Something in the water—life after mercury poisoning

September 26 2017, by Joshua Sokol

From 1932 to 1968, hundreds of tonnes of mercury seeped into the clear waters of Minamata Bay, Japan, causing health and environmental problems still felt today. As the first global treaty on mercury finally comes into force, what have we really learned from this disaster? Joshua Sokol reports from Minamata.

Walking by the side of her house, Rimiko Yoshinaga points at the broad, vine-encrusted tree her grandfather used to climb. During one of the most famous environmental disasters in history, this tree stood over the calm, clear waters of the Shiranui Sea. He would perch up there and call down to say whether the fish were coming, Rimiko says.

The view today is jarringly different. Now the steep edge of Myojin Point in Minamata, Japan, doesn't overlook the water. Standing there now, you see roads, athletics fields, three separate museum facilities, a seaside memorial park and a scenic bamboo garden – because bamboo roots grow sideways instead of down. Under all this new land is a plastic seal. And under that are millions of tonnes of mercury sludge.

Reclaimed after a long, expensive construction project, this was ground zero for a mystery illness known first as 'strange disease' or 'sauntering disease' or, ominously, 'dancing cat disease'. Now it's just called Minamata disease. The cause? From 1932 to 1968, the Chisso chemical factory discharged up to 600 tonnes of mercury into what was then a harbour. The factory was using the mercury to speed along a reaction that produced acetaldehyde, an ingredient in many plastics. But the

company lost so much mercury in the process that it later established a subsidiary to mine it back from polluted sediment nearby.

After flowing out of the factory's drainage channel, some of the mercury was taken in by plankton, which were then eaten by bigger things like horse mackerel, sardines and shellfish, which in turn were eaten by still bigger creatures like cutlass fish and black porgy. At every step, the mercury – a potent neurotoxin – became more and more concentrated, until it ended up between a pair of chopsticks.

In her living room, Rimiko brings out green tea and local pastries, sits down with her mother and husband, and starts talking. Like almost everyone else in Minamata, and especially like the three other families living in their small hamlet close to the pollution's source, they ate a lot of seafood in the early 1950s. They didn't know. Rimiko's grandfather was a fisherman – every day he brought some of his catch home. Her father had a job at the factory that caused the pollution, but he himself would go fishing after coming home at night. Her elder brother gathered shellfish and crabs.

When she gives public talks, Rimiko pauses at this point of the story to show a black-and-white picture of her and her three siblings in formal clothes. Then she asks audiences to pick her out of the line-up. It's easy – she still has the same round, open face and high eyebrows. While her siblings sport bowl cuts, her short brown hair parts in the same place today as it did then. Born in 1951, she is the youngest. She smiles during this part of the story.

The mass poisoning that happened next is famous in Japan and around the globe. It acts as a sort of first cause for mercury researchers and policy makers, many of whom have made pilgrimages to Minamata or who have met survivors like Rimiko at international conferences. The tragedy has also given them a prime directive. Literally. With a UN

treaty that governs the use of mercury, called the Minamata Convention on Mercury, they aim to prevent something like this from ever happening anywhere again.

Since it was signed in 2013, 74 countries have ratified the Minamata Convention. It entered into legal force in August 2017. Just this week, the arrangements for its implementation are being negotiated at the first Conference of the Parties in Geneva. That's good news, made possible because finding alternatives to mercury in industrial processes is not too difficult, says Susan Keane of the National Resources Defense Council. "It's not climate change," she says. "Here's a problem where most of the world agrees we can do something."

Some six decades on, you could argue that the story of Minamata is on its way to a neat resolution. But the town's legacy split into different branches a long time ago. It's part parable: the research Minamata inspired on mercury has helped identify other poisoning episodes, and is now culminating in an attempt to solve a thorny environmental problem. Of course, Minamata is also a real place, saddled with an immense burden and filled with reminders: memorials, old trees that used to stand over the sea, and a large population of activists and ageing victims, many of whom report that their health is now deteriorating.

