

The Chippewas of Nawash:

Is the community exposed to radioactive chemicals and other contaminants from eating locally harvested fish?

A community guide to understanding the results of the Nawash FISHES Study

October 2002

Nawash FISHES



**Fish and Indigenous
Subsistence, Health and
Environment Survey**

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A brief summary of what was learned from the Nawash FISHES study

Good News!!

Eating locally harvested fish is good for health!

Levels of radioactive chemicals and other contaminants analyzed for this report were found to be very low. They are not a concern for health.

Nishshin Giigoonh Jimwadban.

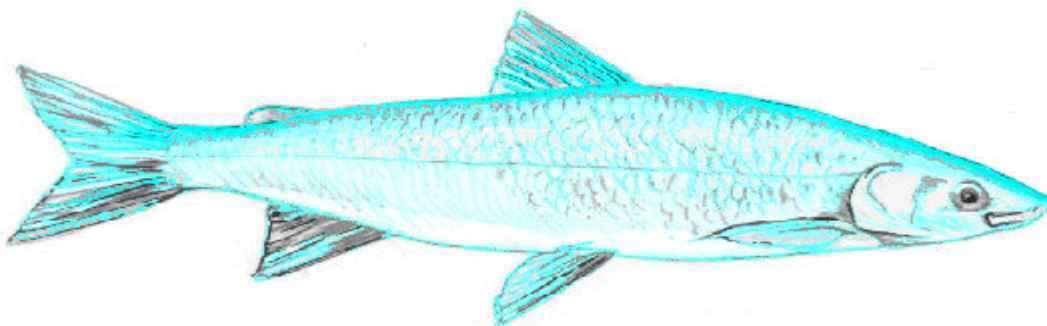
The elders have said it this way - It's good that you should eat fish. Fish is a very healthy food and harvesting and eating fish is part of the way of life of the Chippewas of Nawash. Eating more fish would greatly improve the diet.

On average, people in Neyaashiinigmiing eat fish once or twice per month.

Most people reported eating fish about once or twice per month, but some ate it 2 or 3 times per week at some times of the year. Eating fish 2 or 3 times per week is good for health.

People should stay informed and involved.

There are plans to increase operations at Bruce Nuclear Power Development (BNPD)* and the Chippewas of Nawash need to be aware of how changes may affect them. A community-based Environment Coordinator position could help the Chippewas of Nawash follow these issues.



* see Glossary on page 18 for explanation of the abbreviations used in this manual

Why was this study carried out?

In the mid-90s, Bruce Nuclear Power Development (BNPD) began to run out of space to store medium- and high-level radioactive waste. Ontario Power Generation (OPG) proposed building a used fuel dry storage facility for this waste on the BNPD facility. In 1997, an Environmental Assessment review of this proposal took place. Chippewas of Nawash First Nation expressed concern that their health may be at risk from eating fish caught in Lake Huron, north of BNPD. Nawash commercial fishermen also wanted to be sure that the fish they sell is not a health risk for their customers. OPG agreed to fund a research project to investigate these concerns.



Bruce Nuclear Power Development facility

Radiological Environmental Monitoring Program (REMP)

The BNPD plant is required to determine what impact its operation has on the local environment. The way they do it is by carrying out a Radiological Environmental Monitoring Program or REMP. One of the things the REMP must do is estimate how much radioactivity people living near BNPD are exposed to. These people are considered to be members of a “critical group”. They could be exposed to radioactivity from skin contact with water, air, soil, or sediment. They could also be exposed by drinking water and eating fruits, vegetables, dairy products, meat or fish that are locally produced or harvested. Measurements of food and water are taken regularly to estimate how much exposure the critical groups are getting from all these sources.

Critical Groups

The Chippewas of Nawash do not live close enough to BNPD to be considered members of a critical group. However, a lot of the fish harvested and eaten by Nawash residents are caught in areas not too far from BNPD. Nawash Council and OPG/BP (Bruce Power) agreed that it was necessary to estimate the exposure to radioactivity from fish for the Chippewas of Nawash. This will help determine if they should be considered members of a “critical group”. In order to estimate exposure, it was necessary to measure the levels of radioactive chemicals in fish as well as how much fish people eat.

