org/fish/index.htm.

[5] *See Proposed Rule: National Emission Standards for Hazardous Air Pollutants from Coal- and Oil-fired Electric Utility Steam Generating Units and Standards of Performance for Fossil-Fuel-Fired Electric Utility, Industrial-Commercial-Institutional, and Small Industrial-Commercial-Institutional Steam Generating Units*, U.S. ENVT. PROT. AGENCY, http://www.epa.gov/airquality/powerplanttoxics/pdfs/proposal.pdf (proposed Mar. 16, 2011); *see also* U.S. ENVTL. PROT. AGENCY, PROPOSED MERCURY AND AIR TOXICS STANDARDS FACT SHEET, http://www.epa.gov/airquality/powerplanttoxics/pdfs/proposalfactsheet.pdf; *and EPA Proposes First National Standard for Mercury Pollution from Power Plants / Mercury and Air Toxics Standards Represent One of Strongest Health Protections from Air Pollution Since Passage of Clean Air Act*, U.S. ENVTL. PROT. AGENCY, Press Release (Mar. 16, 2011), http://yosemite.epa.gov/opa/admpress.nsf/1e5ab1124055f3b28525781f0042ed40/55615df6595fbfa38525785500509

The EPA finalized these standards as the Mercury and Air Toxics Standards ("MATS") and issued a final rule in December 2011.[6] The MATS rule requires power plants to install pollution control technologies that prevent over 90 percent of mercury in coal from being emitted into the atmosphere.[7] These standards are a big step forward for mercury pollution prevention, because coal-fired electric facilities are the largest single source of mercury contamination in the United States.[8]

Mercury contamination comes from a variety of sources including facilities that burn coal,[9] mills that directly discharge mercury into waters,[10] hydroelectric facility operations,[11] and even from natural wetland processes.[12] The most commonly attributed contributors are the air emitting sources, such as coal-fired power plants and waste incinerators.[13] When these facilities burn coal that contains mercury, the mercury is released into

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[6] *See* National Emission Standards for Hazardous Air Pollutants From Coal and Oil-Fired Electric Utility Steam Generating Units, 77 Fed. Reg. 32 (Feb. 16, 2012) (to be codified at 40 C.F.R. pt. 60 and 63); *see also EPA Issues First National Standards for Mercury Pollution from Power Plants/ Historic 'Mercury and Air Toxics Standards' Meet 20-year old Requirement to Cut Dangerous Smokestack Emissions*, U.S. ENVTL. PROT. AGENCY, Press Release (Dec. 21, 2011), http://yosemite.epa.gov/opa/admpress.nsf/bd4379a92ceceeac8525735900400c27/bd8b3f37edf5716d8525796d005dd086!OpenDocument; *and Air Toxics Standards for Utilities*, U.S. ENVT. PROT. AGENCY, http://www.epa.gov/ttn/atw/utility/utilitypg.html.

[7] U.S. ENVT. PROT. AGENCY, FACT SHEET: MERCURY AND AIR TOXICS STANDARDS FOR POWER PLANTS 3 http://www.epa.gov/mats/pdfs/20111216MATSfinal.pdf.

[8] Driscoll et al., *supra* note 1, at 34.

[9] *Mercury in Fish*, *supra* note 4.

[10] *Id*.

[11] Driscoll et al., *supra* note 1, at 36.

[12] *See generally* Edward J. Zillioux, Donald B. Porcella & Janina M. Benoit, *Mercury Cycling and Effects in Freshwater Wetland Ecosystems*, 12 ENVT'L TOXICOLOGY & CHEMISTRY, 2245 (1993).

[13] Nicola Pirrone, Sergio Cinnirella, Xinbin Feng, Robert B. Finkelman, Hans R. Friedli, Joy Leaner, Rob Mason, Arun B. Mukherjee, Glenn Stracher, David G. Streets & Kevin Telmer, *Global Mercury Emissions to the Atmosphere From Natural and Anthropogenic Sources*, ***in*** MERCURY FATE AND TRANSPORT IN THE GLOBAL ATMOSPHERE**:** EMISSIONS, MEASUREMENTS AND MODELS 22 (Nicola Pirrone & Rob Mason, eds, Springer 2009).

the air and eventually settles back onto the earth. These mercury deposits fall back to the earth and contaminate freshwater systems when they land directly in surface waters or on land where the mercury deposits are eventually washed into waters.[14] Mercury contamination also occurs as a result of sources that discharge mercury directly into waters, such as pulp and paper mills and chlorine-alkaline plants.[15] Wetlands are yet another source of mercury contamination: the environment in wetlands converts naturally occurring mercury into toxic methylmercury and contaminates downstream lakes.[16]

Hydroelectric facilities' activities have been recognized as a contributing source of mercury contamination only within the past 35 years.[17] It is unclear exactly how much the hydroelectric industry contributes to mercury contamination in freshwater compared to other sources. However, studies on anthropogenic sources of mercury focus on coal-fired power plants, rather than hydroelectricity.[18] As a result, mercury contamination caused by hydroelectric facilities tends to be overshadowed

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[14] ENVTL. DEF. FUND, MERCURY ALERT: CLEANING UP COAL PLANTS FOR HEALTHIER LIVES 3 (2011), *available at* http://www.edf.org/documents/11661_mercury-alert-cleaning-up-coal-plants.pdf.

[15] Chlorine-alkaline plants use mercury cell technology to produce chlorine products.

[16] Carl P.J. Mitchell, Brian A. Branfireun and Randall K. Kolka, *Spatial Characteristics of Net Methylmercury Production Hot Spots in Peatlands*, 42 ENVTL. SCI. & TECH. 1010, 1010 (2008).

[17] *See* A.R. Abernathy & P.M. Cumbie, *Mercury Accumulation by Largemouth Bass (Micropterus Salmoides) in Recently Impounded Reservoirs*, 17 BULLETIN OF ENVTL. CONTAMINATION & TOXICOLOGY 595 (1977).

[18] *See generally* ARCTIC MONITORING AND ASSESSMENT PROGRAMME / UNEP CHEMICALS BRANCH, TECHNICAL BACKGROUND REPORT TO THE GLOBAL ATMOSPHERIC MERCURY ASSESSMENT (2008), *available at* http://www.unep.org/hazardoussubstances/LinkClick.aspx?fileticket=gwLbyNhGtn8%3d&tabid=3593&language=en-US; *see generally also* M.J. BRADLEY & ASSOCIATES, BENCHMARKING AIR EMISSIONS OF THE 100 LARGEST ELECTRIC POWER PRODUCERS IN THE UNITED STATES (2010), *available at* www.nrdc.org/air/pollution/benchmarking/2008/benchmark2008.pdf (analyzing coal-fired power plants and other electric generation plants' relative mercury contributions).

by the larger contributors and is understudied, under-regulated, and its full impacts are unknown.

Despite, or perhaps due to, the legislature's lack of knowledge surrounding hydroelectric facilities' contributions to the mercury problem, new facilities continue to be built and existing facilities continue to receive operating license renewals with little regard to potential impacts from mercury pollution.[19] Although hydroelectricity is an attractive energy source because it has relatively few global environmental impacts,[20] it is crucial that the legislature acknowledge that hydroelectric facilities contribute to the mercury problem. Ecosystems can only handle so much stress, as evidenced by Lake Erie's proclaimed "death" in 1969.[21] A lack of knowledge surrounding hydroelectricity as a mercury source should not prevent legislatures from protecting against this pollutant.[22] The weakness of this 'wait and see' approach is exposed in conservation biologists Paul and Anne Ehrlich's parable of the rivet popper.[23] In this parable, a man removes rivets from the wing of an airliner one by one, reassuring the reader not to worry

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[19] The U.S. Department of Energy Secretary Steven Chu announced that the Obama Administration committed $32 million in Recovery Act funding to aid existing non-federal facilities in the United States in 2009. *Obama Administration Announces up to $32 Million Initiative to Expand Hydropower*, U.S. DEP'T. OF ENERGY, Press Release (June 30, 2009), http://www.energy.gov/news/7555.htm (last visited Apr. 27, 2011).

[20] Nathaniel Stevens, *Canada and the United States—Dealing With the Hydro Power Paradox: Evaluating the Environmental Effects of a Natural Energy Source*, 19 SUFFOLK TRANSNAT'L L. REV. 273, 273 (1995).