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To get to Minamata from Kagoshima airport in Kyushu, Japan's southernmost major island, I take a bus and then a train that hugs the coast. Summer is the wrong time to go. It's so hot and humid that the green islands out in the Shiranui Sea fade into a grey mist of water vapour. In the city itself, mountains prickled with narrow cedars run almost straight into the water – there's a small downtown and a few scattered communities crammed into a network of valleys.

Right across from the central train station is the front entrance of the same sprawling factory as in the history books. Today, with a slight makeover, the sign reads JNC – standing for Japan New Chisso – which is the entity that took over the chemical business in 2011. Chisso itself now exists mainly to administer settlements. Modern Minamata, mindful of its history, has embraced an eco-friendly identity. In the 1950s, though, Minamata resembled feudal Japan, with the entire community in orbit around the company's castle.

Before anyone in Rimiko's family fell ill, they started seeing what are now recognised as omens of environmental catastrophe. Fish floated to the surface, struggling, and could be caught by hand; they still tasted fine, though. Then the family cat was racked with convulsions, fell into the sea and died. Hundreds of other cats, valued because they protected Minamata's fishing nets from being chewed on by rodents, died after similar dancing fits all over town. The mouse population boomed. Crows dropped from the sky.

Rimiko was too young to remember much about when the neighbours got sick, or when her father fell ill, or when he eventually died – shivering and crying in bed – in 1956. But her mother, Mitsuko Oya, a sprightly if reserved 92-year-old, does. After her husband returned from a stay at the hospital, Mitsuko tried to help him recover the best way she or anyone knew how: by feeding him more nutritious fish from the bay. Her father-in-law, the fisherman, died the same year.

To feed her children, Mitsuko took up part-time fishing and construction work. She says her most vivid memories from that whole period are not her husband's final days but the very beginning, when he started discussing his symptoms. "He complained about [how] he cannot talk properly," she says, through an interpreter. "He wants to talk, but the words will not come out."

Numbness in the mouth and in other extremities, along with difficulty speaking, are some of the hallmarks of mercury poisoning. But, by now in this story, saying just "mercury poisoning" is too vague. Mercury, element number 80 in the periodic table, occurs in a variety of chemical forms. Each has its own particular character.

The mercury you might find as a silvery liquid in a thermometer is dangerous but not the worst form. In 2014, doctors in India treated a teenage boy months after he had secretly injected his forearm with liquid mercury in an attempt to transform his bones into metal like the X-Men character Wolverine. He recovered. When the same liquid mercury vaporises into an odourless gas, it's worse: it can be absorbed through the lungs and go on to cause tremors, behavioural changes and kidney damage.

These forms are inorganic, which means that they have no carbon to tempt carbon-rich biological molecules into ill-advised interactions.

But the mercury that spilled into the Shiranui Sea and infiltrated Minamata's main sources of protein was methylmercury, an organic form with one carbon and three hydrogen atoms attached.

In living flesh, organic mercury binds with certain biological molecules and stops them from working. In some situations this also allows it to masquerade as one of the many types of amino acid in the body, the building blocks of proteins. Because of this, organic mercury can smuggle its way through erstwhile protective walls like the placenta and the blood–brain barrier. And it sticks around in a body for months, long enough to get concentrated into higher and higher doses through the food chain.

With an efficiency you might admire under different circumstances, the human gut can pull out up to 95 per cent of the methylmercury contained

in each bite of fish. It enters blood cells, where it binds with haemoglobin, and some of it goes to the liver. But the real damage comes from the sizeable amount of methylmercury that makes it into the brain, where it wreaks neurological havoc in various regions. There, it slowly changes back to inorganic mercury, which can stay in the brain for years.

The same year that Rimiko's father died and grandfather fell ill, doctors at the Chisso factory hospital began seeing the same constellation of symptoms again and again. Numbness. Loss of motor control. A narrowing of the visual field that one victim described as like looking through a bamboo pipe. In parallel, methylmercury also caused cerebral palsy-like symptoms in children born during this period, like in the Kaneko household next door.

