THE NORTH AMERICAN REGIONAL ACTION PLAN ON MERCURY

Public Consultation

Observations and recommendations submitted to the Commission for Environmental Co-operation by the Grand Council of the Crees (Eeyou Istchee)

Montréal, Canada

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Executive summary

The following brief respecting the proposed Mercury NARAP is submitted by the Grand Council of the Crees (Eeyou Istchee) on behalf of the nine Cree aboriginal communities in Northwestern Québec, Canada. The major conclusions and recommendations contained in this brief are summarised below:

1. The Grand Council has intervened because of a long history of environmental mercury contamination in the traditional hunting territories of the Cree population. The emergence of mercury as a public health concern has had important consequences for local subsistence fisheries, which have greatly declined as a result, leading in turn to other health-related issues of considerable concern to health authorities. We believe that this experience is relevant to the Mercury NARAP;

2. The Cree hunting territories in Québec are also the site of one of the largest hydro-electric complexes in North America, and methyl mercury contamination associated with this project - by far the most obvious anthropogenic source of mercury contamination - has added considerably to the difficulty of addressing regional problems of environmental mercury contamination. We also draw attention to the significance of the experience of Manitoban Cree communities of mercury contamination arising from hydro-electric development.

3. Because of this thirty-year experience with environmental mercury contamination, the Cree territory is a potentially useful source of information and guidance with respect to different aspects of mercury policy;

4. The proposed Mercury NARAP does not deal adequately with methyl mercury contamination arising from hydro-electric development. Moreover, A NARAP for mercury which does not address this energy sector as a major regional source of contamination will likely be regarded by aboriginal communities as incomplete and selective.

5. The proposed NARAP suggests that environmental impact assessment might be used to address the problem of mercury in reservoirs. The validity of this claim depends very much on the possibilities of mitigation. Considerably

more emphasis should be placed on the development of mitigation strategies in this sector; the brief elaborates on possible approaches to mitigation and related research needs, and explains why we believe that the use of environmental impact assessment is unlikely, in isolation, to resolve the problems posed by this form of mercury contamination;

6. The brief explains our concerns about the emphasis on industrial use of mercury and the control of point-source atmospheric emissions, and explains why we consider it important that the NARAP stimulate and encourage research directed at a better understanding of the behaviour of mercury at a watershed level, and in particular the role of hydrological processes in levels of contamination of individual lakes and streams;

7. We point out the need for integration between the ecological and the toxicological dimensions of environmental mercury contamination, and we explain some of the serious limitations in the existing toxicological and epidemiological data when applied to problems of risk assessment for northern aboriginal communities and probably to other human populations; significant further work is required in this area if credible public health advice is to be provided to such communities;

8. We draw attention to the significance of monitoring as an issue in the evaluation of the Mercury NARAP in the course of its implementation, and we focus on the use of fish as biological indicators; we comment on some of the methodological difficulties associated with the use of fish, and offer some suggestions regarding the type of research needed to define appropriate monitoring strategies to meet different societal objectives;

9. We also draw attention to the importance of reliable data on mercury in the waste streams and emissions from the industries subject to control, pointing out the importance of credible base-line values as a basis for subsequent evaluation of performance.

10. Finally, we emphasise that the control of emissions of inorganic mercury to the atmosphere from point sources is not a sufficient policy response to our present understanding of the biogeochemical and toxicological evidence. As we have explained, efforts directed at atmospheric emission controls also need to be supported by initiatives directed at the management of existing methyl mercury contamination in aquatic ecosystems, and at the biogeochemical processes responsible for that contamination.

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1. Introduction: the regional ecological and social context

This document has been prepared in order to provide input to the public consultation process initiated by the Commission for Environmental Co-operation in connection with the proposed North American Regional Action Plan (hereafter 'NARAP') on Mercury.

We will begin with a brief introduction which explains why the Mercury NARAP is potentially of considerable significance for sub-arctic aboriginal communities in Canada in general, and to the Grand Council of the Crees (Eeyou Istchee) in particular.

This brief has been prepared on behalf of a group of nine aboriginal (Cree) communities in Northwestern Québec, with a combined population of approximately 12,000. The communities are located within the Canadian boreal forest zone, in the geological province known as the Canadian Shield. This physiographic region extends from the sedimentary formations in the foothills of the Rocky Mountains to the West to the Atlantic coast to the East. This sparsely populated region, with a combined area of the order of 3 million square kilometers, includes many isolated aboriginal communities which together account for approximately half of Canada's aboriginal population.

