Is the Quality of Fish from the Mackenzie River Related to the Norman Wells Oilfield Operation?

Studies Under the Imperial Oil, Norman Wells Aquatic Effects Monitoring Program

March 2008

Esso Imperial Oil

Golder Associates

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This booklet is dedicated to the memory of Alfred Masazumi. Alfred was a key member of the whitefish study (see page 14), and he helped us with the selection of study participants and also provided English to North Slavey translation. Some of Alfred's art is shown on page 3.

WELCOME

It is with pleasure that we present the results of the studies completed as part of the Aquatic Effects Monitoring (AEM) Program for the Norman Wells Operation.

The objective of the AEM Program was to determine if the Norman Wells Operation is affecting fish, water quality and other parts of the Mackenzie River near Norman Wells and Fort Good Hope.

Over the course of the 5-year AEM Program, we worked extensively with residents of Fort Good Hope, Tulita and Norman Wells. Residents from these communities played an important role in this Program, and, in particular, they made significant contributions to the fish studies.

In addition to examining the quality of the water, the AEM Program examined the quality of fish because communities downstream of Norman Wells, including Fort Good Hope, were concerned about the quality of some of the fish in the river. The health of these fish also tells us about the health of the river. Two types of fish that are important to the communities, loche and whitefish, were examined.

SUMMARY

The Norman Wells oilfield Operation is owned by Imperial Oil Resources N.W.T. Limited. The Norman Wells Operation includes wells and production facilities located along the shore of the Mackenzie River, on 2 natural islands and on 6 artificial islands on the Mackenzie River.

This booklet is about the fish, water and other environmental studies of the Mackenzie River. The studies were part of a program called the "Aquatic Effects Monitoring" (AEM) Program. The AEM Program was done for the Sahtu Land and Water Board.

Here is a summary of what we found in our AEM studies, which started in 2002 and ended in 2007:

Consultation

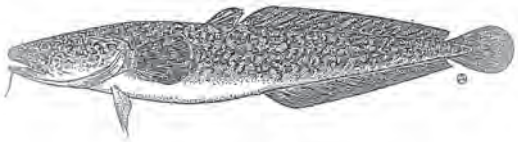
Residents of Fort Good Hope and Tulita did all the fishing for the studies, and they judged the quality of the loche. The whitefish testing panel (to test texture) was formed entirely of Fort Good Hope residents. Community Awareness Meetings took place in the Sahtu region.

Previous Studies

In the 1980s, after the construction of the artificial islands in Norman Wells, several studies looked at the quality of fish because people reported that several fish had bad livers. The studies did find bad livers in loche downstream of Norman Wells, but loche from other rivers and lakes also had bad livers. No link between the Norman Wells oilfield Operation and fish problems was found. The studies found that a few fish with bad livers was normal for loche.

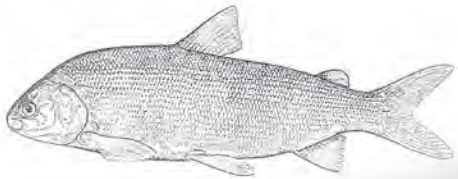
Loche Liver Study

Residents from Fort Good Hope and Tulita did the fishing and assisted us with the judging of loche liver quality. Most of the livers were judged to be good to eat. The small livers from young fish in Tulita were too small to eat. This study found that the problem with livers is better compared to the earlier studies in the 1980s. This study also found that the number of Loche with bad livers in the Mackenzie River is less than in many other rivers and lakes. So a few fish with small, dark livers appears to be normal in loche.



Whitefish Flesh Study

In the 1980s, communities along the Mackenzie River noticed more whitefish with watery flesh. In this study, 14 residents from Fort Good Hope formed a testing panel and were shown how to judge whitefish flesh texture. The panel found that female fish with eggs had watery flesh, and male fish did not. The overall condition of the whitefish was very good, and the more watery flesh in fish with eggs is normal.



SUMMARY (CONTINUED)

Mixing of Discharge Water

Discharge water released into the Mackenzie River from the Norman Wells Operation was followed to see how far downstream it goes. To do this, we put a bright dye in the discharge water and measured the dye in the river. This release water moves downstream along the shore and is hard to find at Rader Island (8 kilometres downstream).

Water and Sediment Quality

We sampled the water and bottom mud (sediment) where we found the discharge water with the dye. The amount of chemicals from oil that can harm fish was very low and was lower than the amounts needed to harm fish. The amount of chemicals in the location where we find water released from the Norman Wells Operation was about the same as the amount upstream of Norman Wells.

Testing of Discharge Water for Toxicity

Discharge water released into the Mackenzie River from the Norman Wells Operation was tested to see if it is toxic (or harmful) to fish. The tests found that discharge water is not harmful to fish.

Testing of Discharge Water for Water License

The Sahtu Land and Water Board requires that Imperial Oil perform a number tests of all waters discharged to the Mackenzie River. Water can only be released into the river if the tests show that the release water does not harm fish and it does not contain chemicals that can harm fish or other aquatic (or water) life.