The mothers of children affected in this way were possessed by a haunting notion: that their babies had absorbed the toxin, sacrificing themselves to save their mothers. "I saw these babies with severe neurological symptoms, and at first I couldn't believe [this was] why the mother was so safe," says Mineshi Sakamoto, a researcher at Japan's National Institute for Minamata Disease. Medically, this painful belief turned out to be right: in 2004, Sakamoto showed, with rats and later with people, that methylmercury flows out of pregnant mothers and into fetuses.

This all took a while to figure out, but court proceedings ultimately found Chisso responsible in 1973, charging it with negligence for not foreseeing the risk posed by its wastewater. Long beforehand, in the summer of 1959, factory hospital doctor Hajime Hosokawa had been conducting his own experiment by giving Chisso wastewater to cats. When one of these – the now infamous cat 400 – developed signs of Minamata disease, he reported it to management.

They ordered him to keep further experiments secret, then spent years denying responsibility as Minamata's disease outbreak drew media attention. Backed by the national government and scientists in Tokyo, Chisso criticised researchers who blamed the disease on mercury from the factory and supported research that hunted for other potential causes, like the victim-blaming theory that Minamata residents had eaten already-spoiled fish. The corporation even staged a misleading photo-op to prove the wastewater was being safely treated.

A strong argument in the company's favour was that similar factories didn't seem to be linked to the same problems. Then, almost a decade after the Minamata outbreak, the strange disease popped up again along the Agano river in faraway Niigata in northern Japan, next to another factory that used mercury in the production of acetaldehyde. It took until September 1968 for Japan's Ministry of Health and Welfare to make a formal announcement on both cases. Yes, the cause was methylmercury. Yes, it was from the factories.

The following years brought Minamata even more national and then global attention. Sympathetic outsiders moved into town from other parts of the country. In 1972, a Life magazine article by photojournalists Eugene and Aileen Smith brought chiaroscuro images of Minamata's victims to many for the first time. Activists and patients made trips to Tokyo to press the government and Chisso for compensation, leading up to the pivotal 1973 court case, subsequent negotiations and other trials.

But for many families with one or more probable victims at home, Minamata disease was something to hide. Once meaningful settlements started to come into play after the 1973 court ruling, successful claimants were afraid of what jealous neighbours would say behind their backs. And the town's economic fortunes still depended on Chisso. These tensions even played out in individual people: Rimiko's mother Mitsuko had taken on construction work for Chisso, then felt torn when

she found herself attending a sit-in at the factory's gates.

Even today, patients are cautious and deliberate about the decision to come out publically with a connection to Minamata disease. Mitsuko, who won't complain about any possible symptoms of neurological harm even now, attended a meeting or two at an activist's house. She was out; her daughter wasn't. "I wanted to live without Minamata disease," Rimiko says. "I wanted to forget about the fact, even though my father, mother – they are all patients."

Once the Ministry of Health and Welfare made its announcement, with social tensions in Minamata coming to a boil, the basic science of preventing methylmercury poisoning seemed like an easy solve by comparison. You just needed to prevent methylmercury pollution. But a young scientist at the same ministry was about to help muddy the waters.

It seems fair to describe Hirokatsu Akagi, now 75, as a Dumbledorean figure in the world of mercury science and among people with Minamata disease, who view him as a sympathetic ally. He has style: usually white or tan pants, a tucked-in shirt in a similar colour and a signature stingy brim hat, out from which pokes a ring of white hair. "Everybody knows Dr Akagi," says Laurie Chan, a toxicologist and environmental scientist at the University of Ottawa. "Everyone calls him Akagi-sensei: a teacher."

Growing up south of Minamata in Kinzancho, meaning literally 'gold-mine town', Akagi first encountered mercury as a child. "Mercury is very good play material. If you push it down, it spreads," he says, before laughing and extending a half-serious invitation: "I have [it] here."

A retired government researcher, Akagi now maintains his own lab in Fukuro, a neighbourhood of Minamata struck hard by the disease. Stacks of old papers have precipitated out over available surfaces. The walls of

his side-room office are plastered with photos of scientists in conference rooms next to pictures of wedding parties next to CVs of international researchers he considers peers and friends. One such person, Swedish scientist Arne Jernelöv, has particularly high billing above his desk.