[21] Cleveland, Ohio's Cuyahoga River caught on fire in 1969, prompting *Time Magazine* to run a piece proclaiming Lake Erie devoid of all aquatic life. *See America's Sewage System and The Price of Optimism*, TIME, Aug. 1, 1969, available at http://www.time.com/time/magazine/article/0,9171,901182,00.html.

[22] *See generally* David M. Rosenberg, R.A. (Drew) Bodaly & P.J. Usher, *Environmental and Social Impacts of Large Scale Hydroelectric Development: Who is Listening?*, 5 GLOBAL ENVIRONMENTAL CHANGE 127, 147 (1995) (asking "why?" to their conclusion that despite publicly available information that hydropower causes mercury emissions, policymakers continue to approve projects).

[23] PAUL R. EHRLICH & ANNE EHRLICH, EXTINCTION: THE CAUSES AND CONSEQUENCES OF THE DISAPPEARANCE OF SPECIES xi-xii (Ballantine Books 1983).

because he has already removed lots of rivets and the 'wing hasn't fallen off yet'.[24] Much like the rivet-popper, we continue to develop and rely on hydroelectricity without putting regulations for mercury in place. Our persistence in this behavior runs the risk of driving ecosystem collapse and the subsequent loss of the multiple services they provide, such as cleaning our air, purifying our water, and providing crops with a source of pollinators.

This paper investigates the current policy approach to regulating hydroelectric projects for mercury contamination by examining the mercury problem, licensing requirements, and the scientific uncertainty surrounding the process. In Part I, this paper describes generally how hydroelectric facilities cause mercury contamination. Part II provides a regulatory background by describing the legal framework for licensing hydroelectric facilities. Part III delves into a case study of the largest hydroelectric facility

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[24] *Id*. The full text of the parable is as follows:

> As you walk from the terminal toward your airliner, you notice a man on a ladder busily prying rivets out of its wing. Somewhat concerned, you saunter over to the rivet popper and ask him just what the hell he's doing.
>
> "I work for the airline—Growthmania Intercontinental," the man informs you, "and the airline has discovered that it can sell these rivets for two dollars apiece."
>
> "But how do you know you won't fatally weaken the wing doing that?" you inquire.
>
> "Don't worry," he assures you. "I'm certain the manufacturer made this plane much stronger than it needs to be, so no harm's done. Besides, I've taken lots of rivets from this wing and it hasn't fallen off yet. Growthmania Airlines needs the money; if we didn't pop the rivets, Growthmania wouldn't be able to continue expanding. And I need the commission they pay me—fifty cents a rivet!"
>
> "You must be out of your mind!"
>
> "I told you not to worry; I know what I'm doing. As a matter of fact, I'm going to fly on this flight also, so you can see there's absolutely nothing to be concerned about."
>
> Any sane person would, of course, go back into the terminal, report the gibbering idiot and Growthmania Airlines to the FAA, and make reservations on another carrier. You never *have* to fly on an airliner. But unfortunately all of us are passengers on a very large spacecraft—one on which we have no option but to fly. And, frighteningly, it is swarming with rivet poppers behaving in ways analogous to that just described.

in New England to assess mercury restrictions placed on an individual complex's operating license. Part IV addresses the lack of scientific certainty that exists as an underlying theme in mercury restrictions imposed on hydroelectric facilities. Finally, in Part V this paper suggests studies necessary to better understand the extent of hydroelectric facilities' contributions to the mercury problem and provides suggestions for implementing precautionary measures until the studies are conducted. This paper concludes that until hydroelectric facilities' contributions to the mercury problem are acknowledged, owners will continue to develop and regulators will allow projects to go forward—all blindly contributing to a problem without sight of the risks.

I. HYDROELECTRIC PROJECTS CAUSE MERCURY CONTAMINATION

Hydroelectric projects generate power by controlling water pressure.[25] First, the facilities build dams on existing rivers to impound reservoirs.[26] The reservoirs give facilities control over water flow because the dam can be opened or closed depending on energy demand.[27] Opening the dam releases reservoir waters, a process referred to as drawdown.[28] Dams hold

[25] *Hydroelectric Power: How It Works*, U.S. GEOLOGICAL SURVEY, http://ga.water.usgs.gov/edu/hyhowworks.html.
26 *Water Power Program*, *Types of Hydropower Plants*, U.S. DEP'T OF ENERGY, http://www1.eere.energy.gov/water/hydro_plant_types.html.
[27] *Clean Energy*, *Hydroelectricity*, U.S. ENVTL. PROT. AGENCY, http://www.epa.gov/cleanenergy/energy-and-you/affect/hydro.html.
[28] *Drawdown*, MERRIAM-WEBSTER DICTIONARY, http://www.merriam-webster.com/dictionary/drawdown.

back incoming waters, which increases the water pressure released when the reservoir is drawn down.[29] Hydroelectric facilities then harness this water pressure to generate energy, adjusting the drawdown quantity based on energy demand.[30]

Part A of this section describes the process by which hydroelectric facilities convert the naturally-occurring mercury in the soils into the toxic methylmercury form. Part B illustrates methylmercury's toxic effects on humans by describing the symptoms and discussing past major mercury poisoning outbreaks. Part C describes some of the toxic effects methylmercury has on fish and Part D discusses how methylmercury impacts ecosystems. Finally, Part E addresses the debate over whether the health benefits associated with consuming fish outweigh the risk of mercury poisoning.

A. The Methylation Process

Hydroelectric facilities elevate mercury levels by creating reservoirs and manipulating water levels in existing reservoirs.[31] When land areas are flooded, the vegetation on the land dies and decomposes. The decompositional environment makes the water anoxic (oxygen-depleted) and favors bacteria that transforms naturally occurring inorganic mercury

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[29] *Hydroelectric Power: How It Works*, *supra* note 25.
[30] *Id*.
[31] Driscoll et al., *supra* note 1, at 36.

into toxic organic methylmercury (MeHg).[32] This process is called biomethylation.[33] The MeHg is then absorbed by organisms in the water and is subsequently passed up the food chain once predatory fish eat bottom-feeding organisms.[34] Methylmercury then builds up in the bodies of fish over time, a process termed bioaccumulation.[35]

Methylmercury also increases in concentration in each organism that eats another contaminated organism in a process called biomagnification.[36] Humans become exposed to MeHg when they consume contaminated fish.[37] Methylmercury contamination in reservoirs can last 20 to 35 years before returning to normal background levels.[38]

B. Methylmercury's Toxic Effects on Humans

Methylmercury is a neurotoxin to humans that "specializes in attacking the brain."[39] Methylmercury exposure, especially toxic to young children and fetuses, can cause delayed development, changes in muscle tone and

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[32] David M. Rosenberg, F. Berkes, R.A. (Drew) Bodaly, R.E. Hecky, C.A. Kelly, and J.W.M. Rudd, *Large-scale Impacts of Hydroelectric Development*, 5 ENVTL. REV. 27, 32 (1997).
[33] RICK SMITH & BRUCE LOURIE, SLOW DEATH BY RUBBER DUCK: THE SECRET DANGER OF EVERYDAY THINGS 153 (Counterpoint 2009).
[34] B.D. Roebuck, *Elevated Mercury in Fish as a Result of the James Bay Hydroelectric Development: Perception and Reality*, *in* SOCIAL AND ENVIRONMENTAL IMPACTS OF THE JAMES BAY HYDROELECTRIC PROJECT, 75 (James F. Hornig, ed., McGill-Queen's University Press 1999).
[35] *See generally* Alain Tremblay, *Bioaccumulation of Mercury and Methylmercury in Invertebrates from Natural Boreal Lakes*, *in* MERCURY IN THE BIOGEOCHEMICAL CYCLE 89 (Springer 1999).
[36] David C. Evers, *Mercury Connections: The Extent and Effects of Mercury Pollution in Northeastern North America*, BIODIVERSITY RESEARCH INST. 6 (2005).
[37] *Id.*
[38] Rosenberg et al., *supra* note 32, at 28.
[39] SMITH & LOURIE, *supra* note 33, at 132.

reflexes, and even cerebral palsy syndrome.[40] Adults who consume toxic fish may experience paresthesia (the sensation of burning or prickling similar to the feeling when a hand or foot "goes to sleep"), tremors, ataxia (gross lack of coordination of muscle movements), speech articulation problems, deafness and vision impairment, and possibly even death.[41] The first MeHg study found that these symptoms, aside from death, progressed in this sequence even after the original source of exposure was removed.[42]