Natural Oil Seepage

Natural oil bubbles up into the river at several locations along the shore of the Mackenzie River at Norman Wells. Testing found that this oil comes from natural sources deeper than the river bottom.

CONSULTATION

Why we included consultation

Consultation with local residents was done to incorporate traditional knowledge in the studies. Residents from Fort Good Hope and Tulita participated in the fish studies because they understand life on the Mackenzie River.

What we did

With the help of the local Renewable Resources Councils, fishermen from the communities were hired to catch the fish needed for the fish studies. Residents from the communities then helped us with the setup of the studies and they judged the quality of the fish. We felt that the best way to incorporate traditional knowledge into our AEM Program was to work directly with the local residents.

30 residents of Fort Good Hope attended the initial meeting for the whitefish study (described on page 14). 14 residents were then selected to be part of the testing panel. Following 5 days of training, the panelists participated in the whitefish study.

We shared the progress of the studies and our findings with communities at several events: at Community Awareness Meetings; at a meeting held to discuss plans for the whitefish study and another meeting to discuss the results; and during tours of the Norman Wells facilities.

A total of 29 community meetings were held from the start of 2003, and discussions about the AEM Program were held at several of these meetings. These took place in Fort Good Hope, Deline, Tulita, Colville Lake and Norman Wells. The focus of the June 2004 Community Awareness Meetings was the AEM Program. The response from the communities towards the content and size of the AEM Program was positive. Discussions took place beside an AEM poster that had been set up. Questions about the results and who was approving the Program were asked, and the original fish quality concerns were discussed.

What we learned

Traditional knowledge was shared by community elders who participated in the fish studies, the Community Awareness Meetings and in other meetings about the whitefish flesh study (see page 14). Working with the elders was important because they know where the fish are and what the concerns are.

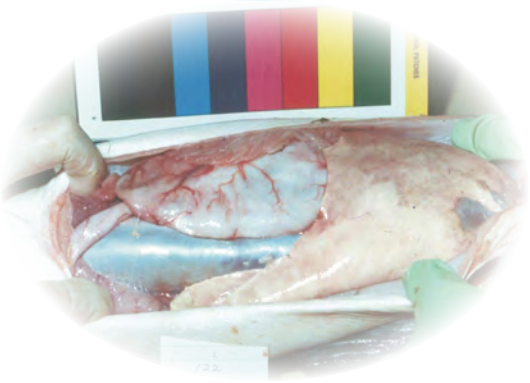
PREVIOUS STUDIES

Why we looked at previous studies

It was important to know what other studies have found so we could see if the same problems still exist. Also, the previous studies raised some questions, which we tried to answer in this AEM Program. Finally, the previous studies addressed concerns raised by the Sahtu people; however, some of these concerns still exist today. So we needed to understand what those previous studies looked at.

What we did

We reviewed about 60 reports and scientific documents and prepared a summary of all of this work. Our findings from this review were used to help design the fish, water and sediment surveys in this AEM Program.



What we learned

Water

The previous studies found the water quality of the Mackenzie River to be very good. Substances (also called chemicals) related to oil have been found in the Mackenzie River. The amount of these chemicals that can harm fish (known as PAHs) was much lower than the amount needed to cause problems in fish. The PAHs enter the river from natural sources, such as natural oil seeps.

Normal loche liver (above) and a small, dark liver judged unacceptable to eat (left). These loche were caught near Fort Good Hope in 1984.

Fish

Loche with small, dark livers were found in several other northern rivers where oil and gas development is not present. This means that exposure to oil cannot be the only possible cause of bad livers in fish near Fort Good Hope.

To see if there was a link between oil exposure and fish quality, loche and arctic grayling from small streams were placed in cages. These cages were installed at several locations in the Mackenzie River, just downstream of oil seeps and downstream of the former refinery discharge water from the Norman Wells Operation. The fish held in cages next to the oil seeps and the former refinery discharge water had more PAHs in them than in fish in other cages; however, grayling actually captured in the Mackenzie River had even more of these chemicals than the caged fish.

This means that fish are likely more exposed to natural sources of oil than to possible sources of oil entering the river from the Norman Wells Operation. Also, there was no relationship between the amount of PAHs in caged loche and the quality of their livers.

Starvation alone can cause loche to have small, dark livers. So an experiment was done to see if exposure to oil can cause fish to starve. The study found that large amounts of oil are required to cause fish to starve. The amount of oil in the Mackenzie River is much smaller than the amount required to starve fish.

LOCHE LIVER STUDY

Why we did a study on loche

Fish are a very important part of the Mackenzie River environment, and fish are an important source of food for communities along the river. One type of fish that is eaten is loche (also called burbot). In particular, the big, cream-coloured livers are highly prized. However, residents downstream of Norman Wells were concerned that some loche had small, dark livers that were not good to eat.

