Response Procedures for Natural and Pollution-Related Fish Kill Incidents in the Atlantic Region



Canada

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Response Procedures for Natural and Pollution-Related Fish Kill Incidents in the Atlantic Region

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Abstract

The procedures in this guide have been prepared to promote interagency coordination and communication and to encourage timely and appropriate response to natural and pollution related fish kills in the Atlantic region of Canada. The guide contains information on roles and responsibilities, notification, initial and on-site assessment, safety considerations, external communications, environmental damage assessment, and enforcement. In addition, a variety of technical information is presented in the appendices on issues including site assessment, causes of kills, field monitoring and sampling, impact mitigation, site restoration/cleanup, and fish identification.

Résumé

Ces procédures ont été préparées pour promouvoir la coordination et la communication entre les agences et pour encourager une intervention rapide et appropriée en cas de mortalité soudaine de poissons, soit de cause naturelle ou reliée à la pollution, dans la région du Canada atlantique. Le document contient de l'information sur les rôles et responsabilités, les avis, l'évaluation initiale et sur le site, les questions de sécurité, les communications externes, l'évaluation des dommages à l'environnement et l'application de la loi. De plus, diverses informations techniques sont présentées en annexes. Ces informations portent sur l'évaluation du site, les causes de mortalité, le suivi sur le terrain et la prise d'échantillons, la réduction des impacts, la restauration/nettoyage du site et l'identification des poissons.

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1 Introduction

Each year in the Atlantic provinces, a number of fish kills occur as a result of habitat disruptions or alterations, fish health problems, chronic and acute effluent discharges, agricultural runoff, spills or leaks of toxic materials, inappropriate or illegal fishing activities, and natural die-offs. Fish kills are often very visible indicators or warnings of potential problems in the natural environment. In addition, the public looks upon any loss of fish with concern as these losses may relate to health, safety, and recreation issues.

Fish kill response and on-site assessments in the Atlantic Provinces are a shared responsibility among four provincial environment departments[1], Environment Canada (EC), and Fisheries and Oceans Canada (DFO)[2]. Staff members from these organizations will normally assume the role as representative of the lead government agency or resource agencies during kill incidents. The primary goals associated with responding to fish kills include identifying the cause, identifying the responsible party, mitigating damage, monitoring impacts, and enforcing legislation.

This guide has been developed to promote interagency coordination and communication and to encourage timely and appropriate response to natural and pollution-

[1] Prince Edward Island Department of Environment; Energy and Forestry; Newfoundland and Labrador Department of Environment and Conservation; Nova Scotia Department of Environment and Labour; and the New Brunswick Department of Environment and Local Government.

[2] Fisheries and Oceans Canada is divided into three regions in Atlantic Canada: the Gulf Region; the Maritimes Region; and the Newfoundland and Labrador Region.

related fish kills, in both the freshwater and marine environments. Information is provided on procedures for site assessments, field monitoring and sampling, impact mitigation, cleanup and site restoration, incident documentation, and site safety. As each fish kill is different, judgement must be exercised in applying these procedures in various different situations.

In responding to an incident, the **first priority** is the **safety of response staff and the public** followed by protection of the environment and private property.

Fish kills involving **hazardous materials** require special safety precautions, equipment, and training, which are not covered in detail in these procedures. Responders should refer to the policies and procedures of their own organization for guidance on this issue.

This guide does not provide information on all topics associated with responding to fish kills. Enforcement actions and procedures, for example, are discussed briefly, but not in detail. Information on associated topics is available from other sources.

This guide has three main sections:

- Section 1 is an introduction to this document.
- Section 2 is an overview of administrative requirements including roles and responsibilities, interagency coordination, notification procedures, initial and on-site assessment, safety considerations, external communications, environmental damage assessment, and enforcement.

- Section 3 provides a variety of technical information relating to undertaking field assessments, determination of the affected species and cause of the kill, selecting sampling locations, collecting field measurements, collecting and handling samples, and mitigating, cleaning and restoring the affected area.

For the purposes of this guide, natural and pollution-related fish kills have been subdivided into **small incidents** with limited impacts, and **larger incidents** with more significant impacts (Figure 1). This division was made because:

