Handbook of Diseases of Saskatchewan Fish

Saskatchewan
Ministry of
Environment

Handbook of Diseases of Fish in Saskatchewan

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Produced by
Saskatchewan Environment

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Acknowledgements

Thank you to the following people for their editorial comments:

Dr. F.A. Leighton, CCWHC

Dr. Trent Bollinger, CCWHC - Saskatoon

Ed Dean, A/Director, Fisheries Branch, SERM

Tom Maher, Fisheries Branch, SERM

Bruce Howard, Fisheries Branch, SERM

Kevin Murphy, Fisheries Branch, SERM

Rick Orr, Fisheries Branch, SERM

Peter Ashcroft, Conservation Officer, SERM

Bev Larson, Fish & Wildlife Division, Alberta Forestry, Lands & Wildlife.

A special thank you to Ian Shirley and Kathy Caspell, WVCM, Saskatoon for photography assistance.

Photographs courtesy of:

Figures 2, 4, 6, 7, 8, 9, 11, 12, 16, 17 and 18

Department of Veterinary Pathology, Western College of Veterinary Medicine, University of Saskatchewan, Saskatoon SK

and

Canadian Cooperative Wildlife Health Centre, Dept. of Vet. Path, WCVM.

Figures 3, 10 and 13

Bev Larson, Lab Scientist - Fish Diseases, Fish and Wildlife Division, Alberta Forestry,Lands and Wildlife, Edmonton, AB

and

Animal Health Laboratories Branch, Agriculture, Food and Rural Development, Government of Alberta

Figures 5 and 14

Gerry Johnson, Atlantic Veterinary College, University of Prince Edward Island, Charlottetown,PEI.

Introduction

Disease in the Ecosystem

The occurrence of diseases within an ecosystem is not new and is, in fact, an integral part of the natural ecosystem and its dynamic balance. Diseases can be caused by infectious agents, natural or manmade changes within the environment or pollutants. They generally occur as a result of the interactions among a host organism, a causative agent and the environment in which they find themselves. For example, a fish (host) may have a poor immune system resulting from malnutrition caused by environmental conditions such as a severe and prolonged winter. The abundance of a common parasite (causative agent) may be increased in response to environmental conditions (overcrowding of resident fish populations and/or favourable water conditions). With these conditions combined, the chances of a fish succumbing to an infection from the parasite are increased.

This handbook uses the term "disease" in the broadest sense and deals with, not only diseases caused by infectious agents, but also with disease conditions caused by environmental changes.

The Importance of Disease Surveillance

In the 1950s, wildlife and fisheries biologists, managers and scientists began to recognize that diseases may be an indicator of ecosystem imbalances brought on by human activity. Examples include: Overcrowding within a population resulting from habitat destruction, natural predator persecution or contamination of waterways.

The expansion of aquaculture in the world has made it economically feasible to learn more about fish diseases and their causative agents. It has also created a need to have a better understanding of possible exotic disease-causing agents that might be imported into the country. A greater awareness of the environment is allowing scientists to investigate contamination and pollution of waterways. It is the role and duty of the field officers, anglers and others to be aware of diseases affecting fish so that new disease states and unexpected disease states or dieoffs can be investigated by the proper authorities. By acting as the front line observers, the field officers play an essential role in protecting the health of our fisheries resource.

Who to Contact When You Find a Diseased Fish

District conservation officers, Saskatchewan Environment and Resource Managment (SERM) at 1-800-667-7561 should be notified immediately whenever a fish dieoff or a diseased fish is found. They in turn will submit the specimen(s) for diagnostic analysis to the Canadian Cooperative Wildlife Health Centre (CCWHC) who provides diagnostic services for diseased fish.

The CCWHC has developed a data base for recording fish and wildlife disease that will provide a better understanding of the distribution of disease and greatly improve our disease surveillance capabilites. Until the creation of the CCWHC, the location of disease occurrences were not recorded in an efficient manner and the historical distribution of fish diseases in Saskatchewan is difficult to ascertain. The CCWHC is located at the University of Saskatchewan in Saskatoon, telephone (306) 966-5099, FAX (306) 966-8747 or by the toll free National Information Line (1-800-567-2063).

How to Handle and Store Tissues

The choosing of samples for fish disease investigations must be well thought out. Collection for investigation of fish die-offs is different than individual fish submissions. Tissue preservation is essential for the proper identification of the disease. This handbook will only touch on the basic principles for specimen collection. For more in-depth information, please refer to "Field Manual for the Investigation of Fish Kills" (see bibliography). In general, the sooner the fish can be examined by a disease specialist, the better the chance of a diagnosis being made. If you know where you are going to send the fish, call ahead to ensure that you can be as effective as possible in having the disease diagnosed.

History information:

- Date and location
- Number of species, individuals and sexes involved;
- Abnormal events in the week prior to the submission; and
- Visible abnormalities on the surface of the fish.

Water collection: You should, if you have the capability, collect water samples and blood samples from sick but not dead fish. Special techniques and containers are required to test for gases in the water such

as oxygen. Clean watertight freezerbags are ideal for collecting water containing suspected toxins. If gases are not being tested refrigeration and/or freezing are acceptable means of storage.

Fish collection: You should select the most recent dead fish for examination. Live fish provide the best specimens for examination. They are best kept in a cooler filled with oxygenated water from their environment. Fresh fish kept cool for no more than eight to 12 hours are useful. A mixture of fresh, frozen and formalin fixed tissues is also a useful submission for the investigator.

If fish must be kept for a long period of time, they should be promptly frozen at the coldest temperature available. Attempt to protect the fish from freezer burn by limiting the air touching the fish and double wrapping it. Label the fish well so that it does not get mixed up with other samples. Samples preserved in 10 per cent formalin are useful for microscopic examination but may only have limited tests performed on the tissues. Keep duplicate samples of the same tissues, fresh or frozen so that alternative test for toxins, bacteria, viruses, parasites and such can be performed.

Always wash hands thoroughly with soap and water after handling diseased fish.

Shipping samples: If no hazardous materials or disease agents are suspected, then the package may be shipped as a "Diagnostic Specimen" (See Transportation of Dangerous Goods Control Act - Saskatchewan). Ensure all samples are shipped with enough ice or cooling packs to remain frozen or cool and a leak proof container is used for shipping.

Human Safety: Federal government regulations under the Fish Inspection Act, which apply to commercially caught fish, prohibit the sale of fish which is "tainted, decomposed or unwholesome". It would be prudent for the angler to apply similar guidelines to his or her own fish consumption.

Most bacterial and viral diseases, if noticeable, render the fish unwholesome enough in appearance that no-one would want to eat it.

Most parasites which infect freshwater fish will not infect humans; a notable exception is the fish tapeworm, Diphyllobothrium latum (see "Diseases of the Internal Organs: Tapeworm cysts"). In any event, parasites present in freshwater fish are killed by cooking, hot smoking, or by freezing and therefore should not constitute a health hazard.

The best rule of thumb is; if the fish appears unwholesome, or if consumption is questionable, don't eat it.