These aboriginal communities depend in varying degrees on the harvesting for subsistence purposes of a range of wildlife resources, including fish. Many of these communities are impoverished and have limited contact with the outside world. However, historically, these are the communities which have often been most severely affected by the emergence of methyl mercury as a potential health threat in Canadian society.

These communities are relevant in general to the Mercury NARAP both because of their involvement in subsistence fisheries and because their geographical setting places them at particularly high risk of exposure to methyl mercury. These circumstances will be explained later in this brief in greater detail.

In the case of the Crees of Northwestern Québec, the history of mercury goes back to the early 1970's and the first years of operation of a mercury cell-based chlor-alkali plant. At the time, the loss of over 50 tonnes of mercury inventory into one of the major river systems draining towards James Bay and Hudson Bay triggered substantial controversy. Local (subsistence) fisheries were closed over a wide area following reports of apparently frequent neurological disease attributed to methyl mercury.

Later, more extensive surveys of blood and hair mercury concentrations at the community level revealed widespread elevation of mercury levels across the region in which the Cree live (an area of some 300,000 square kilometers). The forest products industry was implicated, along with the mining and smelting industries. However, it was becoming clear that exposure to methyl mercury was widespread, and by no means limited to the waterbodies immediately downstream from the chlor-alkali cell referred to above. As often happens in such cases, litigation followed the original medical reports and had the practical effect of putting an end to efforts to ascertain the extent and nature of mercury-related neurological disease and to explore the biogeochemical pathways of exposure of the Cree population to mercury.

Political leaders were asked to approach their communities to close the subsistence fisheries until the nature of the problem was better understood. The fishery did, in fact, re-open on a reduced scale, but under the cloud of neurological assessments (nearly half the adult population at the time, as well as a large cohort of young children representing most of the live births in a given year, underwent assessment). These medical interventions were accompanied by repeated blood and hair surveys, maintained at varying levels of intensity until the early 1990's.

The fishery declined. Some older families continued, undeterred by the successive interventions to collect samples and warnings of impending risks. But the great majority of young and middle-aged households effectively ceased to use fish as they had done in the past. Most of the population, therefore, were no longer considered 'exposed'; but the underlying toxicological and biogeochemical issues remained largely unresolved.

While this was taking place, hydro-electric development arrived in the form of the La Grande hydro-electric complex in northern Québec. The major reservoirs of this complex flooded over 10,000 square kilometers of boreal forest. The fish populations that later emerged in these reservoirs were found to have levels of mercury four to six times as high as their counterparts in lakes unaffected by reservoir construction. Non-predatory fish were found to have mercury concentrations approaching 1 ppm (a situation unheard of in previous surveys, even in strongly contaminated settings); while predatory fish reached average levels of three or four parts per million, with larger specimens reaching values twice as high. Not surprisingly, mercury came to be identified now with hydro-electric development, and reservoirs came to be seen as the major man-made source of mercury contamination. Moreover, the information available strongly suggested that this was not a short-term problem, and that a period of at least 20 to 30 years would be required before a new equilibrium was reached, particularly in the case of the predatory species.

At the same time, important structural changes were taking place in the Cree subsistence economy in Québec. Initial closure of the fishery, and subsequent restrictions, combined with the construction of highways for hydro-electric development, changed the economics of subsistence food production. In several important respects, the communities began to feel the public health consequences of the arrival of natural resource based industries. The loss of a substantial part of the fishery was a significant component in this picture, and the emergence, for example, of diabetes as a major public health issue has become linked in the public mind with the effects of the closure of the fishery.

We should also mention, in this context, the Churchill-Nelson diversion in Northern Manitoba, another major hydro-electric project constructed in Cree hunting territories during the early 1970’s. In this case, the diversion of the Churchill River into the Nelson River, through South Indian Lake, and the construction of a series of power houses on the Nelson River, had a direct impact on a series of aboriginal (Cree) communities located on these river systems. Ironically, it was commercial fishing by Cree communities on this diversion route which triggered the original discovery in Canada of extensive methyl mercury contamination in reservoir fish stocks. It so happened that the harvested fish were screened for mercury before being approved for sale. Much of the Canadian expertise on mercury, both in relation to its behaviour in reservoirs and the impacts of contamination on aboriginal communities, is derived from this hydro-electric project.