What we did

We did 2 loche surveys to examine the problem. With the help of local fishermen and residents from Fort Good Hope and Tulita, we combined traditional and scientific knowledge to support the loche study. The following people were involved:

Fort Good Hope: Michel Lafferty, Heather Bourassa, Margaret Kelly, Dora McNeely, John McNeely.

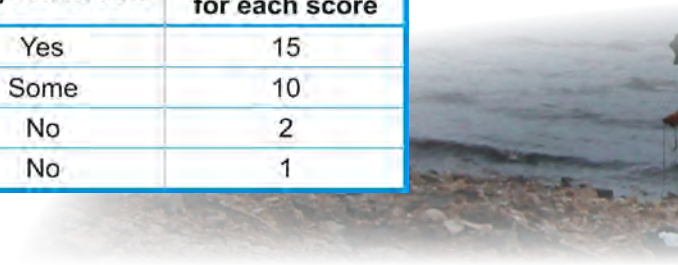
Tulita: Mary Rose Powder, Gordon Yakeleya, Ricky Andrew

Norman Wells: Louie Edgi, Annie Yakeleya-Fournel

Fishing for Loche was done by Michel Lafferty in Fort Good Hope and Ricky Andrew in Tulita. Fishing was done in October and November of 2002. Other residents listed above also provided loche for the study. These residents then judged the quality of the burbot liver. Using photos as examples, each person was asked to judge the liver with a score of 1 (bad liver) to 4 (very good liver).

The scores given by the residents

Score	Score Meaning	Is it good to eat?	Number of fish for each score
4	Very Good	Yes	15
3	OK – could be better	Some	10
2	Not so good	No	2
1	Bad	No	1



Samples of eggs were taken (in the small tube), and the egg mass was weighed.

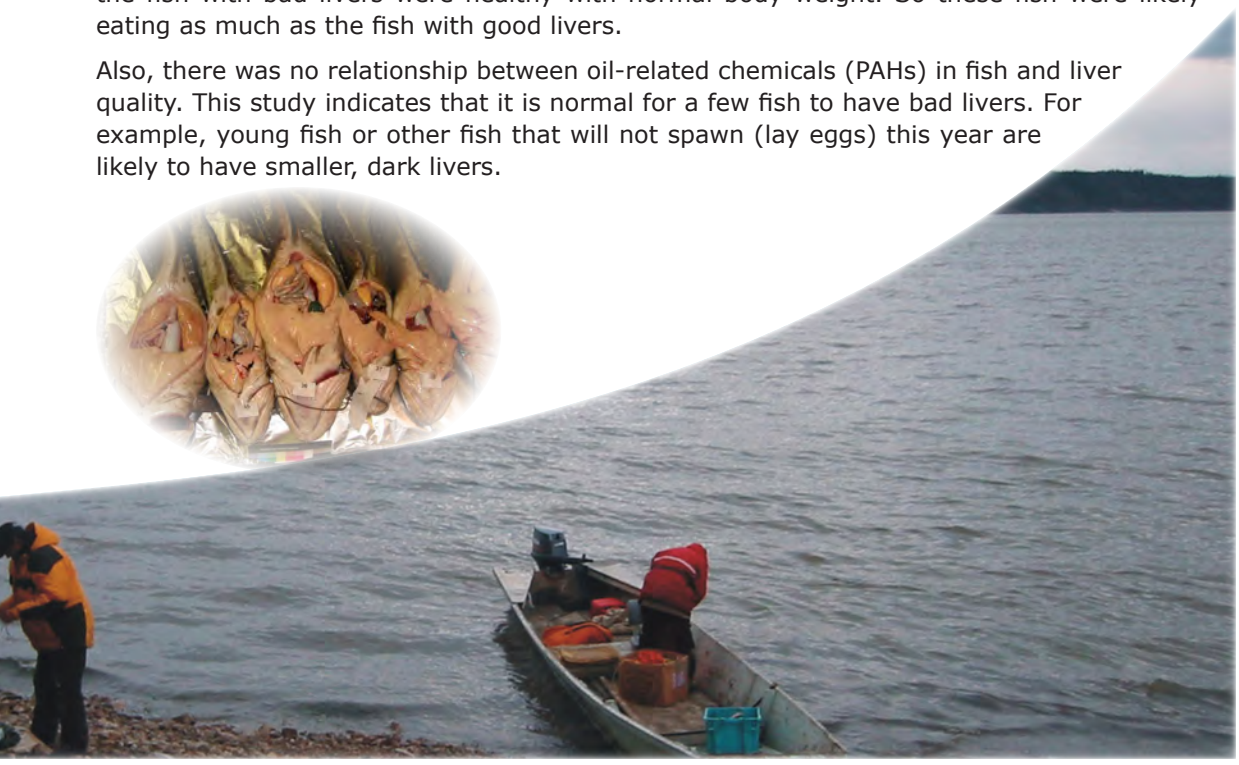
What we learned

Most of the livers were judged to be of good quality and good to eat (see table on page 12). Six of the 28 livers that were judged were considered no good to eat. These included 3 of the fish with scores of 3. The only fish with a bad liver (score of 1) was from a small, young fish captured at Tulita that would not normally be eaten.