Ecology of Saskatchewan Fish

Saskatchewan has an estimated 82,000 km^2 of surface water found in over 94,000 lakes, streams, ponds and man-made reservoirs providing habitat for 69 fish species. (Atton and Merkowsky 1983). Of these, 58 are indigenous (naturally occurring) to Saskatchewan (e.g. northern pike, walleye, lake whitefish), while eight other species have been introduced either by intentional stocking efforts (e.g. brook trout and rainbow trout) or through immigration (e.g. carp).

Fish habitat requirements vary from species to species. In the north, shield lakes and streams provide clear, cold, well oxygenated waters for species such as lake trout and grayling. The south is typified by shallow lakes and warm water streams where species such as bullheads and buffalo fish reside. Walleye, northern pike and yellow perch are found throughout the province.

The following is an alphabetized list of those species considered to have economic importance within Saskatchewan. For further information regarding the range and habitat requirements of these species, please refer to Scott and Crossman (1973).

Arctic grayling (Indigenous)

Range is limited to the clear, cold waters of northern Saskatchewan rivers.

Brook trout (Introduced)

Prefers clear, cool lakes and streams. Has been stocked in selected streams in central and southern Saskatchewan. Some of these stockings have resulted in the establishment of self-sustaining populations.

Burbot (Indigenous)

Found throughout Saskatchewan in deep or cool waters.

Carp (Introduced)

Inhabits warm, shallow lakes and rivers. This species was introduced in the United States and moved through the Red River into river systems in south-east Saskatchewan, specifically the QuAppellle, Souris, Assiniboine and Frenchman rivers.

Cisco (Lake herring) (Indigenous)

Found primarily in the midwater depths of lakes in Saskatchewan's central and northern regions.

Goldeye (Indigenous)

Occurs in quiet, turbid waters of the North and South Saskatchewan rivers and associated lakes, ponds and marshes.

Lake sturgeon (Indigenous)

Occurs only in the Saskatchewan and lower Churchill river systems.

Lake trout (Indigenous)

Restricted primarily to the cold, well-oxygenated lakes in northern Saskatchewan.

Lake whitefish (Indigenous)

A cool water, bottom feeding species which occurs in lakes and rivers throughout Saskatchewan, except the most southerly portion.

Largemouth bass (Introduced)

Requiring very warm waters to reproduce, this species was introduced and is restricted to the thermally heated waters of Boundary Reservoir.

Longnose sucker (Indigenous)

Found throughout Saskatchewan but primarily in the clear cold lakes and rivers of the north.

Northern pike (Indigenous)

Widely distributed throughout Saskatchewan, occurring in clear, warm, slow, heavily vegetated streams or warm weedy bays of lakes.

Rainbow trout (Introduced)

A highly tolerant aquaculture species which has a wide range but prefers moderately deep, cool lakes.

Sauger (Indigenous)

Found within the Saskatchewan and Churchill river systems, this species prefers large lakes and rivers with shallow, turbid waters.

Walleye (Indigenous)

Widespread throughout Saskatchewan in lakes or large turbid streams or rivers.

White sucker (Indigenous)

Widely distributed throughout the lakes, ponds and streams of Saskatchewan.

Yellow perch (Indigenous)

Found throughout Saskatchewan except in the extreme northeast. This species is abundant in warm or cool lakes which support a moderate growth of vegetation.

Anatomy

External and Internal Anatomy

See Figure 1.

Seasonal Changes in Organs

Depending upon the species, spawning occurs in the spring (e.g. walleye, pike, grayling, suckers) or the fall (e.g. lake whitefish, lake trout). During the non-spawning season ovaries appear as tubes where developing eggs can be seen as tiny, but distinct round structures.

As the spawning season approaches, yoke sacs develop and the eggs increase in size, swelling the ovaries to fill the body cavity. Testes appear as pale tube-like structures which expand and thicken, becoming milky white in colour as spawning season approaches.

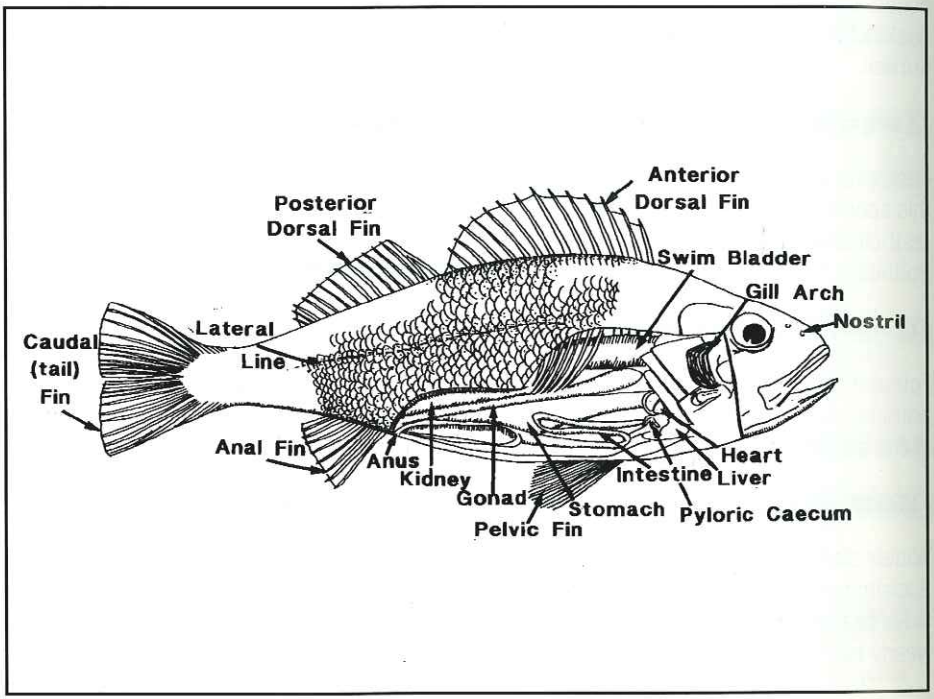

Figure 1. General anatomy of the fish.

Diseases of the Skin, Muscle, Gill and Fin

Bacterial Diseases

Haemorrhagic Disease

(Haemorrhagic Septicemia)

Cause: Infection with the bacterium Aeromonas hydrophila

Fish affected: Many fish found in fresh, warm water as well as cool water brown trout.

Locations found: Reported commonly in the southern part of the province but most likely throughout Saskatchewan.

Appearance: Lesions include pinpoint haemorrhages under the skin and on internal organs and/or a swollen abdomen full of fluid. Sometimes the fluid build-up in the abdomen results in bulging of the anus and eyes. Less commonly, this bacteria may cause chronic ulceration of the skin.

About the disease: The disease is caused by infection by bacteria of the genus Aeromonas. These bacteria are normal inhabitants of surface water and act as "opportunists" in that they will cause disease in fish which are stressed, traumatized, overcrowded or in abnormally warm water or low oxygen conditions. The bacteria enter the fish via the mouth or a wound and enter the blood stream where they multiply and spread to affect many organs. Large numbers of fish can be affected and the majority die.