Research Questions

The main questions Chief and Council wished to have answered were:

- **Is the health of the people of Neyaashiinigiing at risk due to eating fish caught in Lake Huron and Georgian Bay that may have come in contact with emissions from BNPD?**
- **Should the local food of the Chippewas of Nawash be more closely monitored by OPG?**

To answer these questions, the following steps were taken:

- (1) a review of what is already known about radioactive chemical emissions from nuclear power plants and how they might accumulate in fish;
- (2) sampling and testing fish from traditional waters;
- (3) carrying out a dietary survey to find out how much fish people eat and to describe their diet;
- (4) assessing whether the Chippewas of Nawash are exposed to “unsafe” levels of radioactive chemicals and other contaminants in their diet due to eating fish.

Who participated in the study?

In the summer of 1998, Councillor Paul Jones and Nawash Fisheries Biologist Steve Crawford met with Dr. Meg Thorburn, a professor at the University of Guelph and asked her to represent Nawash and help develop the research project. Dr. Thorburn was recommended for the project because of her knowledge about the connection between fish health and human health. A first meeting between Paul, Steve, Meg and representatives of OPG took place in September 1998. Many more meetings between Nawash representatives, OPG, Meg and Nawash Band Council were required to agree on the study objectives and on how the project would be carried out.

Dr Peter Berti, a nutritionist who works with PATH Canada, was approached to conduct the dietary survey and exposure assessment. Kathleen Lindhorst supervised the dietary survey and Sue Hamilton helped with the writing of this manual.

A local artist, Polly Keeshig-Tobias, was hired to develop the study logo.



James Ashkewe

Fish sampling

Nawash Fisheries Assessment crew (Andrew Muir, Ray Chegahno and James Ashkewe) and/or commercial Nawash fishermen (Alison Pedoniquotte, Jay Jones & crew and Turtle's Fish Shop) caught the fish. Each fish was individually coded, weighed, measured and filleted before being put on ice and shipped to labs for testing.



Sharon
Johnston

Dietary surveyors

Three interviewers from the community were hired to complete the dietary survey: Manley Jones, Sharon Johnston and Mary LaValley-Montour. They received two days of training on how to conduct interviews commonly used in dietary surveys.



Manley Jones

Mary LaValley-Montour

And last but not least...

174 Nawash residents. Many thanks to all the people who said “Yes!” when one of the interviewers knocked on their door and asked them to participate. They were chosen randomly, that is, the names of all Nawash households were put into a hat, and 85 household names were pulled out. Around 180 people lived in these 85 households. All the information provided by participants is confidential.

How much fish do the Chippewas of Nawash eat?

The short answer...

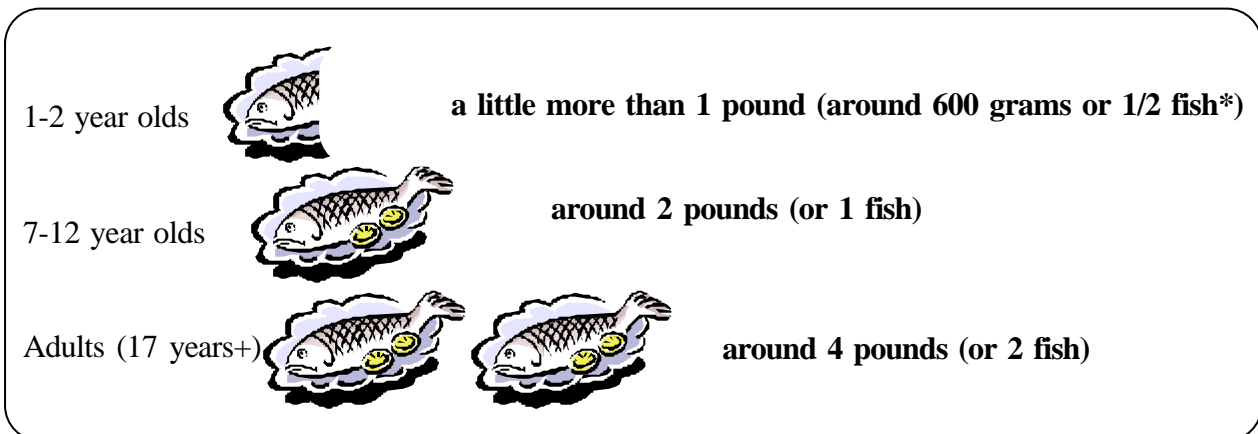
Of the 174 people (children, women and men) interviewed, many reported eating fish, especially in the summer months when about 9 out of 10 people eat Lake Huron or Georgian Bay fish at least once. Lake whitefish is the most popular species, and lake trout (splake) and rainbow trout are also widely eaten. A few people eat fish 2 or 3 times per week during some seasons, but most people eat fish once or twice a month. People eat fish most between April and October, and least in February.