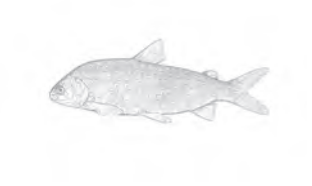
More fish with bad livers (score of 1) were found in the previous study discussed earlier. The previous study took place in the fall of 1985 and 1986, and 27 of the 81 livers were judged to be bad with a score of 1. The results of our study could mean that the quality of loche liver is getting better.

We mentioned earlier (in Previous Studies) that starvation can cause bad livers. In this study, the fish with bad livers were healthy with normal body weight. So these fish were likely eating as much as the fish with good livers.

Also, there was no relationship between oil-related chemicals (PAHs) in fish and liver quality. This study indicates that it is normal for a few fish to have bad livers. For example, young fish or other fish that will not spawn (lay eggs) this year are likely to have smaller, dark livers.



WHITEFISH FLESH STUDY



Why we did a study on whitefish

In addition to loche being an important source of food for communities along the river, the communities also eat whitefish. An important time to go fishing is during the fall when the whitefish lay their eggs in the Ramparts area.

In the 1980s, there were some concerns that the quality of the whitefish flesh (or meat) had gone down. More specifically, the whitefish flesh had become too 'watery' in texture. We did this study to look at the quality of whitefish flesh. The focus was to answer this question on flesh texture: is the flesh still 'watery'?

What we did

We asked several residents of Fort Good Hope to participate in the whitefish study. 30 residents attended the initial meeting, where we gave an overview of the project and talked about concerns raised by the residents. An explanation of texture, which describes how the meat feels in the mouth, was given.

Residents interested in being part of a texture testing panel participated in a number of texture testing exercises. Individuals who best performed the exercises were selected for the panel. 14 residents were selected for the panel, and they participated in a 5-day course to learn the texture testing methods needed for the study.

Michel Lafferty caught 36 whitefish for the study, and these fish were brought to the Chief T'seleie Centre on the same day. Elders in the panel looked at each fish to judge the quality of the fish. All of the fish appeared to be good, and the elders then opened up the fish and removed fillets (strips of meat).

The fish were coded, measurements were taken, and the fillets were prepared and cooked in a microwave oven for the testing panel. The testing panel was presented with coded samples, and they had no idea if the sample was from a male or female fish.

The following residents were members of the panel:

Cathy Kelly	Leon Kelly
Alfred Orlias	Jerry Lennie
Jonas Kakfwi	Alfred Masazumi
Tom Kakfwi	Alexis Chinna
Bella T'seleie	Norman Pierrot
Mary Pierrot	Elaine Harris
Jane Kelly	Jenna Grandjambe