The first recorded MeHg poisoning outbreak occurred in 1956 in the rural fishing town of Minamata, Japan.[43] A petrochemical company dumped approximately 27 tons of the toxic substance from 1953 to 1968, contaminating Minamata Bay.[44] Local residents relied on fish as an important food source, so they continued eating Minamata Bay fish unaware of the MeHg contamination.[45] Soon, people began to notice strange animal behavior.[46] Cats appeared to be 'dancing' as a result of their convulsions.[47] Birds fell from the sky in mid-flight.[48] It was not long before residents began to suffer from a strange disease of unknown origin.[49] Their symptoms ranged from the relatively mild (numbness, tunnel vision, and blindness) to

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[40] Charles Dumont, Mamon Girard, Francois Bellavance & Francine Noel, *Mercury Levels in the Cree Population of James Bay, Quebec, from 1988 to 1993/94*, CAN. MED. ASS'N 1439, 1440 (1998).
[41] *Id.*
[42] Roebuck, *supra* note 34, at 75.
[43] Masazumi Harada, *Minamata Disease: Methylmercury Poisoning in Japan Caused by Environmental Pollution*, 25 CRITICAL REVIEWS IN TOXICOLOGY 1, 1 (1995).
[44] CARL F. CRANOR, LEGALLY POISONED: HOW THE LAW PUTS US AT RISK FROM TOXICANTS 82 (Harvard University Press 2011).
[45] *Id.* at 83.
[46] Harada, *supra* note 43, at 3.
[47] SMITH & LOURIE, *supra* note 33, at 150.
[48] Harada, *supra* note 43, at 3.
[49] SMITH & LOURIE, *supra* note 33, at 150; Roebuck, *supra* note 34, at 76.

the very severe (paralysis, seizures, convulsions, and even death).[50] Just ten years after the Minimata disaster, another outbreak occurred in Japan. This time nearly 500 Niigata residents suffered "Minamata disease" symptoms.[51]

Yet another severe methylmercury epidemic occurred in Iraq in the 1970s when Iraqi farmers consumed wheat grain seeds that had been treated with MeHg fungicide as a preservative.[52] The Iraqi government distributed approximately 80,000 tons of seeds for planting, but drought depleted available food stocks and the residents used the grain to make bread.[53] The widespread contaminated bread consumption triggered a massive Minimata disease outbreak among Iraqi farmers, with a death toll estimate of approximately 5,000.[54]

Although the Iraq MeHg outbreak was nothing short of a disaster, it did provide scientists with the opportunity to conduct studies on human reactions to MeHg exposure.[55] Studies conducted on 90 mother-infant pairs during the Iraq epidemic revealed that even though mothers only suffered mild and reversible symptoms, the children born from these pregnancies suffered from symptoms significantly more severe.[56] It is now understood that MeHg concentrates in the fetal brain can be at levels up to five times

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[50] CRANOR *supra* note 44, at 83.
[51] Roebuck, *supra* note 34, at 76.
[52] CRANOR, *supra* note 44, at 83-84; Jack C. Clifton II, *Mercury Exposure and Public Health*, 54 PEDIATRIC CLINICS OF NORTH AMERICA 237, 246-47 (2007).
[53] CRANOR, *supra* note 44, at 83-84.
[54] *Id.*
[55] *Id*. at 83.
[56] Roebuck, *supra* note 34, at 77.

greater than in the mother's blood.[57] Consequently, unborn children are much more susceptible to the toxic effects than adults.

C. Methylmercury's Toxic Effects on Fish

A study analyzing over 15,000 freshwater fishes and 64 different fish species conducted from 1980 to 2005 revealed that the highest mercury concentrations occurred in white perch that reside in reservoirs.[58] When fish eggs are exposed to mercury, they experience problems with growth, development, and hormonal status in early life stages.[59] Adult fish that are exposed to mercury may have difficulty spawning and their schooling movements may be altered.[60]

D. Methylmercury's Toxic Effects on Ecosystems

Beyond fish and human health concerns, MeHg contamination also poses a toxic threat to ecosystems. Studies have found mercury poisoning in species living in habitats as diverse as mountain-tops and small headwater streams.[61] For example, crayfish have been used as yardsticks for comparing mercury levels throughout the upper Connecticut River

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[57] CRANOR, *supra* note 44, at 83. Such higher concentrations in fetuses are a result of the active transport of MeHg through the placenta as well as into the fetal brain. *Id*.
[58] Evers, *supra* note 36, at 11.
[59] *Id.* at 7.
[60] *Id.*
[61] *Id.* at 14.

watershed, as illustrated below in Figure 2.[62] Since several other species eat crayfish, including bass, loons, and raccoons, these species also risk mercury exposure.

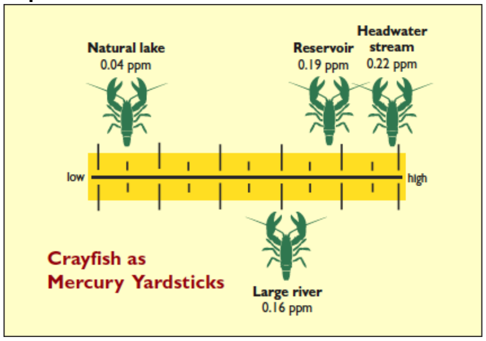

Figure 2: Studies conducted on Crayfish in the Upper Connecticut River watershed indicate mercury concentrations change based on habitat. Eighty-eight percent of the mercury found in the species examined existed in the toxic MeHg form. Evers, *supra* note 36, at 14.

Other studies have revealed high mercury levels in various aquatic birds, mink, and otters. When birds are exposed to mercury, they suffer from symptoms similar to those that occur in exposed humans.[63] Exposed birds suffer from severe neurological problems, such as brain lesions, central nervous system dysfunction, tremors, and the inability to coordinate muscle movement.[64] A recent study found that low levels of mercury (0.3 parts per million) in the white ibis' diet (a wading bird in south Florida) causes the male ibises to prefer mating with each other instead of with females.[65] Consequently, fewer females are able to breed and produce chicks.[66] Contaminated mink and otter have experienced anorexia, brain damage and even death.[67]

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[62] Chris M. Pennuto, Oksana P. Lane, David C. Evers, Robert J. Taylor & Jeff Loukmas, *Mercury in the Northern Crayfish:* Orconectes virilis (Hagen), *in New England, USA*, 14 ECOTOXICOLOGY 149, 149 (2005).
[63] Evers, *supra* note 36, at 7.
[64] *Id*.
[65] Peter Frederick & Nilmini Jayasena, *Altered Pairing Behaviour and Reproductive Success in White Ibises Exposed to Environmentally Relevant Concentrations of Methylmercury*, PROCEEDINGS OF THE ROYAL SOC'Y B, doi: 10.1098/rspb.2010.2189 (2010); *see also* Michael Marshall, *Mercury Poisoning Makes Male Birds Homosexual*, NEW SCIENTIST, Dec. 1, 2010, *available at* http://www.newscientist.com/article/dn19784-mercury-poisoning-makes-male-birds-homosexual.html.
[66] Marshall, *supra* note 65.
[67] Evers, *supra* note 36, at 7.

E. Consuming Fish: Health Benefit or Health Hazard?

Fish consumption provides humans with an important source of protein and fatty acid.[68] Even the health departments that issue fish consumption advisories for mercury strongly encourage people to eat fish for health benefits.[69] The EPA reference dose level for mercury in humans is 5.8 micrograms per liter (µg/L), which means that any person with mercury levels higher than this "safe" level may experience Minamata disease symptoms.[70] This "safe" level does not easily translate into a formula for determining what fish quantities are safe for consumption because mercury levels vary depending on the waterbody the fish is from and even the fish itself.[71] Larger predatory fish have higher levels of mercury than small fish because the mercury biomagnifies up the food chain.[72] Thus, it is important for fish consumers to be aware of the local fish consumption advisories in their region, the types of fish that accumulate more mercury, and the fish's origin.

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[68] *Mercury in Fish*, *supra* note 4.

[69] *See id*; *see also* N.H. DEP'T OF ENVTL. SERVICES, NEW HAMPSHIRE FISH CONSUMPTION GUIDELINES 1 (2009), available at http://www.des.state.nh.us/organization/commissioner/pip/factsheets/ard/documents/ard-ehp-25.pdf.