Human safety: Fish affected by this disease are in poor condition. Flesh of the infected fish may have an off taste and should not be eaten. Aeromonas species are found in untreated water and under normal circumstances are not harmful to humans. They have been reported to cause diarrhea in children and various infections of the skin, eye and other organs. Persons in contact with the fish should wash their hands thoroughly. Aeromonas hydrophila produces some toxins which may cause food poisoning.

Furunculosis

(Red Plague)

Cause: Infection with the bacteria Aeromonas salmonicida.

Fish affected: Freshwater and marine fish. This disease is found in both wild and captive reared fish.

Locations found: Common throughout North America.

Appearance: Lesions include small hemorrhages, blisters and ulcers of the skin commonly found at the base of the fins. Secondary infections by fungus are common as the bacteria damage the immune system of the fish by producing a toxin. Much of the damage caused by this organism to internal organs is microscopic.

About the disease: The bacteria can infect fish which ingest contaminated feces from infected fish or through direct contact with infected fish. Normal mucous and intact skin along with normal bacterial microflora

offer protection against this bacteria. Fish can recover from the infection but many die. Stressors including low oxygen levels and warm water or loss of mucous or skin abrasions will make individuals more susceptible to infection.

Human safety: Fish found affected by this disease are in poor condition. Flesh of the infected fish may not have an appealing taste and should not be eaten. Aeromonas species are not harmful to man under normal conditions, however they have been the cause of diarrhea in children and various infections of the skin, eye and other organs. Persons in contact with the fish should wash their hands thoroughly.

Columnaris Disease

Cause: Infection with the bacteria Flexibacter columnaris

Fish affected: Most species of freshwater fish.

Locations found: Warm water above 18 degrees celsius as found in shallow ponds of southern Saskatchewan.

Appearance: Lesions are usually confined to the head, back and gills. They begin as raised blisters surrounded by a ring of reddened tissue. Blisters will slough off creating an open wound often covered by an orange or yellow film. In Saskatchewan, the absence of lesions has been noted for some suckers with this disease.

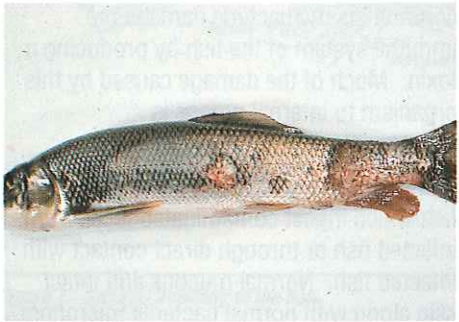

Figure 2. Columnaris disease lesion on the body wall of a sucker.

About the disease: The bacteria can be found on the skin of normal and diseased fish. Infection and disease are a result of a loss of balance between the host fish's immune system and the multiplication of the bacteria. Poor water quality and oxygen levels can predispose a fish to this disease. Once infected, many fish do not eat, lose condition and die from the disease. In one report of suckers affected in Saskatchewan, death due to septicemia occurred.

Human safety: Flexibacter bacteria are not known to infect humans. Diseased fish should not be eaten because of poor quality of the flesh.

Tail Rot

Cause: Infection with the bacteria Flexibacter psychrophila.

Fish affected: Trout species and most freshwater fish species.

Locations found: Not common in Saskatchewan but occasionally reported in the cold water regions of northern Saskatchewan.

Appearance: Lesions are usually confined to the skin muscles and fins. Ulcers can be apparent on the body surface but the fins are most commonly misshapen and ragged in appearance.

About the disease: The bacterium Flexibacter psychrophila is suspected to live on the skin of healthy fish and in water containing high levels of organic material. Mortality is high among fish affected by

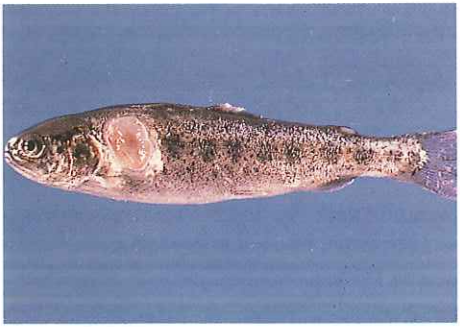

Figure 3. Rainbow trout fingerling affected by Flexibacter psychrophila.

this disease, however some fish do appear to recover. The fishs ability to mount a good defense by its immune system is hampered presumably by cold temperature of approximately 4 to 12 degrees celsius. This is the optimal temperature range in which the bacteria flourish.

Human safety: Flexibacter bacteria are not known to infect humans. Diseased fish should not be eaten because of poor quality of the flesh.

Fungal Diseases

Saprolegniasis

Fish affected: Trout species and white suckers are commonly reported to suffer from this disease in Saskatchewan. However, any species can be affected.

Locations found: Common throughout Saskatchewan.

Appearance: Grey-white patches on the skin which, if observed while the fish is in water, have a cotton-fibre-like appearance. Infected areas are initially small and circular but often join to form large patches which may darken as the broken skin captures silt and dirt. Fungal infection can occur as a secondary occurrence within skin tumours. Due to the breakdown of the fishs protective skin and scales by these fungal lesions, the fish may appear "waterlogged".

About the disease: The term Saprolegniasis is used to describe fungal infections of the skin and gills caused by a variety of fungi. A combination of trauma (such as rough handling by anglers), overcrowding, pollution, cold temperature and/or bacterial infection can predispose a fish to a fungal infections. Recovery of a diseased fish is possible but severely affected fish die.

Human safety: Fungi are common to natural water. Affected fish should not be eaten because of the poor quality of flesh. Hands should be thoroughly washed after handling affected fish.

Figure 4. Fungal skin infection in a brook trout.

Parasitic Diseases

Cestodes

Tapeworm Cysts

Cause: Infection with a larval form of a tapeworm. Please see Diseases of the Internal Organs-General -Tapeworms for further description.

Trematodes *(Flukes)*

Black Spot

(Fluke Larvae)

Cause: Infection with the larval form of a fluke.

Fish affected: Yellow perch, longnose sucker, cisco, white sucker, brook trout, sauger, northern pike and walleye have all been reported. However, any species of freshwater fish can be affected.

Locations found: The parasite is common to North America and can cause great losses in pond reared fish.

Appearance: Small poppy seed-sized cysts in the muscle and skin of the affected fish.

About the disease: The term Black Spot refers to the formation of small cysts in the muscle and skin around the parasite. The cyst accumulates black pigment cells around it which cause little harm to the fish. Young fish can have growth problems if heavily infected. The first intermediate host for this parasite is a mollusc, the fish is the second intermediate host and the final host is a heron or kingfisher.

Human safety: The unsightly nature of this parasite when fish are heavily affected often makes the fish unsuitable for human consumption.

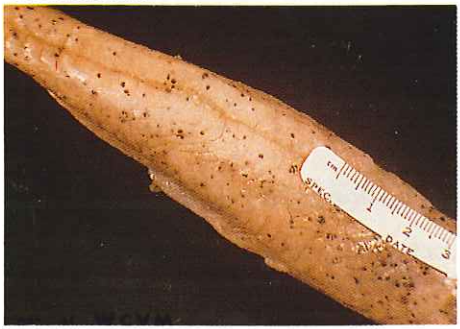

Figure 5. Black Spot in the skin and flesh of a yellow perch.