To know more...



dikmeg

The average amount of whitefish eaten in one year (between summer 2000 and spring 2001)



* These results assume that an average whitefish weighs a little more than 3 pounds (1.5 kg) and gives around 2 pounds (1 kg) of edible flesh/skin.

To get an idea of what average means, imagine that everybody who participated in the study got together and threw all the fish they ate in a year into a big box. People who didn't eat fish would be present but would throw in nothing. The fish in the box would then be divided up so that everybody present, even the people who ate no fish, would get the same amount of fish. That would be the average amount of fish eaten in the year.

The amount of whitefish eaten by people who ate the most

7 - 12 year olds	17 pounds (around 8 and 1/2 fish)
Adults (17 years +)	40 pounds (around 20 fish)

People who ate the most fish ate around 10 times more than the average person. The dietary survey also found that people eat the most fish in the summer.

More about how much fish is eaten by people in Nyaashiinigmiing...



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Based on the dietary survey results, for adults aged 17 and older:

- 14 % (or around 1 out of 10) ate no fish
- 48 % (or around 5 out of 10) ate between 0 and 1/2 pound of fish per month
- 16 % (or around 2 out of 10) ate between 1/2 and 1 pound of fish per month
- 18 % (or around 2 out of 10) ate between 1 and 2 pounds of fish per month
- 3 % (or around 3 out of 100) ate between 2 and 5 pounds of fish per month

Amount of fish (all types) eaten by people in Nayaashiinimiing in a year, compared to other groups:

Chippewas of Nawash (average)	8.4 pounds
Chippewas of Nawash (people who ate the most)	59 pounds
Kahnawake Mohawks ^a (people who ate the most)	30 pounds
Akwesasne Mohawks ^b	20 pounds
Wisconsin Chippewa ^c	21 pounds
Ontario Amerindians ^d	13 pounds
Canada, 1990 ^e	11 pounds

This table shows that the average amount of fish eaten by the Chippewas of Nawash is less than that of some other Aboriginal communities. High fish consumers in Nayaashiinimiing ate more than high consumers in Kahnawake.

Another survey of fish consumption was done on a much smaller number of people in Nayaashiinimiing in the early 90's, by the EAGLE project. They estimated that people were eating around 62 pounds of fish per year, which is similar to what we found for people who ate the most fish, but not for the average person. We could not find details on how they selected the people they surveyed, but this could explain the difference in the results.

^a Chan LHM, Trifinopolous M, Ing A (1999) Consumption of Freshwater Fish in Kahnawake: Risks and Benefits. Environ Res.80: S213-S222.

^b Forti A, Bodan KG, Horn E (1995) Health risk assessment for the Akwesasne Mohawk population from exposure to chemical contaminants in fish and wildlife. New York State Department of Health, Centre for Environmental Health, Bureau of Toxic Substance Assessment. Albany, New York.

^c Peterson DE, Kanarek MS, Kuykendall MA et al (1994) Fish consumption patterns and blood mercury levels in Wisconsin Chippewa Indians. Arch Environ Health 49:53-58.

^d Richardson GM, Currie CJ (1993) Estimating fish consumption rates for Ontario Amerindians. J Exp Anal Environ Epid 31:23-38.

^e Agriculture Canada, Handbook of Food Expenditures, Prices and Consumption, 1990.

Do fish in Georgian Bay and Lake Huron contain radioactive chemicals?

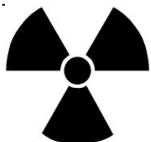
The short answer...

Very low amounts of some radioactive chemicals, such as tritium, carbon-14, strontium-90 and cesium-137 were found in the fish sampled for this study. The levels were similar to those in fish caught far away from nuclear power stations. They were so low that they should not affect the health of fish or of the people eating fish. However, some of the strontium-90, carbon-14 and tritium found in fish may be due to emissions from Bruce Nuclear Power Development. So, while the levels were very low, we recommended that BNPD monitor these radioactive chemicals in fish more closely than they currently do.