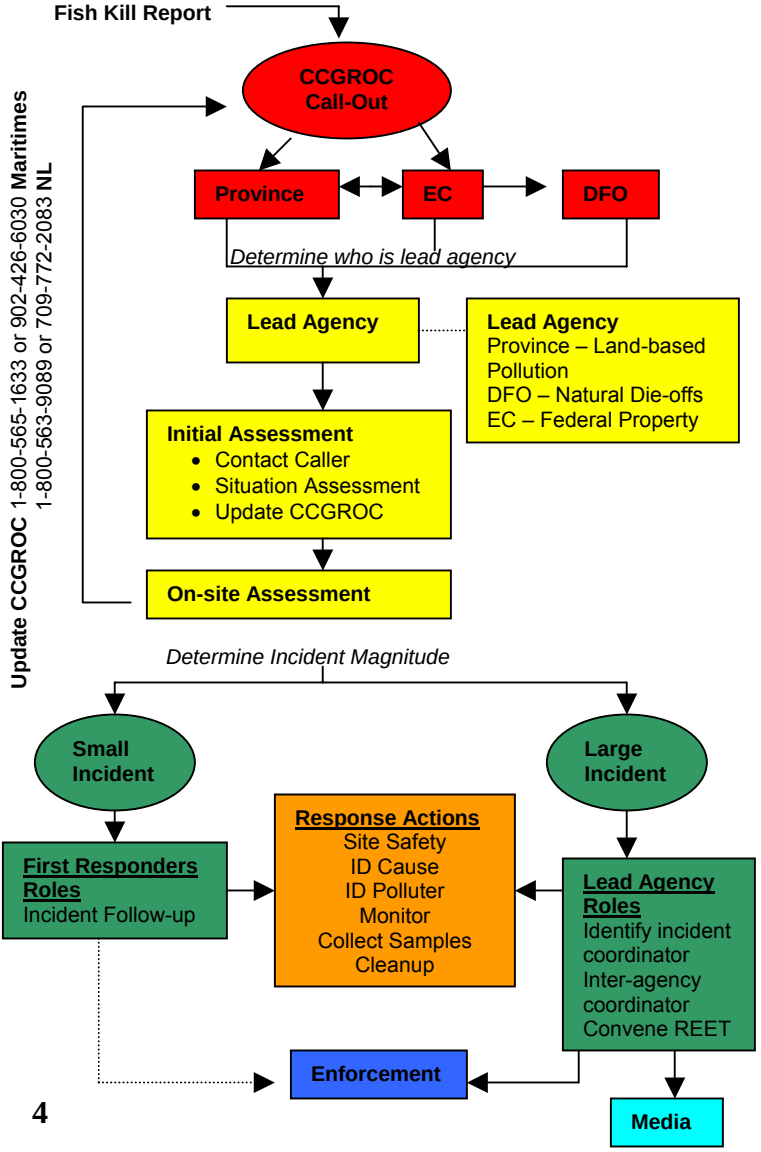
- smaller incidents can usually be handled directly by a first responder and they represent a minor or localized risk to natural resources, the environment, and public property; and,

- larger incidents can have a greater potential for damage to natural resources and property and they have a higher level of public concern; these incidents, therefore, require a more formal leadership and management structure be put in place by the “Lead Agency”, and a greater level of technical support from the various “Resource Agencies”.



(Source: Environment Canada)

Figure 1 Fish Kill Response Flowchart



2 Administrative Requirements

2.1 Roles, Responsibilities, and Coordination

A basic principle in emergency and fish kill response is that the **responsible party** or polluter is obligated by law (Table 1) to initiate appropriate remedial actions ("Polluter Pay Principle") to address their spill or release and to return the natural environment to its pre-impact condition as quickly and efficiently as possible. Unfortunately, in many fish kills, the responsible party is not known or is not able to initiate an appropriate response and hence, government agencies must take action to protect the public and the environment.

Fish kill coordination in the Atlantic Provinces is a shared responsibility among the four provincial environment departments, Environment Canada, and Fisheries and Oceans Canada. These responsibilities arise from various pieces of legislation, which relate directly or indirectly to fish kills (Table 1). To complement this legislation, a number of interagency contingency plans, formal agreements, or procedures have been developed to promote cooperation and coordination, to expedite and guide emergency and fish kill response activities, and to ensure that damage to the natural environment is minimized.

To facilitate coordination and decision-making, the partner agencies have been identified as the **lead government agency** for certain types of fish kills based on both their legislated or traditional responsibilities (Table 1).

Table 1 Agency Mandates and Legislation

Department	Mandate	Legislation
Environment Canada	- kills relating to deposits of deleterious or scheduled substances	- *FA*, Sect. 36, deposit of deleterious substances into waters frequented by fish - *CEPA*, Sect. 95, release of a scheduled substance
Fisheries and Oceans Canada	- kills relating to physical damage of habitat, fish health, and natural die-off	- *FA*, Sect. 32, destroying fish by means other than fishing - *FA*, Sect. 35, harmful alterations, disruptions or destruction of fish habitat
Prince Edward Island Environment Energy and Forestry	- kills relating to land-based discharges (Note: Respond to any reported fish kill. Multi-agency response systems established each summer)	- *PEI EPA*, Sect. 20, discharge of contaminants - *PEI EPA*, Sect. 21, reporting and measures to deal with any releases
Newfoundland and Labrador, Environment and Conservation	- kills relating to land-based substance releases	- *NL EPA*, Sect. 7, release of substances - *Water Resources Act*, Part 2, Protection of waters
Nova Scotia Environment and Labour	- kills relating to land-based discharges	- *Environment Act*, Sect. 67, release of a substance - Emergency Spill Regs, Sect. 6, releases of contaminants
New Brunswick Environment and Local Government	- kills relating to land-based discharges	- *Clean Environment Act*, Sect. 5, release of a contaminant or waste - *Clean Water Act*, Sect. 7, release of contaminant or waste

- Generally the **provincial environment departments** are the lead agency for kills that are caused by land-based facilities and discharges or land-based “mystery” spills.