Protozoa

Myxosporidia

Cause: Infection with the small protozoan Myxosporidian parasite.

Fish affected: Yellow perch and brook trout are the most common species affected in Saskatchewan.

Locations found: Common throughout Saskatchewan and North America in marine and freshwater fish.

Appearance: Haemorrhage on the gills and in the skin. Yellow perch may have cream to white coloured nodules within the muscle.

About the disease: Caused by a small parasite which encysts as it develops. At maturity, the cyst ruptures, releasing spores into the water. The spores become infective and enter other fish by attaching to gills and breaks in the skin. Haemorrhage and cell damage results in an open ulcer on the skin or gill. By occupying space on the gills of the fish the parasite can interfere with normal respiration. Many fish survive with low level infections.

Human safety: Myxosporidial infections spoil the appearance and taste of the fish, making infected fish unsuitable for human consumption. (Also see whirling disease)

White Spot

(Ichthyophthirius)

Cause: Infection with the protozoan parasite Ichthyophthirius species.

Fish affected: Yellow perch, brook trout, smallmouth bass, white sucker and rainbow trout.

Figure 6. White Spot infection on the gills of a Goldeye. Lesions are the raised pale area of the gill.

Locations found: Common to most waterways of Saskatchewan.

Appearance: Early stages of the infection appear as small white spots on the skin and gills. As Ichthyophthirius matures, it ruptures through the skin causing ulcers.

About the disease: The disease is caused by a small self-propelling protozoa. The organism likes warm temperatures and can complete its life cycle in 12 hours. Each individual organism that erupts from the skin of the fish can produce 2,000 infective feeding stage protozoa able to infect other fish. A white spot is caused by the organism rotating in the skin as it feeds.

When the organism is mature, it ruptures through the skin causing severe trauma. Secondary infections by bacteria and fungi can then occur. The fish can die from these secondary infections, as a result of the loss of its protective skin barrier or from loss of function of severely affected gills. Fish which survive an infection appear to be resistant to reinfection for several months.

Human safety: Heavily infected fish are unsightly and loss of skin causes the flesh to be spoiled. The severely affected fish is not suitable for human consumption.

Leech Infestation

Cause: Attachment of leeches to fish. The leech Piscicola sp. is common in Saskatchewan.

Fish affected: Leeches will attach to any fish in their environment. However in North America, there are specific reports of leech infestation of lake sturgeon, walleye, northern pike, longnose sucker, white sucker, yellow perch, largemouth bass, burbot, smallmouth bass, rainbow trout, sauger, lake trout, black bullhead and brook trout.

Locations found: Found in all parts of Saskatchwan but more commonly reported in the southern regions.

Appearance: Small dark soft bodied organism of up to five centimetres in length which attach to the skin.

About the disease: The leeches live in the water and occasionally attach to the skin of the fish to obtain a blood meal by boring a hole through the skin. Heavy infestations usually occur on cultured fish in highly infective environments. Heavy infestations can lead to death due to blood loss. A few leeches on a fish do not directly cause much damage to the fish, except occasionally setting up trauma to the skin allowing secondary bacterial and fungal infections to begin. Leeches are also known vectors of blood and internal parasites.

Human safety: If leeches are removed from the fish and no secondary skin infections are apparent, the fish is safe for human consumption.

Mollusc and Crustacean Infestation

Cause: Attachment of molluscs and crustaceans to fish.

Fish affected: Any species of fish is a suitable host for this organism.

Locations found: More common in the southern part of the province but can be observed anywhere in Saskatchewan.

Appearance: Appearance is very dependent on the organism causing the infection. Many molluscs go unnoticed in the gills of the fish. Some crustaceans cause massive ulcers and erosions on the skin of the fish. These organisms can look like lice or soft ticks attached to the skin, fins and gills.

About the disease: The free swimming larvae of many bivalve molluscs must go through a parasitic state on the skin or gills of fish. The larvae becomes surrounded by fish tissue on the gills and may stay there for seven or eight months while maturing. High mortality of fish is rare but has been reported in hatchery environments. Death can result due to loss of useful gill function. Some other crustaceans have a direct life cycle in which an adult lays eggs in the water and the hatched larvae must find a fish to attach to within a couple of days. The damage to the protective skin of the fish can lead to secondary bacterial and fungal infections.

Human safety: Many fish are unnoticeably infected in their gills with molluscs. These cause no threat to humans. Many of the crustaceans cause massive unsightly open sores to the fish. Fish should not be eaten due to the poor quality of the flesh.

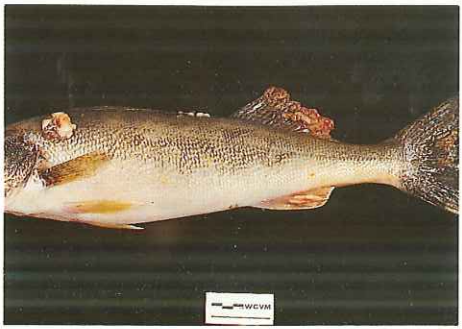

Figure 7. Lymphocystis affecting the skin and fins of a walleye.

Tumours

Lymphocystis

Cause: Infection by a virus.

Fish affected: Walleye

Locations found: Found in most watersheds of North America.

About the disease: Lymphocystis is caused by a virus which invades the fish through breaks in skin. Such skin wounds are a common occurrence in late spawning season as large numbers of fish in small areas constantly damage their skin. Each mass is made up of many infected cells, which swell up to 100 fold larger than normal. These infected cells can each be seen with the naked eye as cyst-like structures. The disease does not cause great harm to the fish unless the masses are extensive. Masses on gills may interfere with the breathing function of the fish. Fish affected by lymphocystis can recover and be reinfected.

Human safety: The virus is not known to infect humans.

Fibromas And Fibrosarcomas

Cause: The cause is unknown in most fish. In walleye, the tumour is caused by a retrovirus and is covered as a separate disease later in this section.

Fish affected: Common disease in northern pike and yellow perch

Locations found: Found sporadically throughout North America.

Appearance: Both tumours appear as loosely attached or firmly anchored raised masses on the body, head, fins or gills. The scales above the mass may or may not

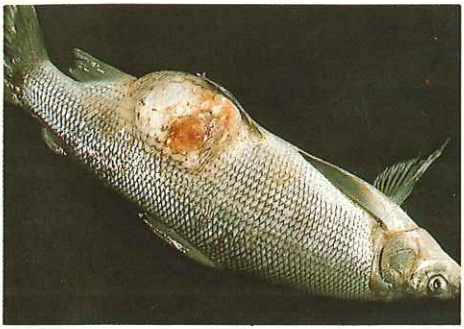

Figure 8. An ossifying fibroma in a whitefish.

have sloughed. The mass itself is solid, white to pink tissue that has the same texture throughout. These tumours may invade muscle tissues and greatly disfigure the normal symmetry of the fish.

About the Disease: Fibromas are solitary distinct masses while fibrosarcomas are cancerous (invading). Little is known about the cause of the tumours. However, both infectious agents (eg. virus) and environmental factors (eg. genetics) are suggested as possible causes. The disease leads to death if the tumour becomes extremely large and impairs the fish's ability to forage and flee from predators.