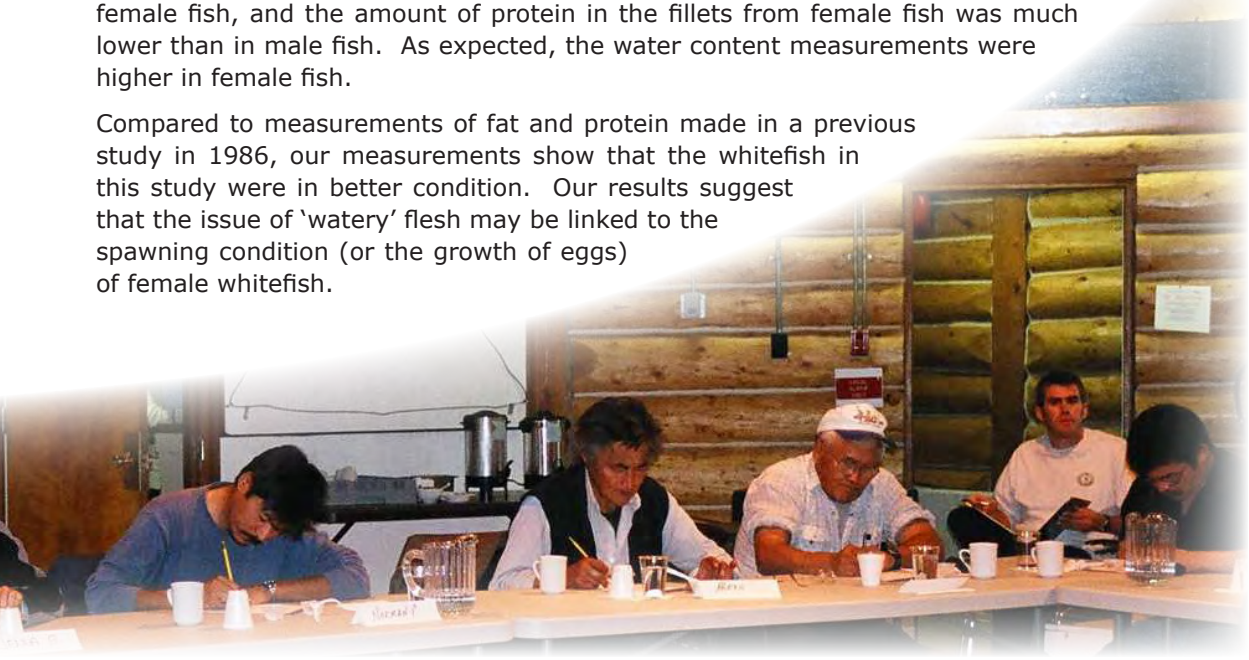
What we learned

The results from all panel members showed that the female fish had a 'watery' texture compared to the male fish. This means that fish with eggs tend to be more 'watery' than fish with no eggs. As an example, the results below for 2 texture categories show that female fish had higher test scores than male fish:

Attribute or Category	Score for Female Fish	Score for Male Fish
Gloss	10.1	7.9
Moistness	11.7	6.8

Other measurements taken on the fish also showed that the quality of female fish with eggs is not as good as male fish. For example, fillet weights were much lower in female fish, and the amount of protein in the fillets from female fish was much lower than in male fish. As expected, the water content measurements were higher in female fish.

Compared to measurements of fat and protein made in a previous study in 1986, our measurements show that the whitefish in this study were in better condition. Our results suggest that the issue of 'watery' flesh may be linked to the spawning condition (or the growth of eggs) of female whitefish.



MIXING OF DISCHARGE WATER

Why we looked at the mixing of discharge water

We wanted to understand what happens to discharge water (also called effluent) that is released from the Norman Wells oilfield Operation. This way we know where substances of concern will go if they are released in the river. Also, this tells us where we should take our samples from so that we can measure these substances in the river.

What we did

We put a bright pink dye in all four of the effluents that are discharged from the Norman Wells Operation. Tiny amounts of this special dye can be seen in water with the human eye. Even smaller amounts can be measured with an instrument designed to measure this dye. Using this hand-held instrument, we then tracked the dye in the river by measuring the amount of dye at several locations in the river.

We did this study over 2 years (in 2004 and 2005) to see what happens to the effluents that are discharged in different river conditions (for example with high water and with low water). This information was put into a computer. The computer can now tell us what happens to the effluent in the river for many different river conditions.

Dye moving along shore

Dye injection equipment

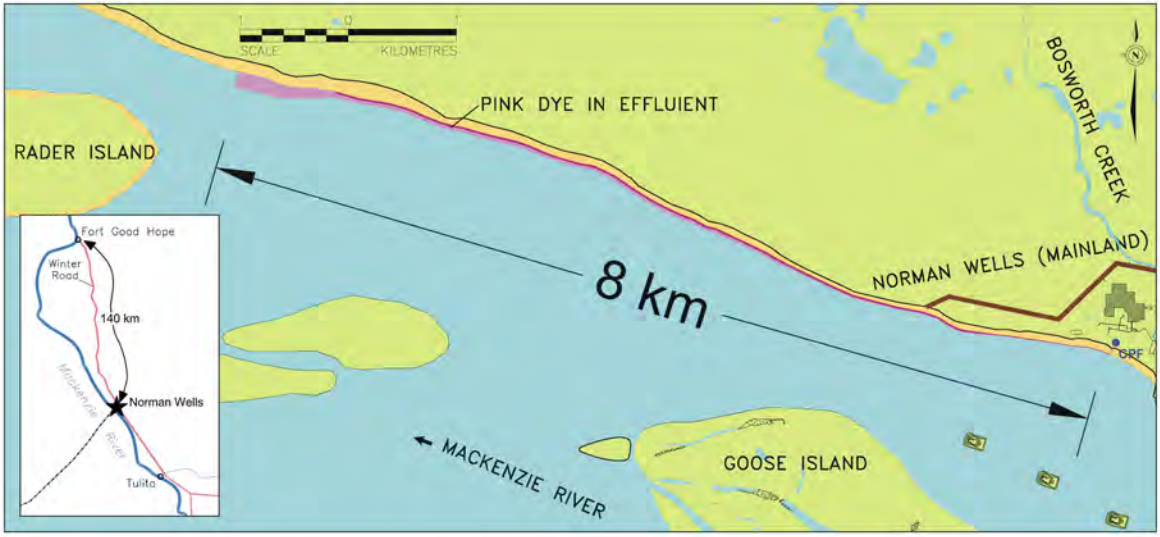
Measuring current

What we learned

The effluent from all 4 locations stays very close to the shore as it moves with the river current downstream. The movement of dye towards the middle of the river is very slow (shown on the map).

The effluents become diluted very quickly. This means that the amount of dye that we measured decreased (became smaller) as we moved downstream. We could still measure the dye at Rader Island (8 kilometres downstream). The amount of dye here was very small and difficult to measure. A very small amount of dye likely goes a bit further downstream, but this is still a long way upstream from Fort Good Hope (see map).