In 1969, Jernelöv published a scientific paper in the journal Nature, which Akagi, fresh out of pharmaceutical school and newly hired at the Ministry of Health and Welfare, read with interest. Strangely, Swedish pike had been measured with high levels of methylmercury, even though nearby factories were releasing only other forms of mercury. Jernelöv and his coauthor hypothesised that mercury could be methylated inside living organisms, setting in motion the discovery that, for evolutionary reasons that remain fuzzy even today, bacteria can convert other kinds of mercury into methylmercury under the right conditions.

Curious, Akagi started digging through the ministry's own archive of chemical samples. He found a piece of mercury acetate, yet another toxic variety of mercury. It was so old that the label was barely legible. The substance should have been a white crystal, he says, absentmindedly sketching out its chemical formula on a sheet of paper.

But Akagi noticed a yellow layer on the surface that he scraped off and tested. Methylmercury, again. Not produced by humans, not converted by bacteria, but made in yet another new way – by light. Not only could other kinds of mercury waste be transformed into methylmercury, but they had more than one path to get there.

In 1972, Akagi first wrote up his findings in Japanese. "People working at companies like Chisso, and [other] chemical companies, they attack me," he says. Industry had a major stake in inorganic mercury being safe. "They call me to discuss. So many come. Old people, like they are president or something, vice-president in the company." Only 30 years old at the time, embedded in a more hierarchical culture than his

Western peers, he says he continued out of a sense of moral obligation. He resolved to publish future work in English instead.

What really mattered, Akagi thought, was not the specific way methylmercury came into being, but how much was flowing through an ecosystem. And so he set out – and succeeded – at developing a chemical method to measure mercury better than anyone else.

After a stint in Canada honing his technique in the polluted Ottawa river, and more time at Japan's Ministry of Health and Welfare, Akagi finally came to Minamata in 1981 to join the newly established National Institute for Minamata Disease, or NIMD. Ten careful, cautious years later he published his mercury measurement bible: a cookbook to count up the amount of methylmercury in a sample of water, soil, blood, hair, fish, whatever. At long last, he could use the method to map out the full rhythms of mercury in history's most famously exposed place, Minamata Bay.

At least that was the plan. Then the world's mercury researchers came knocking, and a much larger picture of mercury around our planet started coming into focus. First it was the Brazilians, concerned about mercury in the Amazon. "There is no reliable data at the time," Akagi says. "Not only in the Amazon but everywhere."

He started travelling to help assess sites of mercury pollution – Brazil and then Indonesia, the Philippines, Tanzania. At the same time, dozens of researchers from all over the world started making pilgrimages to Minamata to learn the technique. They were young and sometimes poor, and they almost always slept at Akagi's house. His wife and children liked it, he says.

Armed with Akagi's method, researchers have shown that the mercury problem is multifaceted. Besides Minamata, there have been other

severe and concentrated mercury poisonings. The indigenous Grassy Narrows people in Ontario, Canada, developed their own cases of Minamata disease thanks to discharges from a paper and pulp mill that created mercury waste, and rural Iraqis died by the hundreds in 1971 after eating imported grain intended for planting that had been dressed with methylmercury fungicide.

Much larger populations are exposed to lower but still harmful concentrations. Inorganic mercury also comes into the world from sources like volcanoes, and in the last few centuries human industry has accelerated its release – it's also emitted by burning coal. The atmosphere is now laden with five times more mercury than in pre-industrial times. This pollution doesn't respect borders. Once in the air it can settle all over the globe, even in supposedly pristine locations like the Arctic, and can be converted to methylmercury in environments ranging from the guts of insects to thawing permafrost to the water column of the open ocean.

For most of the developed world, the health effects are subtle, with adverse effects being largely avoidable. Food webs and biochemistry alike focus mercury into the muscle tissue of large, sleek ocean animals that humans like to eat – so don't consume lots of athletic predators like swordfish and tuna, especially when you're pregnant. But this advice is harder to follow, and the risk of poisoning more immediate, for communities like Minamata with deep cultural ties to the water and no other accessible, affordable protein.