Fish sampling sites



This map shows where the fish were caught for this study. The sites include some of the usual harvesting locations of commercial fishermen. Fish from De Tour and Whitefish Bay were caught very far from BNPD, so they were used for comparison. Fish were sampled several times between November 2000 and June 2002. Fish filets and skin were tested. Most of the testing was done by the lab at BNPD. Some testing was done by the Atomic Energy Control Lab at Chalk River, and some by the OPG lab at Whitby. The people in the lab were not told where the fish came from.



Nuclear power and radioactive chemicals

Many different radioactive chemicals are formed when nuclear power is produced. Very small amounts of some radioactive chemicals are routinely released from the BNPD plant and get into the air and water. They can get into fish through their food and water. As part of this study, we identified those radioactive chemicals most likely to be released from BNPD into the surrounding waters.

Over the next 2 pages we will discuss the four main radioactive chemicals that we felt might be of concern and the values that were found in fish.

More about radioactive chemicals in fish...

Background Levels

It's important to know that even fish living far from nuclear power plants will have radioactive chemicals in them. This is because there are other sources of these chemicals in the environment.

- **Natural sources** - elements in the earth's crust, space, sunshine
- **Man-made sources** - fallout from testing nuclear weapons, emissions from nuclear power production, uranium mining, etc.

The background level is the amount of radioactive chemicals coming from natural sources and man-made sources, not counting nuclear power production. To know if radioactive chemicals from a power plant are getting into fish, we have to compare the levels we find to background levels.

Here is how much carbon-14 was found in whitefish and lake trout:

Carbon -14
(average C-14 in becquerels per kilogram carbon (Bq/kg-C) flesh)

	BNPD	Fishing Islands	Georgian Bay	DeTour	Whitefish Bay
Whitefish	298	269	258	278	238
Lake trout	282	276	259	not sampled	243

Background levels for Ontario are 240 -250 Bq/kg of carbon. This table shows that fish caught in Georgian Bay had C-14 values close to background. Fish caught near the Fishing Islands and BNPD had higher levels than fish caught near Georgian Bay. While these values are not *presently* high enough to be a health risk for fish or people eating fish, we have recommended that BNPD try to further limit C-14 releases.

Cesium-137
(average Cs-137 in becquerels per kilogram of flesh)

	BNPD	Fishing Islands	Georgian Bay	DeTour	Whitefish Bay
Whitefish	1.1	0.9	1.5	1.6	4.9
Lake trout	1.5	1.8	2.0	not sampled	5.0

This table shows that low levels of Cs-137 were found in all the fish we tested. The higher levels in Whitefish Bay (a control site) are because there are many other sources of Cs-137 in the environment that can be far more significant than BNPD.

Go to the next page to learn what we found out about 2 other radioactive chemicals....

More about radioactive chemicals in fish... (continued)

Strontium-90
(Sr-90, expressed as % of fish with detectable levels)

	BNPD	Fishing Islands	Georgian Bay	DeTour	Whitefish Bay
Whitefish	44%	33%	14%	not sampled	not sampled
Lake trout	67%	57%	0%	not sampled	not sampled

This table shows that more fish caught near BNPD had detectable levels of Sr-90, than fish caught in Georgian Bay. The levels are so low that they are not a health risk, but we have requested that BNPD start routine testing of fish for Sr-90, since it is not being done at present.

Tritium
(Average tissue free water tritium, TFWT, becquerels per kilogram, (Bq/kg) of flesh)

	BNPD	Fishing Islands	Georgian Bay	Lake Huron, American side*
Whitefish	5.0	4.6	4.1	3.5
Lake trout	4.1	5.0	3.5	not sampled

* This location can be considered as having background levels of tritium. These results are for whitefish caught for OPG in 2001.

This table shows that fish caught near Fishing Islands and BNPD had levels higher than background and higher than fish caught in Georgian Bay. Another type of tritium, called organically bound tritium (OBT), was also measured. The test for OBT is not standardized, so results are not exact. However, in general, the OBT levels were low, averaging 3.7 to 7.4 Bq/kg. Although these levels are not high enough to be a health risk, BNPD should be encouraged to keep tritium releases as low as possible and to improve the accuracy of the OBT measurements.