In these respects, the experience of the both the Québec and Manitoba Cree population provides a microcosm in which we can see the diverse consequences of methyl mercury contamination, whether anthropogenic or in origin, and the potential consequences of policy actions on the health and even the social and cultural integrity of aboriginal communities. We believe that the issues raised by the experience of the Cree communities in both regions have broad relevance to Canadian sub-arctic communities in general, and probably also to non-aboriginal populations engaged in recreational fisheries.

We invite the Commission, to reflect upon this experience and consider the recommendations we formulate before finalising the present Mercury NARAP.

2. <u>Industrial sources: the significance of hydro-electric energy production</u>

The Mercury NARAP, in its present form, reflects an underlying pre-occupation with the reduction in use of mercury in specific industrial, institutional or household applications, as well with the control of identifiable point-source emissions of mercury to the atmosphere. Although we understand the rationale for such a strategy, we are concerned about the difficulties of situating these releases in relation to regional-scale biogeochemical cycles of mercury and related public health issues.

Ultimately, if regulators are to be able to evaluate the ecological consequences of some combination of use restrictions and reductions in releases to the atmosphere, it will be necessary to evaluate the role of non-anthropogenic sources of mercury in a much more comprehensive manner than has been undertaken to date.

It will also be necessary, in our view, to situate the releases from known and quantifiable point sources in relation to more diffuse sources of mercury transport to and from the atmosphere, as well as hydrological processes which act to transport mercury stored in watersheds directly into aquatic systems. There is growing evidence that land use patterns which affect soil water regimes and the hydrological behaviour of rivers in valley lowlands and wetlands may influence both the production and transport of methyl mercury. This is of particular interest to us.

However, from our regional perspective, the greatest single regional industrial determinant of tissue mercury levels in fish (and, by implication, of the overall (net) rate of production of methyl mercury) is hydro-electric development.

We do not believe that the proposed NARAP deals at all adequately with this source of methyl mercury contamination.

We note that the influence of flooding during reservoir formation on tissue levels of mercury in fish has been known in Canada and the United States for approximately 20 years. In Canada, since that time, an additional 15,000 MW of hydro-electric generating capacity has been built, supplying nearly 100 TW.h of energy annually. In eastern Canada, plans are well under way for the addition of approximately 30 TW.h of energy from hydro-electric sources, as well as roughly 2500 MW of additional generating capacity. These figures imply, for northeastern North America, that hydro-electric production is a major, and possibly dominant factor in the planning of additional regional electrical energy supply.

Mercury contamination as a consequence of hydro-electric production has not generally been regarded by the utilities as amenable to mitigation. This position can be explained in part (but not necessarily justified) by the advanced stage of project planning by the time the evidence of methyl mercury contamination became widely known. Pre-occupation with the control of costs of construction or system operation has also been a factor.

It has been, in our experience, a relatively straightforward matter for utilities to argue, therefore, that mercury contamination in hydro-electric development is somehow a ‘natural’ process which cannot be mitigated; it is regarded as a temporary phenomenon (on a scale of 20 – 30 years, but perhaps longer in some cases), and the advocated policy is consequently one of ‘wait and see’. This approach has been consistently reflected in the environmental reports prepared in connection with generating plant built in the decade from 1986 to 1996 (a block of some 3,500 MW).

We believe that government policies towards this aspect of energy production require careful and critical review. There is a notable inconsistency, in effect, between the considerable amount of effort being devoted towards mercury controls in the coal-fired utility sector and the near absence of discussion about control or mitigation in the context of hydro-electric development.

It is surely not sufficient to argue that the subject will be addressed in the course of environmental impact assessment. First of all, impact statements themselves tend to reflect established corporate policy; second, in our experience, there is a predictable tendency for the authorities which approve hydro-electric projects to assume that the utility is in the best position to judge whether mitigation is justified or technically feasible; thirdly, again in our experience, utilities are in fact are public corporations acting as instruments of government policy.

In such a context, impact assessment – taken in isolation from the research and experimentation referred to elsewhere in this brief - is a very unpromising forum for critical analysis either of the issues involved in assessing probable levels of contamination, or in evaluating strategies for impact mitigation.