Overall, the world's coastal indigenous groups fill their plates with 15 times more seafood than the average for their country, a 2016 study found. Faroe Islanders traditionally eat pilot whales, which build up high levels of methylmercury, for example. Many of Canada's indigenous First Nations depend on fish and seals.

Many of the sites Akagi has visited in South America, Africa and Asia are small gold mines, as cavalier with mercury today as Akagi's hometown was in the 1940s. Right now, this is the world's largest source of mercury pollution. If you mix mercury with gold-rich sediment, the two metals form an amalgam, and you can then cook off the mercury as vapour. It's all very convenient for miners ignorant of the risks or resigned to living with hazards. Some 10 to 15 million people are involved in this enterprise, about a third of them women and children, spread over 70 countries. But that mercury then gets into soil and rivers, is converted to methylmercury, and builds up in fish and fish eaters.

"You see people passing around old Coke bottles of mercury, pouring them out haphazardly," says Keane from the National Resources Defense Council, who has also visited many of these small communities. "Often kids are hanging around, and women with babies balanced on their hips." Afterward, mercury in the miners' breath has been measured to exceed the occupational standards for air, she says, adding wryly that the miners themselves might qualify as toxic mercury sources.

It's not a pretty picture. But Akagi's chemical analyses have helped reveal a world where the dangers of mercury still persist, even after decades of better regulations. In person, he seems to prefer talking through the pure chemistry. His scientific progeny, many now big names in the research world, are the ones smiling down from the walls of his office. He comes to the lab to keep chiselling away at – what else – the same old problem of helping people measure mercury, stopping for lunch most days at the roadside noodle restaurant next door.

Another of those CVs up on the wall belongs to Milena Horvat, a chemist who came to visit him several times from Slovenia. She now heads up the Department of Environmental Sciences at the Jožef Stefan Institute in Ljubljana. The institute is about an hour's drive from a town called Idrija – home to a 500-year-old mercury mine, the second biggest

in the world, recently active and now a UNESCO World Heritage Site. With Horvat and her colleagues, Akagi is now working on a method for measuring mercury that uses cheaper chemical ingredients, for developing countries. He thinks it will be his last major project. He doesn't know how many years he'll need.

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Almost 12,000 kilometres from Minamata, Rimiko Yoshinaga, seated next to an interpreter at a desk at the front of the room, picks up a microphone and begins. She is tired from jetlag, and it is cold here compared to Kyushu. The seafood available pales in comparison to what she is used to from Minamata Bay, which was finally declared safe in 1997. "This is my first time in the United States," she says. "I have been here four days, and I am starting to yearn for the fish in Minamata."

She is speaking to a room of researchers in Providence, Rhode Island, gathered for the 13th International Conference on Mercury as a Global Pollutant. Organised by a volunteer committee, the meeting is a get-together that happens every two years. This summer, roughly a thousand researchers are in attendance from some 50 countries, many of them buzzing about the Minamata Convention coming into force. Akagi hosted the sixth such meeting in Minamata in 2001, and he is here too, to present his work with the Slovenians.

Rimiko has come to Providence as a kataribe, a storyteller. People with Minamata disease have been fulfilling this role in official and unofficial capacities at international conferences for 45 years. In her presentation, she shows a picture of her father, breaking down in tears while quoting her mother Mitsuko. She weaves her family story back and forth into the wider history. It's hard but it comes with catharsis, she says later. "Every time I give a talk, I feel like I am releasing whatever things I hide in myself," she says. "That makes me little by little more comfortable."

For years Rimiko kept her status a secret. Unlike many other victims, whatever neurological harm she suffered as a child isn't obvious from the outside – excepting the occasional muscle cramps she worries about – even though she ate the same fish as everyone else. Before she married her first husband, she didn't mention the disease until his parents, snooping on their son's prospective bride, unearthed the connection. Her fiancé asked her point-blank and she had to admit to being a sufferer. But she stayed silent in public until 1994, during a period of official apology and reconciliation called moyainaoshi, a local term that alludes to fisherman connecting their boats to work together.

When she did speak out, a delegation of city officials showed up at her door. Long-time Minamata activist Toshio Yoshinaga, the man who is now her husband, accompanied them. They asked her to give a speech in front of several hundred people. At first, she balked. "It was that time when I started to think about my father," she says. "I felt I had to do it."