Human Safety: There is no evidence to link fish and human cancers. However, the cause of some of the tumours is a virus. Therefore, fish with tumours should not be consumed by humans or domestic animals.

Lymphosarcoma

Cause: In some species, the cause of this malignant tumour is a virus. In others, the cause is unknown.

Fish affected: A distinct disease occurs in northern pike. Similar but unrelated tumours have been reported in rainbow trout and other species.

Locations found: Reported throughout North America and the world.

Appearance: Usually seen as skin or muscle tumours. The tumour can spread to the liver, kidney, spleen and thymus.

About the disease: In northern pike, the disease is caused by a virus which infects the white blood cell known as a lymphocyte. Some studies in eastern Canada suggest large numbers of a population can be affected and tumours appear in greatest numbers after spawning and into the summer. The cancerous white blood cells progress from the skin and muscle to affect internal organs.

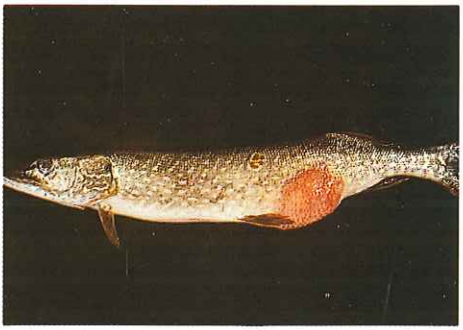

Figure 9. Lymphosarcoma behind the pelvic fin of a northern pike.

Occasionally, the fish may recover and heal from very superficial tumours but over 99 per cent of the fish affected are expected to die.

Human safety: Any fish with a tumour is considered unsuitable for consumption by humans and their pets.

Walleye Dermal Sarcoma

Cause: The cause of this tumour is a virus.

Fish affected: Walleye

Locations found: Reported sporadically in North America and confirmed in Saskatchewan.

Appearance: The tumours are similar in appearance to fibrosarcomas. They are found on the surface as smooth, solid firm, white masses up to one centimetre in diameter. Often, congestion of blood vessels makes the tumour have a patchy red color dispersed in the white mass.

About the disease: The disease has been reported in spawning walleye. A retro virus causes this locally invasive tumour by invading damaged skin. The virus infects cells and causes them to multiply uncontrolled.

Human safety: Any fish with a tumour is considered unsuitable for consumption by humans and their pets.

Other Diseases or Abnormalities

Gas Bubble Disease

Cause: A sudden change in the gas content of water usually associated with a sudden temperature change.

Fish affected: Any species can be affected.

Locations found: Reported in recently translocated fish and fish near warm outflows.

Appearance: Tiny blisters can be seen on gills and under scales. Many younger fish have protruding eyes due to gas accumulation behind the eyeball.

About the disease: This disease can be a result of manmade or natural changes in the gas content of the water. During times of rapid plant growth and oxygen release, water can greatly increase in its dissolved oxygen levels. Man-made outflows may have high gas levels due to the temperature of the out flow or the mechanical pumping of the water. The dissolved gases are absorbed by the fish, but when the gases enter the blood stream, they come out of solution to form gas bubbles. This disease is more common in cultured fish but does occur in wild stocks. Young fry are killed

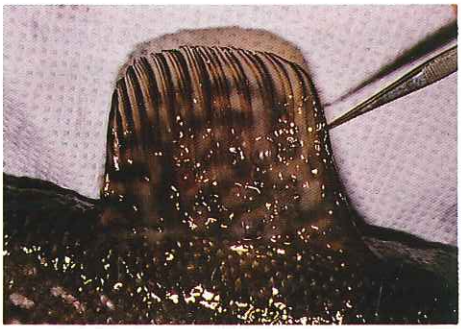

Figure 10. Gas bubble in the fin of a northern pike.

by this disease while adults have a better chance of recovery. Permanent damage to the eye can result and the survivability of a fish which recovers is poor.

Human safety: Fish are usually found dead and in a state of decomposition. Fish caught with this condition should be safe to eat.

Muscle Wasting

(Muscle Atrophy or Degeneration)

Cause: Unconfirmed

Fish affected: Many species can be affected.

Locations found: Reported in Saskatchewan and other provinces.

Appearance: Fish may be abnormally thin for their length and the fillet flesh (muscle) may be gelatinous or have a chalky material speckled thoughout.

About the disease: Muscle atrophy has been experimentally reproduced by feeding a diet low in vitamin E and selenium to fish in colder water temperatures. Similar muscle loss is seen in fish with disease of the pancreas. Starvation will also cause the animal to use its own muscle tissue as a form of energy. All muscle damage appears to be compounded by cold water temperature.

Human safety: Fish in this state are unsuitable for human consumption as the disease affects the texture and taste of the muscle (flesh).

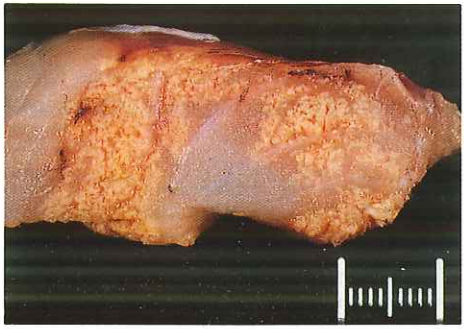

Figure 11. Cross section of the flesh of a walleye.

Muscle Necrosis of Walleye

(walleye myopathy)

Cause: Unconfirmed

Fish affected: Walleye

Locations found: Common in Saskatchewan and Manitoba, but reported in other provinces.

Appearance: The affected flesh is dark brown fibrous and sometimes appears as scar tissue (dense and white).

About the disease: The loss of muscle seen often in walleye appears different from starving fish. Some researchers suggested this disease is a result of injury associated with gill netting while others strongly dispute this theory.

Human safety: Fish in this state are unsuitable for human consumption because the disease affects the texture and taste of the muscle (flesh).

Endogenous Pigment

Cause: Ingestion of colored pigments that are absorbed and cause the muscle to take on the color.

Fish affected: Any foraging species of fish can be affected. In Saskatchewan, most commonly reported in yellow perch and trout species.

Locations found: This discoloration of the flesh of fish can occur anywhere and is common in waterways with an abundance of algae and plant life.

Appearance: A green to orange colour discoloration of the muscle with no accompanying change in texture or odour.

About the disease: This is not truely a disease state but rather a consequence of the food consumed. The pigments which are present in plants and invertebrates are absorbed from the gut and deposited in the muscle. The resulting discoloration depends on the plant product eaten.

Human safety: There is no danger to humans eating the fish. However for asthetic reasons, humans may chose not to eat the affected fish.

Trauma

Cause: Varied

Fish affected: Any species of fish may be affected.

Locations found: In spawning grounds or waterways with man-made dams, commercial or sport fishing.

Appearance: Cuts, scrapes, swelling or discoloration of the fish. Lesion may be bleeding or secondarily infected.