These results tell us that a substance of concern released from the Norman Wells Operation would stay very close to the shore. Because of the very small amounts that would be seen in the river, it would be difficult to find this substance past Rader Island.



This shows where effluent discharged from the Norman Wells Operation goes. The darker pink area contains more effluent (1% effluent) and the lighter pink area contains less effluent (0.1% effluent).

WATER AND SEDIMENT QUALITY

Why we looked at water and sediments

The quality of the water is essential to all life. Animals, fish, plants and humans depend on clean water for survival. The river bottom consists of rocks and mud, also called sediment. Many of the small animals that fish eat live on the bottom of the river.

Chemicals from oil (such as PAH) can be harmful to fish and other aquatic life. We wanted to see if any of these chemicals were being released into the Mackenzie River. These chemicals can be measured in water and bottom mud.

What we did

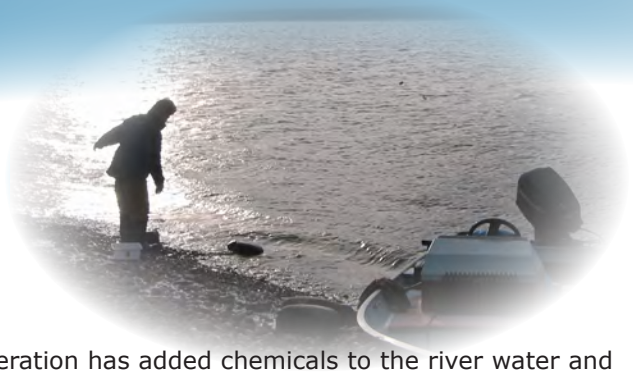
We collected water discharged from the Norman Wells Operation (effluent), water from the Mackenzie River, and mud from the bottom of the river (sediments).

In 2003 and 2004 we collected samples of effluent from the Operation to see what types of chemicals were present. We also collected samples of water and sediments from 4 areas in the Mackenzie River. Two sample areas were located upstream of the Operation, so we could see what is found naturally in the river.

Chemicals from oil occur naturally in the Mackenzie River from natural oil seeps along the river (see page 22). Therefore, one of these sample areas was located next to a natural oil seep.

The two other sample areas were located downstream from the Operation. We sampled water and sediments in the same place where we found the dye used to track the effluent along the shore (see previous page).

All of these samples were then taken to a laboratory and the amount of chemicals in each sample was measured. The results from the different sample areas were compared



to each other to see if the Norman Wells Operation has added chemicals to the river water and sediments.

What we learned

We found very small amounts of the chemicals called PAH in all of the water and sediment samples collected from the Mackenzie River. The amount of PAHs we found in the samples was lower than the levels which are known to be harmful to fish and other aquatic life.

The amount of PAHs in the effluent was even less than what was found in the river upstream of the Operation. As well, the amount of PAHs downstream of the Operation was the same as what was found upstream of the Operation. This tells us that the Norman Wells Operation is not adding more of the chemical (PAH) to the river than what is naturally occurring.

The samples taken next to the oil seep did show some small increases in the amount of PAHs present. This showed us that these natural seeps are a source of oil and PAHs.

Residents from the communities assisted us with our sampling programs.

TESTING OF DISCHARGE WATER FOR TOXICITY

Why we tested discharge water for toxicity

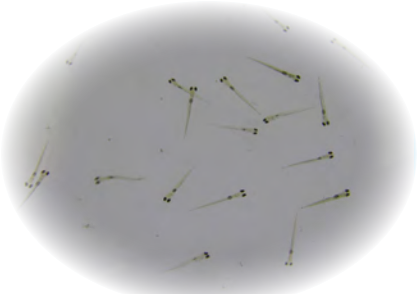
We wanted to see if water discharged from the Operation (also called effluent) could affect fish. Substances that harm fish are called toxic substances. The type of testing we did is called a toxicity test. We also wanted to see if effluent could cause liver problems in rainbow trout.

What we did

Discharge water from the Operation, as well as water from the Mackenzie River, was collected over 3 seasons (winter, spring, and fall) for 3 years (in 2003, 2004 and 2006). This water was taken to a laboratory and tested to see if it was harmful (or toxic) to fish. Two different types of fish were tested – fathead minnows and rainbow trout.

Fathead minnows were placed in either discharge water or water from the Mackenzie River for 7 days. Rainbow trout were placed in either the discharge water or water from the Mackenzie River for 4 days and 28 days.

We looked at the survival and growth of both types of fish at the end of the testing. After a month (28 days) of exposure to effluent, we also looked at survival, weight, length and the liver of rainbow trout.



These are very young (less than 1-day old) fathead minnows that we used in our toxicity tests. Young fish are usually among the most vulnerable stages of the fish life cycle. As a result, these very young fish are very sensitive to harmful chemicals. These tests are a powerful and meaningful way to see if discharge water (effluent) is possibly harmful to fish.