Rimiko, who makes and sells small ornaments of recycled glass from a small shed behind her home, is the current vice-president of the storytellers' group. She is a charismatic, emotional speaker, and as one of the youngest, healthiest people in the Minamata disease community, she can still travel widely. Over the years, she has also spoken in the Philippines and in Johannesburg. But given the timing, the conference this summer in Providence is particularly special. "I am relieved to hear that the Minamata Convention on Mercury will come into force," she tells her audience. "I truly hope that no more people suffer health damage caused by mercury."

The experts in Providence express cautious hope as well. "All of the pieces are in place for the international community to be able to move forward if they want to," says Boston University's Henrik Selin, a professor of international relations who visited Minamata and nearby Kumamoto City in 2013, when the convention was first opened for

signatures.

The convention comes with a long checklist of deadlines. Nations must immediately give up building new mercury mines and, within three years, they need to submit a plan of action to come to grips with small-time gold miners. By 2018, they need to have phased out using mercury in the production of acetaldehyde – the process that poisoned Minamata is still in use. By 2020, they need to have begun phasing out products that contain mercury.

But beyond that, the actual decision-making power on mercury control comes from those Conferences of the Parties, starting in Geneva. It isn't yet clear which countries will pony up the cash to pay for campaigns to raise awareness about the dangers of mercury, for example, Selin says. Nor is it clear whether countries like China, and especially India – who were dragging their feet in 2013 with the argument that stricter mercury standards would be prohibitively expensive – can be convinced to beat the deadlines.

Rimiko won't be in Geneva, so Providence is her last chance for a while to get her specific message out. At the end of her story, she launches into a plea to the assembled scientists. "We, the ones who live by the sea, are the first ones to realise the strange phenomena," she says. "Always listen to the voices of nameless persons.

"What you are protecting are the irreplaceable lives of human beings. This is the wish of Minamata, Japan, where many lives were sacrificed, and [where] some 10,000 people with health damages are still living."

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Three times a week, a support group of about a dozen people living with the lingering effects of Minamata's poisoning gathers. It's Monday

morning and they trickle into a room at a community centre and sit on chairs or on the floor around a low table. Patients and activists chat, glancing at nonstop coverage of the latest Kim Jong-un provocation on the news. Two attendees bring their cats in carriers, and the organisers let the cats out in an adjacent room. People take shifts to go play with them.

Yoichi Tani, a long-time Minamata activist who first recruited Rimiko's now-husband Toshio Yoshinaga to the cause in 1972, hosts this informal meeting. It draws a diverse crowd. There are a few high-profile storytellers, several patients who were poisoned in the womb, a couple who recently came out and were covered in the newspapers, and two sisters who spend most of their time with the cats and ask to not have their picture taken.

Hunched over by the wall, her arm bent and held close to her chest, is Shinobu Sakamoto, who was affected in the womb and is maybe the most 'famous' living Minamata victim. In 1972, she travelled to an international environmental conference in Stockholm with her mother to talk to scientists about Minamata. Her haircut today is the same as in the pictures, and she's still flanked by her mother, a tiny, determined-looking woman. Shinobu has never quite abdicated that role: Tani's group is paying to bring her to Geneva. Hovering in the background is a journalist who quit his newspaper gig last year to write a book about her, and who now serves as an expert in understanding her slurred speech.

Another patient, Hideo Ikoma, shares his own version of the story many victims have spent their lives telling. He lived by the sea and caught fish, but nothing happened until he was on summer vacation aged 15. He was hanging out with friends up in the mountains as they gathered vines to make crafts. They stopped for a cold treat of shaved ice, and after a few scoops the spoon jumped out of his hand. His friends, thinking he was overheated, suggested he go home and take a nap.

Hideo's own speech is slurred, and as he talks through an interpreter he occasionally pauses, bends his face down, and brings a mug of green tea to his mouth in jerky steps. "I don't know how long I slept, but when I woke up, from my head to the toe I felt the hairy worms all around my body," he says. "I wanted to tell my father but I realised I can't. I couldn't talk properly at that time, having numbness."