The limited discussions which have taken place about the mitigation of the impacts of hydro-electric development on mercury levels in fish have focused on the fish themselves, and on the removal of organic matter. The argument runs that in the right circumstances, the harvesting of fish might be used to influence the time-course and amplitude of mercury contamination. The mechanisms involve such factors as the removal (in species such as pike, which are very effective accumulators of methyl mercury), the modification of community structure (removal of the relatively contaminated predators) and the stimulation of growth (producing a growth-dilution effect on tissue mercury levels). However, in the absence of field experimentation on realistic scales and the carefully designed testing of hypotheses, these arguments will remain academic. They are certainly not likely to be dealt with rigorously in the context of an impact assessment.

In the case of organic matter, the argument runs that the problem in reservoirs originates with the accelerated heterotrophic decomposition of the organic matter associated with flooded soils and vegetation. The basic idea is simple enough – if it is practical to do so, the removal of organic matter prior to flooding may reduce the microbial activity which is assumed to give rise to the methyl mercury. The problem, especially in the case of large, northern projects, is one of scale and of targeting a biologically relevant fraction of the flooded organic material. The strategy has so far been dismissed, primarily on the grounds of economics. However, organic carbon is far from evenly distributed within reservoirs, and the feasibility of targeting certain areas – floating peat bogs would be one example – remains to be assessed. It has been found that a significant conversion of inorganic to organic (methyl) mercury lakes place in flooded podzols in the La Grande reservoirs. What is the ultimate fate of this pool of organic mercury? How does reservoir operation affect its ultimate fate? Is it possible, by judicious management of seasonal water levels, to attenuate the rate of methyl mercury production?

These are real questions, but they require experimentation, modelling, and the acquisition of relevant data from existing reservoirs. These are not activities likely to take place in the context of impact assessment.

In Canada, in the well-known Experimental Lakes Area (ELA), we now benefit from the results of an experimental reservoir in a flooded wetland (ELARP). A second experiment (known as FLUDEX) is now under way at ELA to explore the biogeochemical behaviour of mercury in an upland forest situation (building small reservoirs in dry upland forest may appear counter-intuitive, but it is seen as a necessary step in understanding what happens to mercury when dry forest soils are flooded). The challenge now is to scrutinise the information emerging from these experiments and apply them to real-world reservoirs. To do this, however, requires the collaboration of the utilities which wish to build new reservoirs (or to operate existing reservoirs); it also requires the active interest and encouragement of regulatory authorities. Despite these excellent experimental initiatives, we have yet to see the interest and motivation on the part of the utilities and regulatory authorities needed to make practical sense of the results of these experiments.

From our perspective, this is the kind of initiative which needs to be encouraged explicitly in the context of the Mercury NARAP. Perhaps, in the broader North-American context, there is a public perception that hydro-electric development is no longer politically or ecologically acceptable. But in Canada, and in particular in Eastern Canada, this is certainly not currently the case. Much of the additional electric energy production in this region is expected to come from hydro-electric sources during the next two or three decades.

A Mercury NARAP which does not, in the final analysis, address hydro-electricity as a significant factor in regional methyl mercury contamination runs the risk of being considered incomplete and selective. That, we believe it is fair to say, is how the matter would be seen from an aboriginal perspective.

3. The need for a clear definition of the nature of the 'mercury problem'

We will turn our attention now to regional problems of methyl mercury contamination which cannot be understood in terms of the relatively short-term perturbations of environmental systems characteristic of new reservoir, and which require an understanding of the operation of the biogeochemical cycle for mercury.

Industrial emissions to the atmosphere have been targeted in the belief that enough is known about the biogeochemical significance of these emissions to warrant intervention. The public, learning about this emphasis, may be inclined to accept this argument at face value. It may well be assumed that the restriction of emissions will indeed result, perhaps with some delay, in reductions of mercury levels in biota and, by implication, a reduced need for fish consumption advisories (or other measures ostensibly designed to protect the health of the population at large).