[70] Human Exposure, U.S. ENVTL. PROT. AGENCY (OCT. 1, 2010), http://www.epa.gov/hg/exposure.htm.

[71] For a discussion of assessing mercury risks when choosing a fish-heavy diet, see Nick Fox, *Taking Worry Off The Plate*, NY TIMES, Jan. 30, 2008, *available at* http://www.nytimes.com/2008/01/30/dining/30fish.html?_r=1&sq=mercury%20fish&st=nyt&adxnnl=1&oref=slogin&scp=3&adxnnlx=1303419907-TjkDEBPzWg8I58Nu0s5/9w.

[72] Evers, *supra* note 36, at 6.

Although some studies assert that the health benefits of fish outweigh the risk of mercury exposure,[73] certain states with mercury-laden reservoirs have advisories against pregnant women or children consuming any fish from that waterbody.[74] These consumption advisories acknowledge that, in certain regions, mercury contamination has turned these fish from a health benefit into a health hazard.

Ecosystems are sensitive. It is now clear that hydroelectric projects are causing elevated mercury levels in reservoirs and downstream waters. Mercury contamination adds another stressor to these already polluted environments and pushes ecosystems closer to collapse. In addition, mercury contamination poses a human health hazard. The studies unequivocally show that mercury poisoning has severe—sometimes lethal—effects on exposed humans. Thus, it is necessary to evaluate how legal protections account for hydropower mercury contributions.

II. CURRENT HYDROELECTRIC LICENSING REQUIREMENTS

The Federal Power Act requires hydroelectric facilities to seek operating licenses. Part A of this section discusses the Federal Energy Regulatory Commission's ("FERC") jurisdiction to issue such licenses. Part B then describes the requirement that hydroelectric facilities seek state

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[73] *Benefits of Eating Fish Greatly Outweigh the Risks, New Study Says*, SCIENCEDAILY, Oct. 18, 2006, *available at* http://www.sciencedaily.com/releases/2006/10/061018094758.htm.
[74] *See, e.g.*, N.H. DEP'T OF ENVTL. SERVICES, *supra* note 69, at 1.

approval before FERC may issue a license to operate. Finally, Part C discusses FERC's responsibilities for enforcing license terms once issued.

A. FERC's Jurisdiction to Issue Licenses

Prospective hydroelectric private project developers must obtain a license or an exemption from FERC before building a hydroelectric facility.[75] FERC has jurisdiction to regulate non-federal projects that affect federal lands, are located on navigable waters, utilize federal dam surplus waters, or affect interstate commerce.[76] FERC typically issues hydroelectric project licenses that are valid for 30 to 50 years.[77] When the license expires, the project owner must reapply before a new license can be issued.[78]

The project developer must complete certain pre-filing requirements before FERC analyzes the application, such as consulting with local agencies that may be affected by the project, conducting studies, and meeting with local agencies that disagree with the applicant's environmental impact assessment.[79] Although the license applicant must provide a preliminary environmental impact assessment, FERC is ultimately responsible for

[75] Federal Power Act, 16 U.S.C. §§ 808 and 797(e) (2006).
[76] *Id*. § 797(e).
[77] *Id*. § 808(e).
[78] *Id*.
[79] 18 C.F.R. § 4.38 (2011).

ensuring the project complies with all existing environmental statutes, including the National Environmental Policy Act.[80]

B. State Certification Requirements

Hydroelectric projects must be certified as compliant with state water quality standards before being licensed because they emit discharges.[81] If the appropriate state agency denies such certification, FERC is not permitted to issue a license.[82]

States develop their water quality standards by establishing designated uses for waterbodies, water quality criteria, and antidegradation policies.[83] Designated uses are the uses that the state wants the waters to be able to support, such as recreational purposes or as a public water supply.[84] Water quality criteria are the numeric and narrative standards for various pollutants, such as pH, temperature, nutrients, and toxins (including mercury) that the water segment must meet in order to support the designated uses.[85] The EPA has reference water quality criteria that often

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[80] National Environmental Policy Act, 42 U.S.C. § 4332 (2006).
[81] Federal Water Pollution Control Act, 33 U.S.C. § 1341(a)(1) (2006); 40 C.F.R. § 124.53 (2011). The U.S. Supreme Court, the EPA, and FERC have each regularly read "discharge" as having its plain meaning and thus covering releases from hydroelectric dams. S.D. Warren Co. v. Maine Bd. of Environmental Protection, 547 U.S. 370, 377 (2006).
[82] 33 U.S.C. § 1341(a)(1).
[83] *Id*. § 1313(c)(2)(A); *Id*. § 1313(d)(4)(B).
[84] 40 C.F.R. § 131.3(b), (d) (2011).
[85] 33 U.S.C. § 1313(c)(2)(B); *see also* 40 C.F.R. § 131.3(b) (2011); *and* Natural Resources Defense Council, Inc. v. U.S.E.P.A., 16 F.3d 1395, 1400 (4th Cir. 1993).

serve as guidelines for states in setting water quality standards, particularly the numeric water quality component.[86]

States also enact and implement antidegradation policies to protect waters that already meet the states' water quality standards.[87] Specifically, section 303 of the Clean Water Act requires states to list waters that do not already meet water quality standards as impaired,[88] and then develop a total maximum daily load (TMDL) that calculates the maximum amount of specific pollutants that may be added to an impaired waterbody on a daily basis without violating water quality standards.[89]

States may impose conditions on hydropower certifications as are necessary to enforce a designated use in a state water quality standard.[90] Even if the state agency has certified that the hydroelectric project's operations under the new license will comply with state water quality standards, FERC may still impose more stringent water quality standards.[91]

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[86] 33 U.S.C. § 1314(b). The EPA's recommended fish tissue criterion for mercury is 0.3 parts per million (ppm). Environmental Protection Agency, 66 Fed. Reg. 1344 (Jan. 8, 2001). Interestingly, in setting this recommended criterion, the EPA concluded that it is more appropriate to derive a fish tissue residue water quality criterion than a water column-based water quality criterion. *Id.*

[87] 33 U.S.C. § 1313(d)(4)(B); 40 C.F.R. §§ 131.6 and 131.12.

[88] *Id*. § 1313(d).

[89] CLAUDIA COPELAND, CLEAN WATER ACT: CURRENT ISSUES AND GUIDE TO BOOKS 58 (Nova Science Publishers, Inc. 2003).

[90] PUD No. 1 of Jefferson County v. Washington Department of Ecology, 511 U.S. 700, 723 (1994).

[91] Snoqualmie Indian Tribe v. F.E.R.C., 545 F.3d 1207, 1218-1219 (9th Cir. 2008) (holding that FERC may require additional license conditions that do not conflict with or weaken the protections provided by the water quality criteria).

C. FERC's Regulating Responsibilities

Once FERC has issued a license to operate, FERC has enforcement responsibilities including monitoring and investigating license compliance.[92] FERC may revoke licenses if the licensee refuses to bring its activities into compliance[93] and even assess civil penalties against licensees who violate FERC orders, regulations, or terms and conditions of their licenses.[94] FERC may also request that the Attorney General seek an injunction against the violation.[95]

Thus, hydroelectric facilities must satisfy state water quality standards and federal environmental impact obligations before being licensed to operate. Once licensed, FERC has the power to fine or seek an injunction against facilities that violate their license requirements. Although FERC can impose license conditions regarding mercury contamination, it is unclear whether FERC commonly imposes such conditions. The following case study addresses the license renewal for Fifteen Mile Falls Hydroelectric Complex ("FMF") in New England with respect to mercury emissions.

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[92] 16 U.S.C. § 823b(a).
[93] *Id*. § 823b(b).
[94] *Id*. § 823b(c).
[95] *Id*. § 820.

III. CASE STUDY: A RECENT LICENSE RENEWAL

The FMF complex is the largest hydroelectric generating facility in New England.[96] The complex is located on the upper Connecticut River, a river that borders the states of New Hampshire and Vermont.[97] The complex applied for a license renewal when its original license expired in 2001.[98] Examining FERC's conditions for renewing this complex's license in 2002 reveals that although FERC considers mercury contamination to be a problem worth monitoring, it does not appear to impose any legal limits on FMF's contributions to the problem.

This section examines the FMF license renewal process in light of FERC's and the states' ability to regulate hydroelectric facilities for mercury contamination. Part A provides a brief overview of the project itself and its licensing history. Part B inspects the provisions pertinent to mercury contamination. Part C describes recent regional efforts to curb mercury pollution by setting a TMDL limit on impaired waters.