Hideo, like Rimiko, has travelled internationally to present Minamata to a wider audience. He's 74, though, and his health is worsening. About five years ago, he still had the dexterity in his hands to make the wooden dolls and crafts that many Minamata disease victims sell to raise money. Now he doesn't. He says he would go to Geneva himself, but his back hurts too much on long flights.

Although methylmercury lingers in the body, its half-life is short compared to human memory: just 50 days. Mercury levels in Minamata's food long ago returned to normal, so Hideo's current symptoms are the tangled product of his severe exposure as a child and everything since.

Other patients report similar recent experiences. In the span of a few years, their health and motor skills can deteriorate quickly. "We see delayed effects," says Chan, the toxicologist from the University of Ottawa. "We know that it is possible, but exactly how we don't know yet."

Hideo's worsening health has left him thinking about the legacy of Minamata's storytellers. "The adults who got affected are now already passed away," he says. People who were affected as children and actually remember the onset of their symptoms are now in their 70s. Those in his generation, he says, "are kind of the last people to talk about these things."

To some of these patients and their advocates, long at odds with the

Japanese government, the Minamata Convention is only a partial resolution. "I will say what no one will say," says Masanori Hanada of nearby Kumamoto Gakuen University, speaking through an interpreter. Hanada, head of a group called the Open Research Center for Minamata Studies, also leads efforts to study and advocate for victims of mercury poisoning in Grassy Narrows, Canada. "The members of this research centre, we would not say Minamata Convention. We say 'mercury convention'," he says. "[The negotiators] understood the lesson of Minamata disease, but not the real fact or the real situation of Minamata."

One gripe goes back to the beginning and is still being contested in lawsuits today: Who exactly qualifies as a sufferer? Who deserves compensation? There have only been about 2,000 certified patients, most of them already dead. It's a strict certification process – you are examined for neurological symptoms by a medical panel and need to prove you lived in Minamata around the right time. In recent years, very few names have been added.

Even Rimiko, one of the most visible Minamata ambassadors, says that she and her siblings have not applied for fear of rejection. Instead, Rimiko is part of a complex, tiered system that pays at least some compensation or healthcare expenses to tens of thousands more. To Tani, the activist, tens of thousands is still too small: he argues a comprehensive approach should be taken that considers historic methylmercury exposure in fish eaters around the full Shiranui Sea.

Another point of conflict is all that untreated mercury under the park, athletics fields and waterfront memorial – which was the site of a ceremony during the Minamata Convention signing. "We think here the Japanese way is just [to] bury mercury underneath the land. It's not safe at all," Hanada says. In 2016, the Kumamoto region containing Minamata experienced a 7.3 magnitude earthquake. Rimiko worries that

a subsequent disaster could free the buried mercury back into the bay.

That isn't as serious a concern as it might seem, says Sakamoto at NIMD, where he is head of the Department of Environmental Science and Epidemiology. According to Sakamoto, over the years the mercury has transformed to mercury sulfide, a stable and safer form. But to Hanada and others, 'mercury sulfide' is an old chestnut. "Nobody has checked," says Sakamoto's former boss Akagi, who speaks ruefully of an unused chemical process he once developed to treat the sludge before it was buried.

For Hideo Ikoma, wrapping up his story at the community centre, Minamata's still-simmering conflicts are worth fighting but are stressful on a personal level. He says he finds solace somewhere both unexpected and blindingly obvious: a small boat with a safety railing that he takes out on the Shiranui Sea.

It's harder to get out there now that he has to visit the hospital every day. And until two or three years ago, he loved to fish, but since then it's become almost impossible to bait a hook. Thinking about it, he lights up. Earlier this week he let a bare line hang in the water, he says, and caught a few octopuses. There's also a social component. "Whenever I go out into the sea, I see an acquaintance or my old friends doing something" – almost all of them Minamata disease 'patients', or 'sufferers', or otherwise connected.

He'll go over and chat, or sometimes just manoeuvre his boat with one hand on the engine, his head clear. "While I am at the sea I don't need to think about anything," he says. "I can be so quiet and peaceful."

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