About the disease: This disease state can result from natural or man-made causes. During spawning season, many fish crowd together and can "rough each other up". Some fish are traumatized when released from deeply imbedded or barbed hooks which leave wounds that may heal or become secondarily infected with viruses, bacteria or fungi. Turbines, water inlets and other man-made structures can provide a dangerous damaging obstacle course for migrating fish.

Human safety: Affected fish should be eaten at the discretion of the angler. Flesh quality may be affected by secondary infections resulting from wounds.

Diseases of the Eye

Parasitic

Eye Flukes or "Cataracts"

Cause: Infection with various trematode or protozoal parasites which results in scarring of the cornea or surface of the eye. An example of a trematode that causes eye lesions is Diplostomum species. An example of a protozoan that causes eye lesions is Myxosoma scleropercae.

Fish affected: Lake sturgeon, longnose sucker, white sucker, cisco, lake whitefish, northern pike, burbot, smallmouth bass, largemouth bass, yellow perch, round whitefish, rainbow trout, brook trout, brown trout, sauger, walleye, arctic grayling and splake.

Locations found: This condition, caused by various parasites, is reported throughout North America.

Appearance: Affected fish have eyes which may appear opaque or have white lines running across its surface. Because of impaired vision or if the disease has caused blindness, the fish may be poorly developed due to its inability to forage. A true cataract is caused when the lens of the eye is affected. Usually cloudiness observed is due to lesions on the surface of the eye.

Figure 12. Close up of a fish eye affected by an unidentified parasite.

About the disease: Specifically, Diplostomum develop in aquatic snails and are released to invade the skin of fish when water temperatures are warm. The parasite larvae migrate throughout the fish but can develop to the next maturation stage in the lens of the eye. The infected fish must be eaten by a piscivorous bird to complete the parasites life cycle to adult trematodes in birds. Myxosoma scleropercae is a protozoan parasite that commonly invades the eye of perch. The formation of microscopic cysts in the eye's surface causes impaired vision of fish. Other conditions can also cause a whitening of the eye's corneal surface. After death, eyes can also become cloudy.

Human safety: There is no known danger to humans who consume the fish with these parasites in the eye. Poor condition of fish which are blinded by this parasite make them unsuitable for human consumption.

Pop-Eye

Cause: Can be caused by inflammation behind the eyeball or the accumulation of gas bubbles. ***Please refer to Gas Bubble Disease for more information.***

Diseases of the Skeleton

Developmental Anomalies and Acquired Fractures

Cause: Varied

Fish affected: Any species

Locations found: Found not uncommonly throughout Saskatchewan. Various conditions are reported world wide.

Appearance: Fish have abnormal curves in their spines or in their jaws.

About the disease: In young wild or hatchery reared fish, abnormal curvature of the spine is frequently seen. Many of these abnormalities are so severe that the fish does not live past an early fingerling stage. Other anomalies of the skeleton are less lethal. It is important to realize that many skeletal abnormalities are a result of previous severe muscle or nervous system damage. Toxins such as pesticides or heavy metals as well as some bacteria, protozoan parasites and vitamin deficiencies can severely affect the muscle of mature fish or the developing skeleton of immature fish. Lightning strike can also cause such a severe muscle contraction that the spine is broken.

Human safety: Because the specific cause of a skeletal abnormality in any particular fish is unknown, it is safest if the affected fish is not consumed by humans.

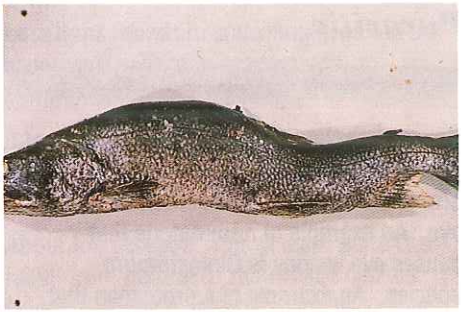

Figure 13. Developmental anomaly in the vertebral column of a lake trout.

Whirling Disease

Cause: Caused by the protozoa Myxosoma cerebralis.

Fish affected: Trout and salmon.

Locations found: Not reported in Saskatchewan. Due to its close proximity in the northwestern United States and its potential devastating effect if introduced, it is included in this handbook.

Appearance: Fish have abnormal curves in their spines or abnormal jaws. A sloped head and cranial bump are observed in young fish. In older fish, a humped back forms and the tail usually twists and bends. The tail can become darker than normal. The infection causes the fish to swim in circles until it exhausts itself.

About the disease: Myxosoma cerebralis spores can live in the environment for many years. The spores infect mud dwelling invertebrates and mature to the stage infective to fish. Infection is by ingestion of or skin contact with salmonids. These mature spores infect and damage the cranial and vertebral cartilage of young fish over a two to eight month time period. The infection causes death of cartilage and calicum deposit in the cartilage. This results in skeletal deformities and damaged nerves.

Damage to the nerves results in the darkening of the tail area. The disease causes death of young fish and can go undetected for years in the wild. In young fish, the disease may cause death with no visible lesions nor microscopic evidence of spores. Infected hatcheries can lead to the spread of this disease to stocked waterways and the infection of indigenous fish. Infected fish die in their first year as they are more susceptible to predation and malnutrition.

Human safety: The parasite is not known to infect humans. Fish are affected within the first year of life. All fish suspected of this disease should be examined immediately to allow early detection.

Diseases of the Internal Organs

General

Tuberculosis

Cause: Infection with Mycobacterium species.

Fish affected: Most freshwater fish are susceptible to the disease but it is most common in hatchery reared fish.

Locations found: More common in hatchery reared fish.

Appearance: Multiple white nodules on organs or the skin which have a chalky material in their centers although some can be quite firm and lack a chalky appearance. The nodules or tubercles can be found in any body tissues. If the skin is affected, there may be multiple ulcers present.

About the disease: The disease is caused by several species of Mycobacterium, some of which can infect humans, other mammals and birds. This is not the same organism that causes tuberculosis in humans but it is a related bacteria. The bacterium is hardy and can resist freezing. Fish can be infected through open wounds or by eating other animals infected with the bacteria. The disease is slow and progressive but may not cause illness in the fish until well advanced. This disease may be mistaken for diseases caused by the Flavobacterium species or protozoa. It requires microscopic examination using special stains for confirmation.

Figure 14. Tubercles in a yellow perch caused by Mycobacterium chelonae.

Human safety: Fish found to contain these types of nodules should not be eaten. After handling affected fish, hands should be thoroughly washed with soap and water to prevent infection via cuts and scrapes.

Lymphosarcoma

This tumour is found both on the surface and throughout the body. Please refer to Lymphosarcoma under the "Diseases of Skin, Muscle and Gill: Tumours" section.

Tapeworm cysts

Cause: Infection with a form of the tapeworm. An example of some common types of tapeworm include Diphyllobothrium species, Triaenophorus species and Ligulid type tapeworms.

Fish affected: Most fish species can be affected by either the adult or larvae of tapeworms

Locations found: Generally in all watersheds in Saskatchewan. Adult tapeworms in the intestines of fish range in size from microscopic to 20 centimetres in length.

Figure 16. Larval tapeworm cysts in the gill tissue of a smallmouth bass.

Appearance: Cysts can be seen in the intermediate host fish in the muscle and organs of the body cavity.