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[96] N.H. DEP'T OF ENVTL. SERVS., NEW HAMPSHIRE WATER RESOURCES PRIMER 11-2 (2008), *available a*t http://des.nh.gov/organization/divisions/water/dwgb/wrpp/documents/primer_chapter11.pdf.
[97] *Id*.
[98] U.S. FEDERAL ENERGY REGULATORY COMMISSION OFFICE OF ENERGY PROJECTS, ORDER ISSUING NEW LICENSE (MAJOR PROJECT) 2 (2002) [hereinafter FERC, ORDER ISSUING NEW LICENSE].

A. The Fifteen Mile Falls Complex

The FMF Hydroelectric Project[99] consists of three developments that collectively comprise the largest hydroelectric generating complex in New England.[100] In fact, the "massive" Comerford Dam was the largest hydro project of its time in the 1930s when it began operating.[101] Besides the Comerford station, the McIndoe Falls and Moore stations comprise the three developments located on the Connecticut River near the Town of Littleton in Grafton County, New Hampshire and Caledonia County, Vermont.[102] These developments have a rate capacity of 369 megawatts (MW) and the complex involves approximately a 26 mile reach of the Connecticut River.[103] Figure 3, below, provides a visual of the river stretch where the complex is located, with the state of New Hampshire to the east of the river and the state of Vermont to the west.

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[99] The Fifteen Mile Falls Hydroelectric Project was originally owned by New England Power Company, which transferred its license to USGen New England, Inc. on November 20, 1998. *Id*. at 1 (citing 82 FERC ¶ 62, 138 (1998). Subsequently, USGen New England, Inc. transferred its license to TransCanada Hydro Northwest, Inc., its current owner and operator.

[100] CONNECTICUT RIVER JOINT COMMISSIONS, WHERE THE GREAT RIVER RISES: AN ATLAS OF THE UPPER CONNECTICUT RIVER WATERSHED IN VERMONT AND NEW HAMPSHIRE 210 (Rebecca A. Brown ed., Dartmouth College Press 2009).

[101] RICHARD J. EWALD & ADAIR D. MULLIGAN, PROUD TO LIVE HERE, 92 (Sharon F. Francis ed., Connecticut River Joint Commissions 2003).

[102] FERC, ORDER ISSUING NEW LICENSE, *supra* note 98at 1.

[103] U.S. FEDERAL ENERGY REGULATORY COMMISSION OFFICE OF ENERGY PROJECTS, FINAL ENVIRONMENTAL ASSESSMENT FOR HYDROPOWER LICENSE: FIFTEEN MILE FALLS HYDROELECTRIC PROJECT, FERC NO. 2077-016 3 (2002) [Hereinafter FERC, FINAL ENVIRONMENTAL ASSESSMENT].

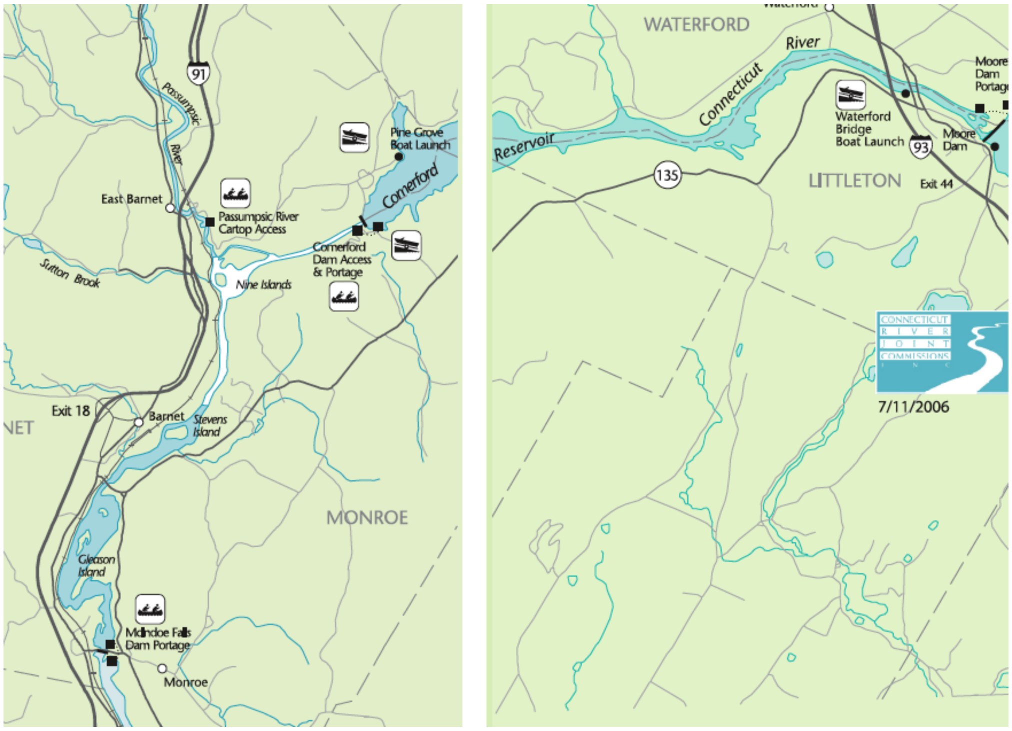

Figure 3: Map of Moore, Comerford and McIndoe Falls Dams, adapted from *Boating on the River*, CONN. RIVER JOINT COMMISSIONS, http://www.crjc.org/boating/boating4.htm (last visited Apr. 27, 2011).

Because the FMF complex is a non-federal project that is located on the Connecticut River, a navigable waterway of the United States, it is subject to FERC jurisdiction and must be licensed to operate. The Commission issued FMF its original license in 1952 and that license expired on July 31, 2001.[104] When applying for a renewal license, the project owner invited various stakeholders to participate in negotiations in order to reach a consensus on the license terms.[105] This then allowed environmental concerns to be addressed by community stakeholders.[106] These negotiations

[104] *See* Connecticut River Power Co., 11 F.P.C. 751 (1952).
[105] CONNECTICUT RIVER JOINT COMMISSIONS, *supra* note 100, at 68.
[106] *Id.*

and corresponding studies lasted for two years.[107] A settlement agreement signed on September 2, 1997.[108]

When the project owner filed its application for license renewal on July 29, 1999, it included an applicant-prepared environmental assessment and the Settlement Agreement ("Agreement").[109] The Agreement itself is confidential, but was incorporated into the license. The Agreement does not address mercury contamination, but does address other environmental impacts by establishing an Upper Connecticut River Mitigation and Enhancement Fund, placing permanent conservation easements on approximately 11,000 acres of lands adjacent to FMF and surrounding the reservoirs, and establishing minimum allowable flows to protect and enhance the aquatic ecosystem.[110]

At the same time, the project owner also understood that mercury contamination in FMF's reservoirs was a legitimate concern among community members.[111] On July 26, 2000, the project owner and certain stakeholders[112] signed a separate Mercury Settlement.[113] Under the Mercury Settlement, the project owner agreed to fund up to $500,000 for studies,

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[107] *Id*.
[108] FERC, ORDER ISSUING NEW LICENSE, *supra* note 98, at 2. The Settlement Agreement was signed by USGenNE, the State of New Hampshire, the State of Vermont, the U.S. Fish and Wildlife Service, EPA, the National Park Service, Appalachian Mountain Club, the Connecticut River Joint Commission, Connecticut River Watershed Council, Conservation Law Foundation, New Hampshire Rivers Council, New Hampshire Council of Trout Unlimited, and the Northeast Chapter of Vermont Trout Unlimited. *Id.*
[109] *Id*.
[110] CONNECTICUT RIVER JOINT COMMISSIONS, *supra* note 100, at 68.
[111] FERC, ORDER ISSUING NEW LICENSE, *supra* note 98, at 10-11.
[112] Although it is likely that these "certain stakeholders" are the same parties who signed the Settlement Agreement, this author was unable to find any documents confirming this assumption.
[113] FERC, ORDER ISSUING NEW LICENSE, *supra* note 98, at 10-11.

plans, and mitigation measures to reduce sources of mercury within the Connecticut River watershed.[114]

Since FMF is located on the Connecticut River, it has identifiable discharges in both Vermont and New Hampshire.[115] As a result, it had to seek water quality certification from both states before FERC could issue its license renewal.[116] The two states agreed to a coordinated approach and New Hampshire issued a single water quality certificate on April 16, 2001.[117] FERC conducted an extensive environmental assessment and subsequently issued FMF a new 40-year license on April 8, 2002.[118]

B. Mercury Contamination Restrictions Imposed

The states addressed elevated levels of mercury obliquely in setting conditions on their water quality certification.[119] Specifically, they set 28

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[114] *Id*. The New Hampshire Pollution Prevention Program uses its funds to supplement its state collection and recycling programs for mercury-containing products and devices, such as fluorescent lamps, thermostats, motor vehicle switches and mercury sources at schools and dental offices. N.H. DEP'T OF ENVTL. SERVS., N.H. POLLUTION PREVENTION PROGRAM BIENNIAL REPORT TO THE LEGISLATURE 2007-2008, *available at* http://des.nh.gov/organization/commissioner/pip/publications/co/documents/p2biennial07-08.pdf (last visited Apr. 27, 2011). Vermont also receives funding to support its Mercury Education and Reduction Campaign, administered by its Advisory Committee on Mercury Pollution. 10 VT. STAT. ANN. § 7113 (2011).