These are 2-month-old rainbow trout. Young rainbow trout were a type of fish we used in our toxicity tests. We used young trout in our tests because they are very sensitive to many chemicals.

What we learned

Based on the survival and growth of the fathead minnows after 7 days, we found that the effluent and river water were not harmful to fathead minnows. We also found that the effluent and river water were not harmful to rainbow trout after being in effluent and river water for 4 days and 28 days. After 28 days, there was no effect on the liver of rainbow trout.

These tests show that the waters discharged from the Norman Wells Operation should not affect fish in the Mackenzie. These test results support what we found with the loche study (page 12) and the whitefish study (page 14). In those 2 studies, the fish collected downstream of Norman Wells at Fort Good Hope were in good condition compared to other areas looked at.

This is an adult male fathead minnow guarding the eggs. The eggs are attached to the underside of the tile just above the fish.

Toxicity testing is done in the laboratory under controlled temperature and lighting.

TESTING OF DISCHARGE WATER FOR THE WATER LICENSE

Why we Test Water for the Water License

The Water License for the Norman Wells oilfield Operation puts a limit on the amount of chemicals from oil and other substances that can be released (or discharged) into the Mackenzie River. These limits ensure that fish, fish habitat and water of the Mackenzie River will not be affected by water released from the Norman Wells Operation.

What we did

To make sure that the Norman Wells Operation meets these discharge limits, a monitoring program was developed specifically to monitor these discharge waters. This program is called the Surveillance Network Program (SNP). The testing done for the SNP provides an "early warning" of a potential problem with water released into the environment.

The Central Processing Facility (CPF).

The Refinery Waterflood Pond. Water from this pond is released to the Mackenzie River twice a year.

Cooling water released from the (CPF)

What we learned

Water can only be released to the environment if it meets the discharge limits. Water that is released continuously is sampled and tested every week. There is only one location where water is released continuously – that is from the Central Processing Facility (CPF), which only releases cooling water. Cooling water is water taken from the river and used to cool various parts of the facility.

Of all of the samples from the CPF taken every week since 2001, there was only one that did not meet the discharge limits for a sample. The amount of oil and grease in the sample collected for the week of November 8, 2005, was slightly higher than the limit. Because of this, the average amount for the Month of November 2005 was also slightly above the limit allowed for any month. Toxicity testing covering that period indicated that the effluent was not harmful to fish.

A CPF water sample collected in March 2006 for toxicity (to see if it can harm fish) failed the toxicity test. This means that the sample killed the fish used in the laboratory. More tests were immediately done to see if there was a problem with the CPF water. However, all of the CPF water samples passed the toxicity tests. This means that the samples did not kill any of the laboratory fish. Since 1991, all other tests for toxicity have passed.

NATURAL OIL SEEPAGE

Why we looked at natural oil seeps

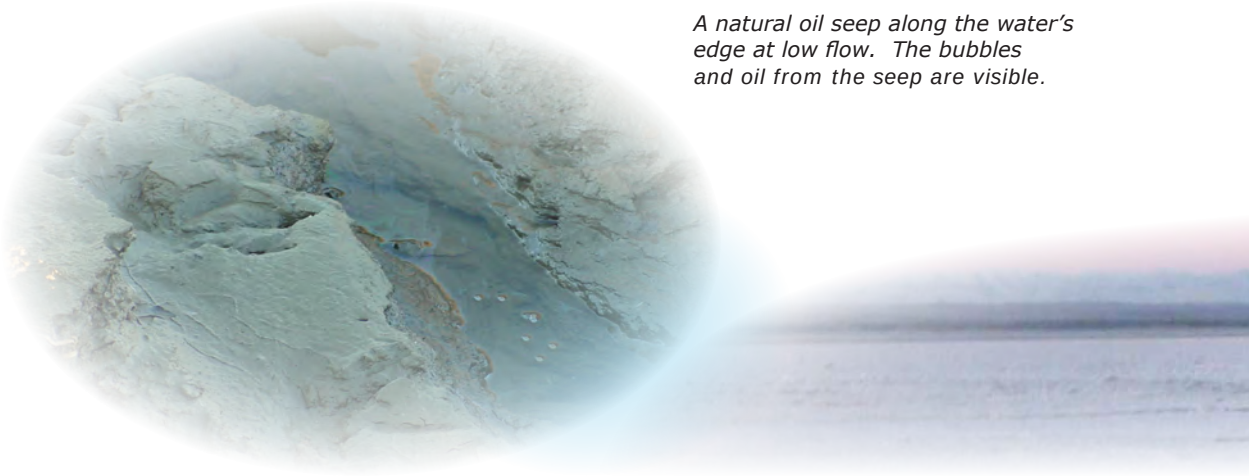
During the summer and fall, oil can be seen bubbling at the surface of the water at several locations along the Mackenzie River. During the winter, oil can be seen as black pools on the ice. It is because of these oil seeps that oil was discovered in Norman Wells almost 90 years ago. This oil comes from beneath the river bottom.