In this debate, the underlying question of the relative importance of anthropogenic and non-anthropogenic sources will inevitably be raised. This topic has become controversial in recent years, as individual researchers have staked out positions. But the issue is clouded by confused definitions, and, we would suggest, by a tendency to avoid certain key unresolved issues in the biogeochemistry of mercury. The problem is also seriously compounded by a shortage of relevant field data. Mercury releases to the aquatic environment may involve direct deposition to water bodies, as well as indirect transfers through terrestrial ecosystems and associated hydrological processes. There may also be direct discharges to the aquatic environment, both from point sources as well as resulting from land use changes (such as, for example, commercial forestry operations). The control of point-source emissions evidently addresses those particular industrial sectors where it is possible (with some margin of uncertainty) to estimate releases to the atmosphere, but it does not address these more diffuse sources. There is also the nagging problem of long-term storage and release in forest ecosystems, and the gradual appreciation, first, of the complexity of the chemical behaviour of mercury in the atmosphere as it relates to deposition processes and rates, and second, of the likelihood of significant short-term transfers of mercury between terrestrial ecosystems and overlying air masses (i.e. in both directions). This situation, unfortunately, makes it very difficult to situate identifiable point source releases in relation to the larger picture of anthropogenic inputs of mercury to the environment.

The situation just described is further complicated by two major and as far as we can see, unresolved, geochemical issues. We know that Canadian freshwater systems are associated with relatively large pools of inorganic mercury – pools which, in a regional context, are very large in relation to the quantities that are being discussed in the context of controls on atmospheric emissions. The 'pool' of inorganic mercury in the surface layers of lake sediment or of typical forest soils is large in relation to annual airborne emissions. Simple calculations using published data on characteristic concentrations of mercury in soils and aquatic sediment will serve to illustrate the magnitude of the problem. We also know that these pools are large in relation to the amounts of methyl mercury in sediments and soils, and much larger than the quantities of methyl mercury actually circulating within lake biota. The amounts of methyl mercury in fish driving fish consumption advisories are probably of the order of a few milligrams per hectare. This is a small fraction of the total pool of mercury associated with the lake sediments, and an even smaller fraction of the mercury associated with the soils through which rain and snow melt pas on their way to surface streams and lakes.

In this setting, subtle variations in the rates at which mercury is methylated and methyl mercury is demethylated are evidently very important; so presumably are the factors which influence the availability of both methyl mercury and mercury (II) to the processes which govern their transformation. These, ultimately, are the processes which govern methyl mercury levels in fish or other wildlife resources used for human consumption. It is, from this biogeochemical perspective, simply not obvious that the supply of inorganic mercury through deposition from airborne sources, or for that matter from any of the other sources mentioned above, is determining the biological availability of mercury and in driving the overall (net) production and bio-accumulation of methyl mercury. It may well be that the real controls are the processes which determine the rates of production and degradation of methyl mercury – processes which are not at all well understood and which are receiving comparatively little attention.

We are, however, encouraged by current research (mostly, but not exclusively, in the U.S.A.) which examines the behaviour of mercury at the watershed level and explores hydrological controls of the biological availability of inorganic mercury and the production of methyl mercury. From our perspective, this is the kind of research strategy which would have considerable relevance in northern Canada. One of our pre-occupations with the proposed Mercury NARAP is that it may deflect attention away from this level of integration through the emphasis on the technology of point-source emission controls.

To summarise, aboriginal communities (and presumably other users of freshwater fish resources) need re-assurance that there is commitment at the level of regulatory agencies and institutions which support environmental research to pursue vigorously a better understanding of the behaviour of mercury in those environmental settings which are currently giving rise to anomalous levels of human exposure to mercury. This is an issue which, we believe, should be reflected in the Mercury NARAP.

4. <u>Dealing with inadequacies in toxicological data</u>

The key point we wish to make here is that risk assessments for methyl mercury in the environment are constrained by some serious shortcomings or limitations in the data available to derive 'acceptable' levels of exposure to methyl mercury in human populations.

This is certainly not the appropriate forum for an extensive critical discussion on this topic, but certain points nevertheless should be raised. There is often an unfortunate tendency to treat issues in ecology and human toxicology separately; we see a need for integration, and the Mercury NARAP should provide an opportunity for such integration.