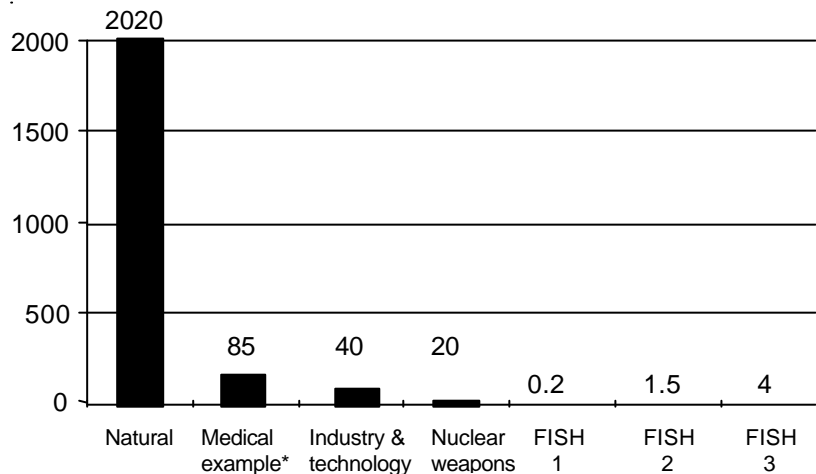
To find out more, consult the technical document called "Radionuclide sampling of lake whitefish and lake trout from Chippewas of Nawash fishing grounds (south-west Georgian Bay and Fishing Islands, Lake Huron and the vicinity of the Bruce Nuclear Power Development site (Lake Huron)". It can be found in the Band Office at the Front Desk.

Are the Chippewas of Nawash exposed to radioactive chemicals from eating locally harvested fish?

The short answer...

To answer this question we had to know 2 things: How much radioactive contamination is in the fish and how much fish are people eating on a regular basis. On pages 6 & 7, we saw that levels of radioactive chemicals measured in fish were very low. We also found out that most people do not eat a lot of fish. This means that *there is no health risk from radioactive chemicals due to eating fish*. This would be true even if people ate fish 3 times per week all year long.

Approximate Nawash exposure to radioactivity from various sources, in micro-sieverts per year**



* equals 1 dental X-ray and 1 chest X-ray
 ** see Glossary on page 15

FISH 1 = exposure for average person
 FISH 2 = exposure for people who ate the most
 FISH 3 = exposure if fish was eaten 3 x per week

This graph shows us that exposure to radioactivity from fish is very, very low. Other natural and man-made sources are much greater. The reason we see no dark bars above Fish 1, 2 and 3 is because the levels are too low to appear on this graph.

To get as much radioactivity from Lake Huron fish as happens naturally, you would have to eat about 100 pounds of fish every day!



Are there health risks from other kinds of contaminants?

The short answer...

To find out if there are health risks from eating fish, we had to look at more than just radioactive chemicals. We also looked at the levels of mercury, PCBs, aldrin, mirex, DDT, toxaphene and hexachlorobenzene in fish. After taking into account how much fish people ate, we found that no one exceeded the Tolerable Daily Intakes, or TDIs, for these contaminants. The TDIs are established by committees of experts who study what is known about the health risks from long term, low dose exposure to environmental contaminants. Even people in Neyaashiinigiing who reported eating around 60 pounds of fish per year did not have levels considered to be a risk for health, for any of the contaminants mentioned above. (The final analyses for another contaminant, dioxins, are not yet available.)

To know more...

These symbols represent sources of many of the environmental contaminants mentioned above.



This symbol represents industries such as pulp and paper mills and those that require the burning of industrial waste and fossil fuels. These contaminants affect the local environment but can also travel to far away places through transport in the air and water. **Mercury** is one of the contaminants released from industrial processes.



This symbol represents organochlorines. These contaminants are manufactured chemicals. **Aldrin, mirex, DDT, toxaphene and hexachlorobenzene** were used to control pests and weeds in agricultural crops. **PCBs** were used in electrical transformers. These organochlorines are banned in Canada and the US, but they can still be measured in wildlife because they break down very slowly. Some are still used in other parts of the world but can end up in North America by travelling in the wind and in oceans and rivers.

You may have already heard the names of some of these environmental contaminants. Indigenous Peoples in Canada, such as the James Bay Cree, Grassy Narrows Ojibway and Inuit, have had to deal with the presence of relatively high levels of contaminants in their locally harvested foods. Fortunately, levels of the contaminants mentioned above were low in fish harvested from traditional waters of the Chippewas of Nawash. It is unfortunate, however, that we were able to measure any contaminants at all in fish. This is why it is important to stay informed about local activities that could be releasing contaminants.