[115] FERC, ORDER ISSUING NEW LICENSE, *supra* note 98, at 11.

[116] *Id*.

[117] *Id*. at 11-12. In New Hampshire, the Department of Environmental Services is charged with ensuring that hydroelectric operations do not interfere with New Hampshire's water quality standards. Certifications are issued by the Watershed Management Bureau. In Vermont, the Agency of Natural Resources is charged with ensuring that hydroelectric projects' operations do not interfere with Vermont's water quality standards. 10 VT. STAT. ANN. § 1004; 33 U.S.C. § 1341. Agency of Natural Resources' Department of Environmental Conservation administers Vermont's certification program. When determining whether to grant certification to hydroelectric projects, DEC considers the numeric and narrative criteria of Vermont's water quality standards and the management objectives applicable to the classification of the affected waters. AGENCY OF NATURAL RESOURCES, PROCEDURE FOR PROCESSING CERTIFICATION APPLICATIONS FOR HYDROELECTRIC FACILITIES 1 (2009).

[118] FERC, ORDER ISSUING NEW LICENSE, *supra* note 98, at 40.

[119] *Id*. at Appendix A.

conditions on the project owner, only two of which specifically address mercury.[120] One condition requires that the owner file a long-term plan with the states' water quality agencies for monitoring and reporting mercury in fish tissue at the Moore and Comerford reservoirs.[121] To comply with this condition the owner must also consult with and report monitoring results to U.S. Fish and Wildlife Service because two species in the watershed (the bald eagle and the freshwater mussel) are listed as endangered under the federal Endangered Species Act.[122] The second mercury-related condition holds the owner responsible for posting and maintaining fish consumption advisories at public access points within the project boundary.[123] FERC incorporated both conditions as part of the project owner's responsibility to mitigate environmental impacts by enacting enhancement measures.[124]

Other than incorporating these two conditions into the license and the funding to mitigate non-hydropower sources of mercury under the Mercury Settlement, there is little addressing the mercury contamination caused by FMF in FERC's environmental assessment and order issuing a new license.[125] Interestingly, FERC acknowledged that in some instances reservoir drawdowns have been linked to elevated levels of mercury.[126] Nevertheless, FERC quickly back-pedaled by noting "[t]he contribution of water level

[120] *Id.*
[121] *Id.*
[122] *Id*; *see also* Endangered Species Act, 16 U.S.C. §§ 1531-1544 (2006).
[123] FERC, ORDER ISSUING NEW LICENSE, *supra* note 98, at Appendix A.
[124] *Id.* at 20.
[125] *See generally id*; *see also* FERC, FINAL ENVIRONMENTAL ASSESSMENT, *supra* note 103,
[126] FERC, ORDER ISSUING NEW LICENSE, *supra* note 98, at 277-78.

management and other factors to the fish tissue mercury levels in Moore and Comerford Reservoirs has not been fully evaluated."[127] Even though FERC goes on to explain that the project owner's fish sampling in 1996 and 1998 reveals higher levels of mercury in fish tissue than the average statewide (for Vermont) levels for mercury-contaminated fish caught in similar lakes and reservoirs, FERC seems to take the stance that there is too much scientific uncertainty to require mitigating actions.[128]

In the end, FERC imposes no limits and merely requires that the owner monitor and report mercury levels and post signs advising residents in the watershed.[129] Since FERC's enforcement duties only extend as far as requiring each licensee to comply with its license, FERC has no ability to impose mercury limits on FMF.

C. Northeast Regional Mercury TMDL

Since FMF was issued its license in 2002, the northeast states have developed a regional cleanup plan to reduce mercury in regional waters to meet water quality standards, called the Northeast Regional Mercury Total Maximum Daily Load (Northeast TMDL).[130]. New Hampshire, Vermont and

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[127] *Id.*
[128] *Id.*
[129] *Id.*
[130] NEW ENGLAND INTERSTATE WATER POLLUTION CONTROL COMMISSION, NORTHEAST REGIONAL MERCURY TMDL FACT SHEET (2007), http://www.neiwpcc.org/mercury/mercurytmdl.asp (last visited Apr. 21, 2011). TMDLs are calculations of the maximum amount of a pollutant that a waterbody can receive and still meet its water quality standards. 33 U.S.C. § 1313(d)(1)(C). Such TMDLs are required under the Clean Water Act when a waterbody has been listed as impaired due to a pollutant, such as mercury. *Id.*

other northeast states have listed the Connecticut River as impaired due to mercury.[131] Subsequently, these states collaboratively developed the Northeast TMDL, which was approved by the EPA on December 20, 2007.[132]

Although the Northeast TMDL focuses on atmospheric deposition sources of mercury and has little mention of hydroelectricity as a source,[133] it is a large step forward for reducing mercury contamination in the region. In particular, the Northeast TMDL specifically targets areas where elevated levels in fish tissue have been observed, including on the upper Connecticut River where FMF is located.[134] It also adopts measurement methods that account for bioaccumulation and biomagnification in fish tissue, rather than sampling the water column for mercury levels in water volume, a method that does not account for bioaccumulation or biomagnification.[135]

IV. SCIENTIFIC UNCERTAINTY CLOUDS MERCURY PREVENTION LAWS

FERC's comment in the FMF environmental impact statement that "[t]he contribution of water level management and other factors to the fish tissue mercury levels in Moore and Comerford Reservoirs has not been fully

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[131] *See* VT. DEP'T OF ENVTL. CONSERVATION WATER QUALITY DIV., STATE OF VERMONT 2008 303(d) LIST OF WATERS (2008), *available at* http://www.anr.state.vt.us/dec//waterq/mapp/docs/mp_2008.303d_Final.pdf (last visited Apr. 21, 2011); N.H. DEP'T OF ENVTL. SERVICES, 303(d) LIST 2008 LIST OF THREATENED OR IMPAIRED WATERS THAT REQUIRE A TMDL (2008), NORTHEAST REGIONAL MERCURY TOTAL MAXIMUM DAILY LOAD 11 (2007) [Hereinafter NORTHEAST TMDL], *available at* http://www.epa.gov/region1/eco/tmdl/pdfs/ne/tmdl-Hg-approval-doc.pdf (last visited Apr. 21, 2011).
[132] NEW ENGLAND INTERSTATE WATER POLLUTION CONTROL COMMISSION, *supra* note 131.
[133] *See generally* NORTHEAST TMDL, *supra* note 132.
[134] NORTHEAST TMDL, *supra* note 96, at 11.
[135] *Id.* at 8.

evaluated"[136] perfectly captures the regulatory attitude towards hydroelectric facilities' contribution to the mercury problem: since it is unclear to what extent water level fluctuations are contributing to the mercury contamination problem, regulators are unsure of how to minimize the problem. Without adequate studies to demonstrate the severity of hydroelectric facilities' contributions, regulators adopt the monitoring and reporting—or the "wait and see"—approach.

This section explores two of the gaping holes in mercury contamination regulation. First, Part A describes the absence of studies surrounding hydroelectricity's contributions to the problem and the resulting difficulties their absence poses for policymakers and legislatures. Part B then discusses the flaws that occur when states use the same measurement criteria for mercury as they do for other pollutants.