The first general point is that public policy on the issue of human exposure has largely been dictated by concerns about the protection of the foetus (i.e. avoidance of levels of exposure *in utero* which may be detrimental to human health). This emphasis raises the question of acceptable exposure in adults and women who are not pregnant (or not of reproductive age). Approaches to controls based on 'typical' purchasing practices of Canadian consumers of fish (as in the United States) may logically be directed at the perceived most vulnerable portion of the population. However, these approaches do not address other segments of the population, and more particularly they do not take into account the temporal distribution of exposure characteristic of subsistence food production systems in aboriginal communities, or for that matter in recreational or sports fisheries. Any aboriginal society seriously concerned with the maintenance of subsistence food production systems must inevitably make important assumptions about how best to deal with such patterns of exposure. This becomes particularly important when the issue at stake is the balancing of the nutritional (and other public health) benefits of fish consumption with the presumed risks associated with methyl mercury. The type of policy advice currently available does not address these issues, and the consequences for aboriginal (and presumably non-aboriginal) communities are important.

On the subject of *in utero* exposure, there is a major debate taking place, primarily but not exclusively in the United States, about the interpretation of two carefully planned and executed prospective studies of the implications of pre-natal exposure for child development. Again, we will not go into detail but will point out that the two studies seem to be generating very different results; to the extent that there is consensus, it is a consensus to the effect that it will probably necessary to track the development of these child cohorts into puberty and the teens using shared protocols before it is possible to derive firm conclusions from either of these studies. The debate about these prospective studies, therefore, may very well continue for another decade.

It comes down to a debate about numbers: a recommended upper level of between 0.1 and 0.5 microgram of methyl mercury per kilogram of body weight per day. We strongly believe that it is important to situate these numbers in relation to plausible levels of methyl mercury in subsistence fisheries (and recreational fisheries). When approached from this angle, it becomes clear that aboriginal communities (as well as recreational fishers) have some very difficult decisions on their hands. Indeed, it is not at all clear that subsistence fisheries are compatible with the advice currently being provided through the tools of risk assessment.

Contrasting interpretations of existing toxicological evidence have direct relevance for aboriginal populations in Canada. In the one case, the argument runs that it is possible to maintain subsistence fisheries, with some prudent limitations on fish consumption during pregnancy, and that the health of the children will benefit as a result. In the other case, the argument is that current tolerances for methyl mercury exposure during pregnancy should be cut back significantly (by about 60% in the Canadian case). The restrictions thus advocated would have the practical effect of closing down the remaining subsistence fisheries in many aboriginal communities, if systematically applied. In our experience, we have had great difficulty reconciling the public health and nutritional benefits of local food fisheries with the implications of conventional advice about maximum tolerable intake of dietary methyl mercury.

Meanwhile, the toxicological evidence for the consequences of life-time, periodic, exposure to methyl mercury in adult populations is seriously limited. It remains very unclear how, and to what extent, exposure should be controlled – and, by extension, what form a risk assessment (balancing public health benefits against perceived toxicological risks) should take. If the preferred policy is to use criteria to protect the unborn child for the protection of the population at large (which is presently the case in Canada), there are potentially significant implications for that population. In our view, both the toxicological and public health implications have been inadequately addressed in the context of aboriginal communities.

For aboriginal communities, and other communities dependent on fish, the issues are critical to the survival of subsistence food production systems. It is important, from this perspective, that the CCME consider very seriously how these toxicological and related public health issues should be addressed. It is particularly important that the policy makers avoid the conclusion from the NARAP that the regulation of the use of mercury and the control of emissions from point sources is an adequate policy response to the available biogeochemical and toxicological evidence. As we hope you will conclude from this text, there are other pressing issues that also need to be addressed.

5. The issue of monitoring

The implementation of the Mercury NARAP raises the general problem of monitoring. How will the effectiveness (in an ecological, or perhaps a toxicological sense) of the NARAP be assessed in the future? How will the performance of individual countries and their institutions be gauged? What is an appropriate geographical or temporal scale for such an evaluation? In this section, we comment on some of the difficulties involved in devising an appropriate monitoring strategy using fish as a biological indicator. Fish are not only possible gauges of the effectiveness of a control policy for mercury, but they are effective accumulators of methyl mercury, and considerable public resources in recent years have been devoted to building data bases for mercury in fish.