We wanted to better understand where this oil comes from. We also wanted to better understand how much of this natural oil enters the river. This information will help us to determine what effects oil potentially released by the Norman Wells Operation might have on the Mackenzie River.

What we did

The location of many of the natural oil seeps was determined. Then, special tools used to map the rocks underground were used see if the oil was coming from below the river.

The amount of oil rising to the surface was determined. Seepage meters were used to estimate the amount of oil seeping to the surface. Another way that was used to determine the amount of oil seeping to the surface was to dig a small pit and see how long it took for that pit to fill with oil.



A natural oil seep along the water's edge at low flow. The bubbles and oil from the seep are visible.

Area along the Mackenzie River that contains several natural oil seeps.

What we learned

There are presently 5 areas where natural oil seepage is active and visible. These occur along the shore of the Mackenzie River, as well as in the Mackenzie River and in Bosworth Creek.

Some seeps have crude oil and gas rising to the surface, and others have only oil seeping to the surface. The height of the water in the river can influence how much oil seeps to the surface.

This oil comes from beneath the river and seeps through the rock at the bottom of the river. This is why we see it at the surface of the water. The amount of oil entering the river from these seeps is about 25 barrels of oil every year.

OVERALL FINDINGS

What we learned

This AEM Program looked at several approaches to see if the quality of fish and water of the Mackenzie River is being affected by the Norman Wells Operation and to determine a cause for any effects we might have found. For fish, we were mainly interested in looking at loche liver quality and whitefish flesh (or meat) quality.

Fish Quality

We did several fish surveys with the help of residents from Fort Good Hope and Tulita. We found that the condition of the fish that the communities were concerned about still exists. These concerns are about the small, dark livers in loche and the 'watery' or mushy flesh of whitefish. The results of these AEM surveys also told us that the quality of these fish appears to be better than in the 1980s. For example, the number of loche with bad livers in our study was much smaller than in surveys from the 1980s. The 1980s is when previous studies were done to look into the original community concerns with fish quality.

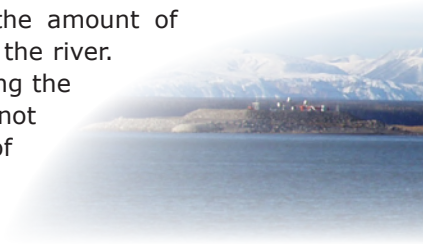
The presence of small, dark livers in loche was not any worse at Fort Good Hope than at Tulita. In fact, studies in other rivers and lakes have also found this liver condition in loche.

The texture testing panel composed of residents from Fort Good Hope found a big difference between the quality of female whitefish with eggs and male whitefish. The study found all the whitefish to be in very good condition, but fish that are about to release their eggs (or spawn) tend to have more 'watery' flesh (or meat). Both the small, dark livers in loche and the 'watery' flesh of whitefish appears to be related to the natural cycles of the fish.

Effluent Quality

We also did toxicity tests in the laboratory to see if water released by the Norman Wells Operation (or effluent) could harm fish. The tests of all Operation effluents showed that they would not affect fish in the river.

Chemical testing of the effluents and river water showed that the amount of chemicals from oil (such as PAHs) was less in the effluents than in the river. With the use of a bright dye, we showed that the effluents stay along the shore of the Mackenzie River as they move downstream. We would not be able to find the effluents much past Rader Island, downstream of Norman Wells. This location is over 100 kilometres upstream of Fort Good Hope.



Water Quality

Most of the oil-related chemicals (such as PAHs) that we find in the river come from natural sources, such as oil. We found that oil enters the river from natural oil seeps along the shore of Norman Wells. We also found that the amount of chemicals like PAHs in the river was below the amount needed to harm fish. We did not find a link between chemicals like PAHs and liver condition in loche.

Conclusion

The results of all of the approaches we took agreed with each other. They all indicate that the Norman Wells Operation is not having an effect on the quality of the fish and water of the Mackenzie River.

Members of the Whitefish Study Panel

Back Row: Elaine Harris, Norman Pierrot, Alfred Orlias, Jerry Lennie, Alexis Chinna, Alfred Masazumi

Front Row: Eileen LeBlanc, Bella T'seleie, Jenna Grandjambe, Cathy Kelly, Mary Pierrot, Jane Kelly, Leon Kelly, Jonas Kakfwi, Raynald LeBlanc

If you want more information about the AEM Program, please contact:

Tyler Colberg

Imperial Oil Resources
237 Fourth Avenue S.W.
P.O Box 800
Calgary, Alberta
T2P 2J7

403-237-3095 or
800-567-3776

Chris Fraikin

Golder Associates Ltd.
1000, 940 Sixth Avenue S.W.
Calgary, Alberta
T2P 3T1

403-299-4666 or
403-299-5600

Esso Imperial Oil

Golder Associates