We have no reason to believe that present activities at Bruce Nuclear Power Development contribute in any significant way to the levels of these contaminants in the fish. However, OPG/BP agreed to pay for these analyses in order to help the Chippewas of Nawash gain a better picture of possible health risks from eating fish. Testing was done by the Ministry of the Environment.

What are the effects of contaminants on people's health?

There is no short answer!

Unfortunately, there is no easy answer to that question. Most of what is known about the health effects of contaminants is based on studying people who were exposed to very high doses due to industrial accidents or, in the case of radioactive chemicals, due to the nuclear bomb explosions in Japan in World War II. Depending on the particular contaminant, high exposures have resulted in cancer, birth defects and neurological problems and/or other diseases. There is not a lot known about low dose, long term exposure. This is the kind of exposure most people have, through our food and water.

Guidelines have been established using what *is* known. For now, these guidelines are scientists' best judgment about the amount of a contaminant a person can be exposed to every day for their whole life that will cause no health risks. Often, this information is based on studies with laboratory animals; sometimes it is based on studies of people who were accidentally exposed to high doses of a contaminant. But people are not laboratory animals. And the health effects of accidental exposure to very high doses may be quite different from the health effects of low dose, long term exposure. Scientists have only recently started producing information from studies of low dose, long term exposure in humans. Their findings are still very preliminary. This is why it's hard for scientists to predict our chance of getting disease from eating foods with low levels of contaminants.

Benefits vs. risks

When it comes to locally harvested food, it's important to think about the benefits as well as the risks. The nutritional and cultural benefits of eating fish and game have always been important to the Chippewas of Nawash. These should not be overlooked because of fear of contaminants.



Do the Chippewas of Nawash have a healthy diet?

The short answer...

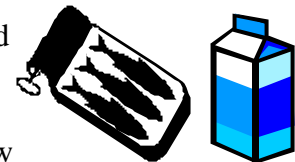
People are getting enough of some nutrients needed for health such as protein, carbohydrates and niacin. Other important nutrients, such as calcium, iron, selenium, vitamin C and folic acid were low in the diets of some people. Teens and young adults were eating quite a bit more sugar than what guidelines suggest. And, like many North Americans, people ate fewer than the 5-10 servings of fruits and vegetables recommended by Canada's Food Guide. The amount of fat in the diet was generally higher than what is recommended.

People could improve their diets by eating more fruits and vegetables, more calcium-rich foods, more lean meat and, of course, more fish!

The nutrients below were found to be low in the diets of some people:

Calcium

Calcium is needed for strong bones and teeth. It is needed by people of all ages, but the most important time for building strong bones is during youth. This is why young people aged 9-18 need the most calcium. Intakes were low for most age groups.



The main source of calcium in the diet of most North Americans is dairy products such as milk and cheese. Calcium can also be found in fish eaten whole, such as smelt, or canned with bones, such as salmon and sardines. Scone made with baking powder, fish head soup, fish skin and almonds also are good sources of calcium.

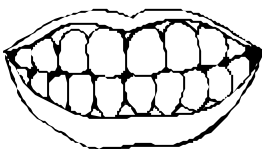
Iron

Iron is needed for strong blood and muscles and for mental concentration. It is especially important for infants, young women and pregnant women. Intakes were quite low for young women. Iron can be found in meat, poultry and fish, as well as in dried peas, beans and lentils, and breakfast cereals. The best sources are liver, wild meats such as deer and duck, and lean red meat (beef, pork, lamb).



Vitamin C

Vitamin C is a vitamin needed for healthy gums and teeth and for helping the body fight disease. Smokers need more vitamin C than non-smokers. Quite a few men and women over 30 years old had low intakes of vitamin C. Vitamin C can be found in many fruits and vegetables. Some good sources are citrus fruits and juices, tomatoes, peppers, cauliflower, broccoli and potatoes.

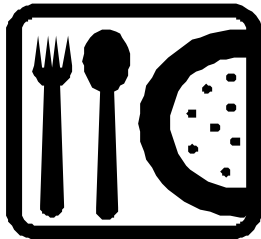


Many other nutrients were analyzed for this study. To learn more, see the technical report called Dietary Assessment of the Chippewas of Nawash, located at the Health Centre.