About the disease: In general, the life cycle of a tapeworm requires three hosts (Fig. 15). Adult worms can be found most commonly in the intestines of a final host. Final hosts include mammals (including humans) and birds which eat fish. Infective stages of the tapeworm are released into the water in the feces of the final host. These infective stages are ingested by intermediate invertebrate hosts and develop to more mature larvae.

The infected invertebrates are eaten by fish fry or other invertebrate-eating fish which become the second intermediate hosts. In this host, the tapeworm larvae escape the intestines and migrate to internal

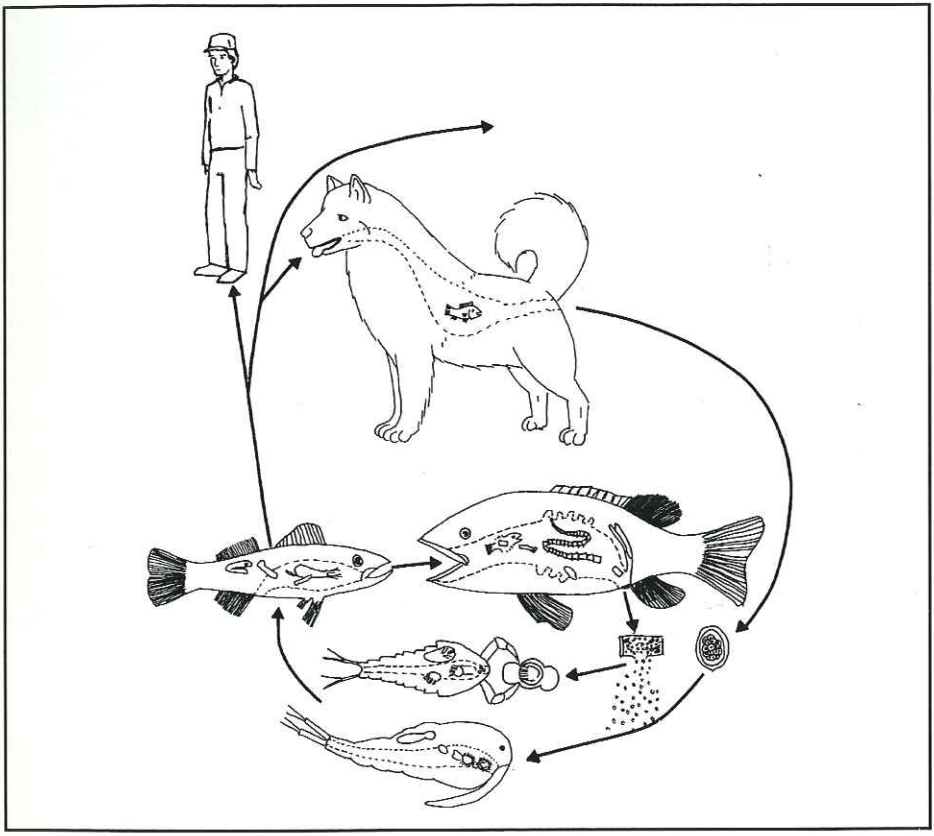

Figure 15. General lifecycle of tapeworms affecting freshwater fish.

organs and muscle where they encyst. It is these cysts and the reaction to these cysts that cause the lesions seen. As second intermediate host fish age, they tend to accumulate a large number of these cysts. If the sex organs are affected, sterility can result. Death can be caused by the damage to organs (eg. heart) caused by the migration of the parasites.

The fish eating mammal, bird or predator fish become the final host for the tapeworm by eating the cystic second intermediate host fish. The encysted tapeworm larvae mature in the intestines of the final host. The adult worms usually cause no obvious disease in the final host unless the load is heavy or the adult worm is extremely large in comparison to its final host. The first intermediate host of the tapeworm, Triaenophorus, is a copepod. A second intermediate host is a fry (including northern pike fry). The final host is a northern pike and the adult tapeworm can cause erosions and ulcers in the pikes intestines.

The first intermediate host of the tapeworm Diphyllobothrium is a copepod. The second intermediate host is a fish (trout or walleye) and a final host is any mammal including humans.

Human safety: Humans, dogs and many other species such as bears and fish-eating birds that eat raw or poorly cooked fish are vulnerable to infection by this parasite. The effect on humans is the development of tapeworms in the intestine.

Liver

Lipidosis

Cause: Poor nutrition, ongoing disease of other organs or high fat intake.

Fish Affected: Rainbow trout reared in captivity or in the wild. Other species of fish can be affected, however, fatty livers in burbot and northern pike may be normal.

Locations found: Reported occasionally throughout Saskatchewan and worldwide.

Appearance: Pale yellow or light brown livers sometimes torn or fractured with associated bleeding. The normally sharp edges of the liver are rounded.

About the disease: Lipidosis can result from poor nutrition because the fish is mobilizing its own fat stores to the liver to be used as energy. Lipidosis can be a result of feeding on a very high fat diet. Increased fat in the liver in this disease results in an easily broken liver. Periods of loss of blood cells, due to disease or toxins, can also lead to this condition. Pen fed fish have patchy pale livers when fed rancid feed. This condition is easily confused with invading tumours or inflammation of the liver and should be examined microscopically to confirm the disease state.

Human safety: Fish in poor body condition may be poor tasting. Consumption of the fish is at the discretion of the angler. Those fish eating high levels of fat should be fit for human consumption.

Testes and Ovaries

Leiomyosarcoma

(Leiomyoma)

Cause: Unknown

Fish affected: Yellow perch are commonly affected. Other species have also been reported to have these tumours but they are less common.

Figure 17. Leiomyosarcoma causing the enlarged testicles of a yellow perch.

Locations found: This disease has been reported throughout North America.

Appearance: Pale shiny firm round to oval masses attached to or involving the testicles or ovaries.

About the disease: These tumours originate from smooth muscle cells in the testicle or ovary in mature fish. Numbers as high as 8 per cent of yellow perch have been observed to be affected in the Great Lakes of Canada. The difference between a Leiomyosarcoma (cancerous) and a Leiomyoma (solitary tumour) can only be determined microscopically.

Human safety: Food safety regulations specify all animals with tumours as unfit for human and animal consumption.

Intestines

Nematodal Granulomas

Cause: Infection with a larval stage of roundworms.

Fish affected: Common in foraging or prey fish.

Locations found: Various species of round worm are found throughout Saskatchewan.

Appearance: The firm white nodules can be found in any internal organ. Sizes range from a few millimeters to one centimetre in diameter. Affected fish may have one to tens of these masses affecting their intestines.

About the disease: Multiple species of nematode parasites (round worms) have larvae which encyst in the organs of the body cavity of fish. Some examples include Eustrongylides species and Philonema species. The life cycle of these parasites is one in which the adult parasite lives in the intestine of fish-eating birds whose feces contain infective eggs or larvae. These infective stages infect a waterborne snail or other small organism. There the parasite matures and the infected organism is eaten by fish. Single or few nodules cause no ill effects in the individual fish. Heavily infected fish can die.

Human safety: The parasites in this form are not known to infect humans that eat the affected fish. Flesh of the infected fish is not affected.