A. Absence of Studies

Although it is widely recognized that impounding reservoirs and damming rivers elevates mercury contamination in fish and ecosystems,[137] mercury emissions studies typically focus on other sources.[138]

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[136] FERC, FINAL ENVIRONMENTAL ASSESSMENT, *supra* note 103, at 61.
[137] *See* Driscoll et al., *supra* note 1, at 36; *see also* Roebuck, *supra* note 34, at 27.
[138] For example, separate studies conducted by the United Nations Environment Programme and the EPA on anthropogenic sources of mercury emissions fail to evaluate hydroelectricity as a source. *See generally* ARCTIC MONITORING AND ASSESSMENT PROGRAMME / UNEP CHEMICALS BRANCH, *supra* note 18; *see generally also* U.S. ENVTL. PROT. AGENCY, MERCURY STUDY REPORT TO CONGRESS, VOLUME I: EXECUTIVE SUMMARY (1997), *available at* http://www.epa.gov/ttn/oarpg/t3/reports/volume1.pdf.

Consequently, there are serious deficiencies in the information available on hydroelectric mercury emissions. Further research is needed on these sources to provide policymakers with the specific data required for effective water management. Specifically, studies are required to assess hydroelectricity's inputs relative to other anthropological sources and to quantify the difference between mercury contamination caused by natural wetlands processes and hydroelectric facilities.[139] Additionally, information on baseline mercury levels in reservoirs is needed to evaluate the extent of mercury contamination typically resulting from hydroelectric facilities.[140] This section looks at each issue in turn.

Currently, studies assessing the relative mercury inputs from different anthropological sources exclude hydroelectricity.[141] As a result, it is impossible to determine where hydroelectric facilities' contributions rank in terms of creating pollution for the purposes of prioritizing efforts to prevent

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[139] U.S. ENVT. PROT. AGENCY, *supra* note 140, at 3-5 ("Further study is needed to determine the importance of natural and re-emitted mercury, and the contribution of water discharges relative to atmospheric deposition."). A search on the scientific database *Web of Science* for terms "mercury AND wetlands AND hydroelectric" returned with 9 publication results, only 6 of which analyze MeHg in both wetlands and hydroelectric reservoirs.

[140] For example, a report prepared by Vermont's Advisory Committee on Mercury Pollution noted that necessary studies include assessing MeHg background levels. VERMONT'S ADVISORY COMMITTEE ON MERCURY POLLUTION, GETTING THE MERCURY OUT OF VERMONT'S ENVIRONMENT: A CALL FOR ACTION 5 (2001), *available at* http://www.mercvt.org/acmp/reports/2001_report.pdf. Because background MeHg levels vary depending on geology, studies must be conducted on the specific site for each proposed reservoir. *See generally* Leena Tuomola, Terese Niklasson, Edinaldo de Castro e Silva, Lars D. Hylander, *Fish Mercury Development in Relation to Abiotic Characteristics and Carbon Sources in a Six-year-old, Brazilian Reservoir*, 390 SCIENCE OF THE TOTAL ENVIRONMENT 177 (2008) (discussing MeHg levels in hydroelectric reservoirs in the tropics); *see generally also* R. A. (Drew) Bodaly, W. A. Jansen, A. R. Majewski, R. J. P. Fudge, N. E. Strange, A. J. Derksen, D. J. Green, *Postimpoundment Time Course of Increased Mercury Concentrations in Fish in Hydroelectric Reservoirs of Northern Manitoba, Canada*, 53 ARCHIVES OF ENVIRONMENTAL CONTAMINATION & TOXICOLOGY 379 (discussing MeHg levels in boreal reservoirs); *and* J.R. Ikingura, H. Akagi, *Total Mercury and Methylmercury Levels in Fish From Hydroelectric Reservoirs In Tanzania*, 304 THE SCIENCE OF THE TOTAL ENVIRONMENT 355 (2003) (discussing MeHg levels in Tanzania).

[141] *See* ARCTIC MONITORING AND ASSESSMENT PROGRAMME / UNEP CHEMICALS BRANCH, *supra* note 18.

mercury contamination. This lack of information inhibits policymakers' successful decisions because without knowledge as to hydroelectricity's relative mercury outputs, an accurate and complete cost-benefit analysis is impossible. Moreover, the lack of studies on hydroelectric facilities' relative contributions means that regulating agencies, including state water quality agencies and FERC, overlook the problem because the full impacts of hydroelectric facilities' mercury inputs have not been quantified in empirical data.

There is also inadequate information regarding the difference in mercury contamination from hydroelectric facilities' operations and natural systems, such as wetlands.[142] Without this information it is unclear whether hydroelectric facilities are a greater or lesser contributor than wetlands. Although it remains possible that mercury contamination from hydroelectric facilities does not pose a significant risk, we do not currently have the data to make such assessments.

There is insufficient information determining baseline mercury levels in waters.[143] Data on mercury levels is meaningless for regulatory purposes without adequate baseline figures because baseline data is necessary to calculate the amount the levels have elevated. Without such calculations, the actual impacts are unknown. For example, the Northeast TMDL uses mercury levels measured in 1998 as its baseline, but the FMF complex had

[142] U.S. ENVT. PROT. AGENCY, *supra* note 140, at 3-5 ("Further study is needed to determine the importance of natural and re-emitted mercury, and the contribution of water discharges relative to atmospheric deposition.").
[143] VERMONT'S ADVISORY COMMITTEE ON MERCURY POLLUTION, *supra* note 142, at 5.

already been in operation for decades prior to 1998.[144] As a result, the baseline levels being used to calculate goals for mercury are baselines based on already impaired waters and not true natural background levels. Without studies assessing natural background levels, setting goals to achieve lower mercury levels are merely 'taking shots in the dark.'

Lastly, there is insufficient information quantifying how much mercury contaminates the food web and how high mercury levels rise when a reservoir is impounded or when water levels fluctuate.[145] Without empirical data on the extent of the damage, it is difficult for agencies and project owners to manage the waters to minimize the problem. In addition, because each reservoir likely has a unique biota (aquatic life), at least to some extent, rates of bioaccumulation and biomagnifications may differ. As a result, the best course of action for managing water is to monitor the problem in each reservoir with an eye for imposing restrictions in the future. However, this method fails to inform future developments how to minimize impacts.

B. Discrepancy between Measuring Systems

Scientists monitor mercury contamination levels by sampling fish tissue in the form of a mass measurement (micrograms or µg/g). However,

[144] NEW ENGLAND INTERSTATE WATER POLLUTION CONTROL COMMISSION, *supra* note 131.
[145] *See* FERC, FINAL ENVIRONMENTAL ASSESSMENT, *supra* note 103, at 61; *see also* VERMONT'S ADVISORY COMMITTEE ON MERCURY POLLUTION, *supra* note 142, at Appendix A, 2-3.

many states' water quality criteria measure mercury by parts per million (ppm) or micrograms per liter (μg/L), which measures mercury in the water. Measuring fish tissue concentrations accounts for bioaccumulation, and thus fish tissue samples are more likely to pick up mercury levels than samples taken from water columns.[146] Moreover, water column samples may vary depending on the place from where the sample was taken; whereas, fish tissue samples account for the mercury contamination occurring in the ecosystem as a whole and over longer time periods.

Many states have recognized the inadequacies of water column samples and have altered their measurements to better account for bioaccumulation in waterbodies.[147] For example, the Northeast TMDL takes into account bioaccumulation by setting targets for fish tissue concentrations, rather than water column concentrations.[148] However, because most states continue to use water column samples to measure the amount of various pollutants in the waterbody, mercury is not adequately measured. Using the same measurement criteria for mercury as for other pollutants ignores the vital fact that mercury is biomagnifying up the food chain and onto our plates.

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[146] NORTHEAST TMDL, *supra* note 132, at 8.
[147] *Id.*
[148] *Id.*

V. PROPOSED SOLUTIONS

It is impossible to propose clear solutions due to the lack of information on hydroelectricity's relative contributions to mercury contamination. However, there are ways forward: certain questions can be addressed to better advise water management practices. Further, the Northeast TMDL provides a useful model for reforming state water quality criteria for mercury. Finally, precautionary measure must be imposed until there is more information surrounding hydroelectric facilities' contributions to the mercury problem. Continuing to proceed with hydropower development and re-licensing existing operations without knowledge of hydroelectricity's mercury impacts is not just ignorant, it is foolish.