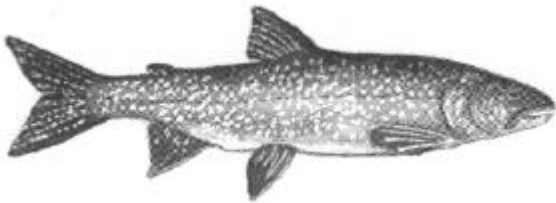
Great things about fish

The short answer...

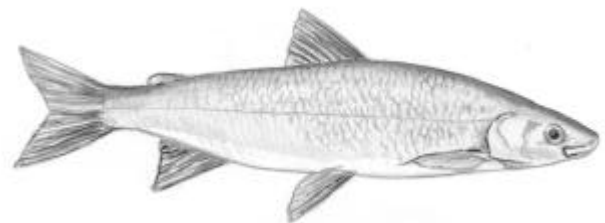
- Taste is just one. Especially when you can get it so fresh. Smoked, baked, boiled, barbequed and in pies, soups and stews. Fish contain nutrients that are hard to find in other animal foods
- - heart healthy fats and vitamin D, for example. It is also a great source of protein, zinc and selenium. Fish is known to have medicinal value. The elders have said that boiled fish soup - Giigoonh Nboob - is good for treating sickness.
- If you catch your own, fishing can help keep you physically fit. And don't forget keeping traditions alive. Fishing is part of the culture of the Chippewas of Nawash.



Just one serving of lake whitefish or trout (around 1/2 fillet or 1 cup or 150 grams) can help you get enough of these nutrients:



Mono and polyunsaturated fats - for heart health



Protein - for growing new cells

Niacin - helps body make energy

Vitamin D* - works with calcium for strong bones and teeth

Vitamin B-12 - helps make new red blood cells

Selenium* - an antioxidant (helps cells stay healthy)

Zinc - needed for wound healing and during growth

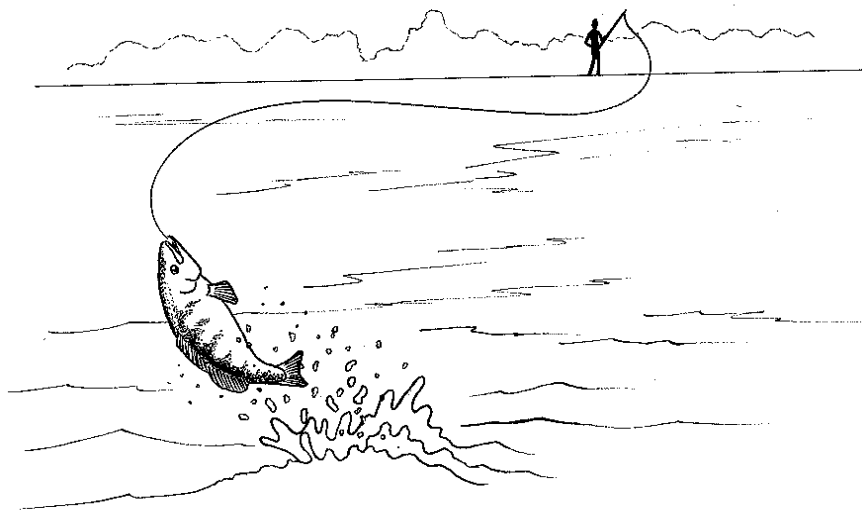
Magnesium* - needed for muscles, nerves and bones

*** the dietary survey found that many people had low intakes of these nutrients.**

What recommendations can be made based on what was learned in the Nawash FISHES study?

- **Stay involved.** With regards to the present level of routine emissions from Bruce Nuclear Power Development, this study shows that it is very safe to eat fish from traditional waters. However, we encourage you to stay interested and involved in monitoring the safety of your fish. Radioactivity from BNPD will increase in the future, after the reactors at Bruce A are started up again (beginning in 2003) or as a result of the new dry waste storage facility. A public report is released every year by OPG giving the results of tests on fish sampled near BNPD, which we encourage those interested to review. Having a local Environment Coordinator would make it easier for the community to stay informed and involved.
- **Ask Bruce Power to test your fish.** Most of the fish regularly tested by Bruce Power are caught by them, just off the BNPD plant itself. It is also important to keep track of the levels in the fish you catch and eat. We recommend that the Chippewas of Nawash supply some fish to BP each year for testing. It would also be worthwhile to conduct a dietary survey every five years or so - if fish consumption increases significantly, then BP should reconsider whether fish from traditional waters and the diets of Neyaashiinigiing residents need to be monitored more closely.
- **Eat more fish!** Fish are delicious, excellent for health and harvesting and eating fish is part of Nawash culture. Work with the CHRs, nurses and teachers to find ways to promote catching and eating fish.