Adult Intestinal Parasites

Fish affected: Any fish species which feed on other fish can act as the "end stage" host for intestinal parasites. Any fish can be affected by parasites that use an invertebrate as an intermediate host.

Locations found: Common in older fish throughout North America.

Appearance: Only visible when the intestine is opened. One or multiple numbers of worms can be present in an individual fish. Round worms are smooth,usually white worms with pointed ends, ranging in size from less than one centimetre to over five centimetres. Tapeworms (cestodes) are less common segmented flatshaped worms that are easily broken into rectangular segments.

About the disease: Parasites, which live in the intestines, usually shed infective eggs or larvae in the feces of the fish. The majority of the parasites act as a drain on the fish, using the food of the fish or its blood for survival. Unless the parasite load is high, the fish is minimally affected by intestinal parasites. Large numbers of parasites can be involved with poor immune systems in the fish affected. Large numbers can also cause physical obstruction to the intestine but this is uncommon.

Human safety: Humans eating the flesh of a fish containing intestinal parasites are not at risk of being infected. Anytime the intestines are opened during the cleaning of fish, the consumer should be concerned about contamination of the flesh by bacteria. The parasites are of minimal risk to humans.

Swim Bladder

Bloat Or Severe Distension

Cause: Sudden change in depth.

Fish affected: Common in walleye but any fish quickly brought to the surface from deep water can be affected.

Locations found: Common where gill-netting or catch and release fishing techniques are practiced.

Appearance: Fish have swollen abdomens and float on their backs, unable to right themselves.

About the disease: Caused by an inability to quickly adjust the volume of gas the fish carries in its swim bladder to regulate its depth. On calm warm days, the fish may suffer from sun exposure or predation by gulls. Some agencies have studied the affect of "fizzing" (poking a hole in the bladder with a sterile hypodermic needle to release the gas and allow the fish to return to deeper water). It is not clear whether fizzing increases the survival rate of fish.

Human safety: There is no disease agent associated with this condition.

Causes of Death for Large Numbers of Fish

Toxins

Heavy Metals

Cause: Contamination of waterways by improperly treated industrial waste.

Fish affected: All species.

Locations found: Downstream from industrial sites and in areas where flooding of tailings ponds could occur.

Appearance: The appearance of exposure to heavy metals can vary depending on the dose and length of exposure. Many heavy metals bioaccumulate and so fish higher in the food chain are the most affected. Large dieoffs due only to heavy metal pollution are rare. Usually fish appear in poor condition or appear long and thin for their age. Many fish may not appear affected, however, fish in these environments may have a reported increase in prevalence of skeletal deformities, and gill and fin abnormalities. Higher prevalences of tumours have also been reported in waterways polluted by heavy metals

About the disease: Heavy metal contaminants include compounds like lead and mercury. The only way to ensure safety of anglers that may consume the fish is to have suspect waterways and their fish population tested often for the presence of these compounds

Human safety: Fish caught from waterways determined to be heavily contaminated should not be eaten. Officials should be aware of the levels of such contaminants in waterways. For further information regarding mercury refer to 'Mercury in Fish: Guideline for Consumption." Saskatchewan Parks and Renewable Resources, Fisheries Branch, 1992.

Insecticides

Cause: The accidental or intentional release of insecticides into the water.

Fish affected: All fish can be affected.

Locations found: Not common but often apparent at the mouth of creeks that were initially contaminated.

Appearance: Numerous species of fish can be involved. There should be a conspicuous lack of water insects. Plant life initially appears normal.

About the disease: Toxic release of insecticides whether chemical compounds, organophosphates or carbamates can have multiple affects on the fish. In high level exposure, the toxin affects the fish's brain and fish will die in large numbers. In low level exposure, the food chain will be severely disrupted and cause slower, less obvious diseases due to inadequate nutrition.

Human safety: Insecticide contamination of fish usually causes death of the fish. Any area suspected of having an insecticide contamination should ban all fish consumption until the problem is resolved and insecticide levels are diluted to safe levels.

Industrial Toxins

Cause: Release of improperly treated industrial waste into waterways

Fish affected: Any fish can be affected.

Locations found: Uncommon in Saskatchewan but must always be considered when large numbers of fish are afflicted with a disease whose cause is undetermined.

Appearance: Varied. Eye problems, affected fingerlings, poor reproduction and poor survival of stocked fish are all signs that should be cause for concern. Acute mortality due to industrial toxin release is also possible.

About the disease: Many suspected toxic contaminations are difficult to research and prove. Many affected fish show up long after the toxins have become diluted. Thorough investigations are required. Toxins cannot be tested for on a random basis. Suspected specific toxins must be determined for accurate evaluation of water and affected fish. Many toxins do not kill the fish but affect their growth, reproduction, immune system and other systems. Liver tumours associated with low level toxins are a good example of the possible long term affects of industrial waste.

Human safety: No fish should be eaten by humans or domestic animals if high levels of industrial toxins are suspected in the waterways.

Oxygen Depletion

Cause: Lack of oxygen in the water.

Fish affected: All fish require oxygen. Large fish tend to die before small ones. Carp and warm water species may be able to survive during low levels of oxygen.

Appearance: Affected fish will be found dead due to summer kill, come to the surface "gulping for air" or appear to be trying to beach themselves. The majority die and decompose underwater therefore adding to the problem. Occasionally, dead fish may be found washed ashore in small calm inlets. The water is not clear but a turbid green or brown color and may have a rotten odour. Dead fish will usually have open mouths and flared, pale gills with no other signs of disease or trauma.

About the disease: Oxygen depletion is a widespread occurrence in shallow lakes and ponds. It commonly occurs in summer and winter and outbreaks are referred to as "summer kill" and "winter kill", respectively. Oxygen levels drop below critical levels and cause suffocation of the fish.

Figure 18. Large numbers of fish found dead.

Summer Kill

Lakes and ponds which experience summer kill characteristically are shallow and have an abundant growth of vegetation and/or algae. In the presence of sunlight, this vegetation and algae, being green plants, produce oxygen from carbon dioxide present in the water, through the process of photosynthesis. During hours of darkness, however, vegetation and algae, like fish, respire, using oxygen from the water to produce carbon dioxide. When vegetation and algae are overly abundant or begin to die in a water body inhabited by fish, they utilize the available oxygen to the detriment of the fish which virtually suffocate. Warm water is less able to contain oxygen gas. Artificial aeration of ponds is a proven method for reducing the chances of "summer kill".

Winter Kill

As with summer kill, fish mortalities generally occur in shallower lakes and ponds in response to a lack of available oxygen in the water. When lakes freeze and become snow covered, the algae and vegetation die due to lack of sunlight. When they die, the decay process uses the oxygen available in the water. If large amounts of vegetation die, the oxygen demand is such that water becomes oxygen poor and fish die. If potential winter kill is expected on a pond or lake, snow removal from the ice may allow sufficient sunlight to penetrate to the vegetation, reducing the amount of vegetation die off and increasing the chance of survival for resident fish.

Human safety: Fish suffering from oxygen depletion are rarely found alive. Those caught live but in poor health should cause no ill effects to humans but may not be palatable.

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