Tissue mercury levels in fish of a given species are a fairly complex function of differential growth rates, the energy costs of reproduction, and the evolution of diet as a function of growth and age. Within a given community, there is considerable variance between specimens of a given age, and relationships (in terms of mercury concentration) depend on fish community structure (food chain length). Many fish communities, especially in relatively accessible regions, are affected to varying degrees by different harvesting (fishing) strategies (or other forms of human disturbance). To the extent that these perturbations affect growth rate or diet, they may affect tissue mercury levels. The probable quantity (as distinct from concentration) of methyl mercury associated with a given fishing strategy (gill net or angling) will also be reflected in the size and species composition of the harvest, and consequently the local history of fishing pressure and other factors which may influence fish community composition and growth.

These are factors which make it quite difficult to design a monitoring strategy capable of detecting subtle temporal or geographical trends in mercury concentration. Agencies which have been engaged in developing fish consumption advisories typically have not needed to deal with these complexities. It has been sufficient for their purposes to obtain a sufficient number of samples to carry out a regression analysis and determine a tissue mercury concentration for a given fish length (or vice versa). Hydro-electric utilities (particularly in the province of Québec), have generated large amounts of data in connection with the construction of reservoirs, but in general have also been content to determine the mercury concentration associated with a particular length of fish.

Monitoring in connection with policy evaluation will require more subtle approaches to the optimisation of fishing strategies to meet explicit monitoring objectives. The very large existing data sets (in Québec, for hydro-electric development, and in Ontario for sports fisheries) might be put to use to explore the question of precisely what kind of knowledge is required about fish stocks in order to devise an appropriate monitoring strategy. The biostatistical and bioenergetic issues are quite challenging, and will require an interdisciplinary effort. It will be particularly important to determine levels of statistical power associated with a given strategy, and to focus on detectable effect sizes. The costs associated with fisheries surveys are significant, and an additional reason for careful consideration of cost effectiveness in monitoring. Indeed, cost-effectiveness is itself a justification for examining existing data sets to derive improved monitoring strategies.

We hope that the need for effective monitoring will be raised in the context of the Mercury NARAP; and we also hope the research needed to design and evaluate different monitoring strategies for different objectives will be identified as a priority. From the perspective of northern aboriginal communities, we believe that it is important to be in a position to obtain reasonably clear answers to questions about trends in mercury concentration over time in such a way that we can distinguish between effects which are linked to the supply of mercury and its biogeochemical cycle, and effects which reflect changes in fish population dynamics.

5. Statistical issues in emission measurement

A problem which has not been dealt with in great detail in the development of the proposed Mercury NARAP is that of the variance associated with the waste streams themselves. Performance at the point-source levels depends on the measurement of concentrations in stack gases and particulate emissions (and presumably in relating these concentrations to total releases to the atmosphere). The waste streams, however, are not of constant composition, and will exhibit variance which reflects the particular type of discharge (e.g. emissions from coal fired generating plant, incinerators, and metal refining). It would appear that a significant amount of additional work is going to be needed to characterise waste streams in order to determine what indeed is an appropriate sampling strategy for a given point source. Otherwise, and in the absence of such background, questions are inevitably going to arise about not only the reliability of the data series generated by particular emitters, but also the reliability of the initial reference level – the starting point. This aspect of source characterisation appears to require further consideration within the framework of the NARAP objectives.

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Conclusion

We hope that we have succeeded in making the case that it is necessary to take a broad view of the scope and objectives of the Mercury NARAP. We have specifically identified hydro-electric development as a neglected area in the existing proposal, and the need to develop realistic mitigation strategies. We have also argued for a strengthening of the biogeochemical foundations used to establish mercury policy. More emphasis will be needed on the behaviour of mercury in the receiving environment, and more specifically at the levels of the watershed, where the transformation of inorganic to methyl mercury takes place, and where demethylation also occurs. Assessing rates of both methylation and demethylation are, at the moment, primary weaknesses in our ability to describe the behaviour of mercury in aquatic ecosystems. We have drawn attention to serious inadequacies in the existing toxicological data, and the considerable difficulties these inadequacies pose for attempts to evaluate risks which take into account the nutritional and other benefits of fish production. Monitoring has been identified as a key area requiring further research, and we have illustrated this theme using the example of fish as a biological indicator. Lastly, we have commented on the importance of source characterisation (including variance) as a credible basis for assessing the performance of control-based strategies.

We hope that with these observations, we will be able to contribute to the development of the final version of the Mercury NARAP.

The Grand Council of the Crees (Eeyou Istchee)
Québec
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