Giminooodag Giigoonh. Fish is good to you. Giminooodag Giigoonh. Fish is good to you.



ACKNOWLEDGEMENTS

A community-wide research project requires much input and collaboration. Chief and Council and the project investigators wish to acknowledge the following people, whose generous contribution of time and knowledge was essential to the project's success.

Elders present at language instruction meetings

Health Committee, 2000 and 2002

Kim Akiwenzie, CHR

Health Centre Staff - Brenda Proulx and Judy Chegahno

Steve Crawford, Nawash Fisheries Biologist

Kathleen Gibson, nutrition student and chemist, University of Guelph

Elisa Levis, dietitian

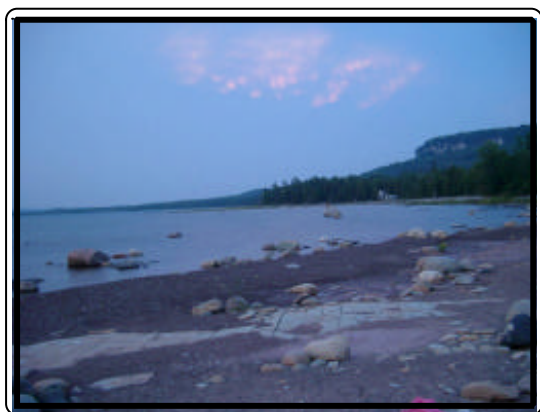
Nadine Desjardins, teacher



Andrew Muir, Supervisor, Fisheries Assessment with Meg Thorburn



Joyce Johnston & Berdina Johnston



Lenore Keeshig-Tobias and David McLaren and their cottage on beautiful Sydney Bay

Nawash fishermen, whose hard work provided all the fish eaten and analyzed during the study!



Glossary

BE: British Energy, is the United Kingdom's largest generator of electricity. It owns around 82% of Bruce Power.

BNPD: Bruce Nuclear Power Development, located on the shores of Lake Huron, is one of the largest centres of energy production in the world. It produces 30% of Ontario's electricity.

BP: Bruce Power, is a subsidiary of British Energy. In the fall of 2000, BP began a 20-year lease of BNPD from OPG. BP agreed to split the costs of the Nawash FISHES project and to respond to the study's recommendations.

OPG: Ontario Power Generation, is a provincial entity that owns Ontario's 3 nuclear generating stations.

Half-life: This is the amount of time it takes for one-half the atoms in a radioactive chemical to decay or lose their radioactivity.

Sieverts: The amount of fish you catch is measured in units called pounds or kilograms. The amount of radioactivity in the environment is measured in a unit called a becquerel (Bq). To estimate exposure to humans, becquerels are converted to **Sieverts or millisieverts**. This is necessary because not all radioactive chemicals are equally dangerous.

Carbon-14: C-14 has a half-life of around 5,730 years. This means it will take around 5,730 years for half of the atoms in C-14 to decay or lose their radioactivity. C-14 is released from BNPD and is easily taken up by small animals and plants and can then get into fish. Slightly elevated levels were found in fish caught near BNPD.

Cesium 137: Cs-137 has a half-life of around 30 years. This means it will take around 30 years for half of the atoms in Cs-137 to decay or lose their radioactivity. It is released into air and water from BNPD and is known to build up in fish through the food they eat.

Strontium-90: Sr-90 has a half-life of around 29 years. This means it will take around 29 years for half of the atoms in Sr-90 to decay or lose their radioactivity. It is known to build up in the scales and gills of fish. While these parts are usually not eaten, Sr-90 is released from BNPD and low levels were found in the flesh of some of the fish studied for this project.

Tritium: Tritium has a half-life of around 12 years. This means it will take around 12 years for half of the atoms in tritium to decay or lose their radioactivity. Tritium gets into fish primarily from water, but also from the food they eat. It is considered the most important source of radiation from BNPD and has been found in slightly elevated levels in fish caught near the BNPD.