Part A of this section recommends the most effective solution for reducing the impacts of hydroelectric facilities' mercury contamination: reduce energy consumption to require less hydropower. Part B suggests studies that may be done to provide more information on the true mercury contamination coming from hydropower. Part C offers an easy first step: reform state water quality criteria to recognize mercury's bioaccumulation and biomagnifications effects. Finally, Part D suggests that hydroelectric facilities minimize water fluctuations as much as possible until further studies evaluating the facilities' true impacts are done and there is more information as to how to best manage waters to minimize mercury contamination.

A. Reduce Energy Consumption

The surest way to prevent hydroelectric facilities from further contributing to mercury contamination is to stop further hydroelectricity development and to consume less energy, which will require less power from existing reservoirs. The less waters are manipulated, the less mercury contamination is likely to occur. However, without additional studies that demonstrate the quantities of mercury contamination caused by water manipulations and reservoir impoundments, it is impossible to know exactly how much reducing water manipulation will help. Further, given the pollution of coal-fired systems, a more sensible reduction strategy might be to reduce power supplied from fossil fuels first, before tackling hydroelectric facilities. Nevertheless, until we can fully and accurately evaluate relative pollution from both sources it is difficult to make intelligent choices.

B. Suggested Studies to Resolve Scientific Uncertainty

Studies should be done to determine what the additional MeHg is adding into an ecosystem when impounding a reservoir or damming a river. Currently, there is information regarding the damage suffered by fish, the ecosystem, and humans that consume contaminated fish, but there is little information as to baseline mercury levels in waters. One approach for conducting such studies might be to estimate naturally-occurring mercury concentrations in wetlands and compare it to dam systems. Another approach might be to measure mercury concentrations in a watershed prior to developing a hydroelectric complex on that water. In the context of the FMF complex, studies could be conducted measuring mercury levels in waters upstream. These measurements could thus provide a baseline against which mercury levels in the FMF reservoirs could be compared. Once that information is available, it will be possible to adjust the Northeast TMDL to account for FMF and other hydroelectric facilities' contributions to the mercury contamination in the upper Connecticut River and require pollution reductions.

Further studies are needed to establish a method for assessing the amount of mercury in the food web when a reservoir is impounded and when water levels fluctuate. Until hydroelectric facility regulators and developers understand what mercury quantities to expect from development or water fluctuations, water management can only be precautionary. Moreover, the lack of knowledge surrounding the amount of damage that hydroelectric facilities cause makes it impossible to place hydroelectricity within a list of priorities to target for mercury reductions. Fish tissue concentrations should be taken from FMF reservoir fish before and after various sized drawdowns occur to quantify the amount of mercury released as a result of water fluctuations. With this data, it will be possible to determine whether several small drawdowns or fewer large drawdowns are more effective in reducing the amount mercury levels are elevated with each drawdown. Because bioaccumulation occurs over a period of time, such studies would have to monitor mercury levels continuously within each system. The states could then incorporate this information into the Northeast TMDL and require FMF, as well as other hydroelectric facilities, to adjust their drawdown practices to minimize mercury level elevations.

In order to understand whether the risk of mercury contamination caused by hydroelectricity is worth its benefits, additional data must be gathered to determine the relative mercury inputs from different anthropological sources, including hydroelectricity, coal-fired power plants, waste incinerators, chlorine-alkaline plants, and pulp and paper mills. With information as to relative inputs, energy policymakers will be able to conduct a cost-benefit analysis of the various power producing options. Once available, this information will also aid regulators in setting different mercury limits based on the source. For example, if these studies demonstrate that coal-fired power plants are contributing a substantially higher percentage of mercury contamination than hydroelectric facilities, policymakers may decide to rely more heavily on hydroelectricity as a power source (or other more efficient methods to remove mercury from gaseous emissions). If this shift in power production occurs, then the relative total mercury inputs will also shift, and there may be more concern surrounding hydroelectric facilities' contributions to mercury contamination. These suggested studies will provide regulators with the information they need to set limits specific to hydroelectric facilities' development and operations.

C. Reform Water Quality Standards

The Northeast TMDL is a good example of how water quality standards may incorporate criteria that accounts for mercury bioaccumulation in fish. The Clean Water Act requires water quality agencies to develop and publish water quality criteria "accurately reflecting the latest scientific knowledge."[149] However, even states such as those in the northeast—states that have determined that accurate mercury quantification requires sampling fish tissue concentrations in order to accurately assess the extent of the contamination—continue to use water volume measurements in their water quality criteria. The Northeast TMDL is what actually implements the requirement that fish tissue concentrations be sampled, *not* the water quality criteria. As a result, it is only impaired waters that receive the benefit of the "latest scientific knowledge." Thus, states should reform their water quality criteria to reflect advances in scientific knowledge and alter their mercury measurements to account for bioaccumulation. Such reform would ensure that not only the impaired waters receive adequate monitoring and protections, but could also potentially stop unimpaired waters from becoming impaired.

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[149] 33 U.S.C. § 1314(a)(1).

D. Impose Precautionary Measures

Further studies that assess exactly how much MeHg is released when water fluctuates will advise hydroelectric facility owners and regulators as to how to minimize mercury contamination, but until such studies are available, owners and regulators should take precautionary measures. Owners should assess any waste being produced by large reservoir drawdowns and make efforts to minimize water fluctuation as much as possible. Additionally, FERC should specify water fluctuation restrictions in future licenses. Even if "[t]he contribution of water level management and other factors to the fish tissue mercury levels in Moore and Comerford Reservoirs has not been fully evaluated,"[150] studies show that such water fluctuations cause mercury contamination and thus hydroelectric facility owners and regulators must take responsibility for minimizing impacts.

CONCLUSION

We do not know how much hydroelectricity facilities are contributing to mercury contamination in the United States. Scientists have only recently recognized hydropower's contributions to mercury pollution and regulators appear focused on reducing mercury air emissions. Thus, perhaps it is not surprising that hydropower flies under the mercury regulation radar.

[150] FERC, ORDER ISSUING NEW LICENSE, *supra* note 98, at 277-78.

However, mercury is a highly toxic pollutant, with well documented impacts on human health.[151] In addition, natural systems can only handle so much stress. Adding toxic methylmercury to an already polluted environment might push that system towards ecosystem collapse. Currently, our ability to predict the ecosystem consequences of pollution is poor, but ignorance is not an excuse for inaction. As in the *parable of the rivet popper*, each pollutant we add (or rivet we pop) increases the risk of collapse.[152] Permitting hydroelectric facilities to be built and operate without imposing mercury limits may place our ecosystems in such a fatal position. Reducing mercury contamination must be a priority, whatever the source.

It is possible that legislatures rightly have more pressing mercury contamination sources to address than hydropower, but until further studies are conducted it is impossible to know this with certainty. This paper suggests a few ways forward: recommending studies to assess the extent of the problem, using natural levels of mercury as a baseline, and quantifying the relative inputs hydroelectric facilities compared with other anthropogenic sources.

In the meantime, there are steps that can be taken now. Specifically, two straight-forward immediate actions can help minimize hydroelectricity's contributions to the mercury problem. First, states should revise water quality criteria to incorporate the latest scientific knowledge and measure

[151] *See* SMITH & LOURIE, *supra* note 33, at 132; Dumont et al, *supra* note 40, at 1440.
[152] PAUL R. EHRLICH & ANNE EHRLICH, *supra* note 23, at xi-xii. *See* note 24 for the full text of the parable.

mercury by sampling fish tissue concentrations. It is important for states to adopt such measurements in their water quality criteria. Although TDMLs provide a valuable function, they are insufficient to regulate mercury pollution because they are only implemented once a waterbody is already impaired. Reforming the water quality criteria would provide a stringent standard for waters *before* they become impaired.

Second, hydroelectric facility owners should exercise precaution by minimizing water fluctuations to reduce mercury contamination until best management practices have been recommended. FERC and state water quality agencies should require such precautionary measures as conditions to issuing operating licenses and state certifications. Until there is more information as to how to best manage hydropower waters, the precautionary principle—rather than the "wait and see" principle—must be followed by owners and regulators alike.

The longer hydroelectric facility owners and regulators continue to ignore impacts of mercury pollution the more stress we put on our waters, our fish, and our ecosystems. Our failure to account for hydropower's contributions to the mercury problem can no longer be ignored. It is critical that we address the scientific uncertainty regarding ecosystem impacts. In the case of methylmercury pollution, ignorance is risk.