- **Environment Canada** is the lead agency for fish kills relating to federal agencies, federal and aboriginal lands and waters, and marine-sourced pollution releases.

- **Fisheries and Oceans Canada** is the lead agency for kills relating to physical damage to fish and their habitat, fish health, and natural die-off.

Environment Canada is responsible for those sections of the *Fisheries Act (FA)* and the *Canadian Environmental Protection Act (CEPA)* relating to the deposit of deleterious or scheduled substances into water exclusive of those situations where the provincial departments are the lead. In these overlapping cases, therefore, communication will be required between the provincial environment departments and EC responders to determine the lead agency and to coordinate the arrangements for follow-up activities.

The lead agency designation allows for flexibility and encourages inter-agency cooperation and communication. As an example, to minimize response time in the initial stages of an incident often the closest available responder or inspector, from any of the mentioned agencies, will undertake the initial assessment to evaluate the cause and severity of an incident and recommend further follow-up actions, where required.

The “lead agency's” primary role is to determine the cause of the incident. In the event the fish kill is caused by pollution or habitat destruction, the lead agency should initiate appropriate actions to assess and mitigate the impacts of the event while attempting to identify the responsible party. When a responsible party is identified, this role changes to one of monitoring to ensure that all reasonable actions are taken.

In **larger incidents**, the lead agency may appoint an “Incident” or “On-scene Coordinator” to initiate and manage the necessary assessment and sampling actions, monitor the responsible party’s (where known) actions, act as a point of contact between the resource agencies and/or polluter, and lead and coordinate external communications, where required. The flowchart in Figure 1 summarizes the various steps involved in coordinating and responding to a fish kill.

Once the lead agency is identified, the other partner agencies may become **resource agencies,** providing technical expertise and resources to assist with fish kill assessment and response activities. Resource agencies often maintain an interest in a fish kill event as they have underlying legislation, which must be satisfied. Resource agencies, however, are not precluded from sending staff to a kill site to provide assistance or satisfy their mandated responsibilities, even though the lead agency has dispatched responders.

There is a significant amount of technical and scientific knowledge about environmental emergencies and fish kills within the provincial departments, EC, DFO, and other federal and provincial organizations. Based on the magnitude of the event and at the request of the "lead agency", Environment Canada may convene and chair

the **Regional Environmental Emergencies Team (REET)** to coordinate and consolidate the input of technical advice and assistance from the various resource agencies and other technical experts.

Key Points

1. ***Identify the Responsible Party***
2. ***Identify the Lead Government Agency***
3. ***Identify the Resource Agencies and Technical Experts***
4. ***Convene REET, as required***

2.2 Notification

The primary phone numbers for reporting environmental emergencies and natural or pollution-related fish kills are:

Maritime Provinces	**1-800-565-1633** (or 902-426-6030)
Newfoundland and Labrador	**1-800-563-9089** (or 709-772-2083)

The toll free numbers connect the caller to the **Canadian Coast Guard Regional Operations Centres** (CCGROC) in either Dartmouth, Nova Scotia or St. John's, Newfoundland. These centres are staffed

continuously (24 hours per day, seven days per week) to receive reports and updates.

Upon receiving a pollution or fish kill report, the CCGROC staff will ask the caller for as much information as possible about the event (see Appendix A for sample questions) and relay this information to the appropriate provincial environment department and Environment Canada emergency response staff through existing 24/7 reporting networks**.** Fisheries and Oceans Canada, Area Habitat Coordinators, or Biologists will be contacted by EC emergency staff based on the details provided in the fish kill report (e.g., does it relate to physical damage to fish and their habitat, fish health, and/or a natural-die off). Staff from DFO can also be contacted for technical information relating to fish or the fishery, or if assistance is needed in field response activities.

It is important to emphasize that **the public and all response staff should use the CCGROC as the "one window" for all fish kill notifications and updates.** Relaying calls to the CCGROC will ensure all the appropriate partners receive incident reports and timely updates. Therefore, if the person reporting an environmental emergency or fish kill contacts an emergency responder or other government staff member directly, the responder **must ensure** that the CCGROC has been notified.

To prevent duplication, response staff receiving incident reports should notify CCGROC if they, or someone from their organization, intend to undertake a site assessment. Following a site assessment, updated information should be relayed through the CCGROC who in turn will notify the partners mentioned previously.

Response staff from the provincial environment departments, EC, and DFO are encouraged to contact one another directly to discuss follow-up requirements or to request or exchange technical assistance and advice. Environment Canada will coordinate the exchange of information between the CCGROC and the provincial DOE and DFO and ensure summary reports are prepared and circulated. The provincial DOE and DFO will, in turn, provide timely updates on their activities to the CCGROC and EC to assist information exchange and task coordination. A fish kill response form (Appendix B) should be completed by the first responder or lead agency for each incident to document the facts relating to site assessment and monitoring activities.

It should be noted that some federal and provincial legislation contains mandatory spill or emergency reporting provisions. In most cases, calls to the CCGROC numbers satisfy these legal obligations.

Key Points

1. ***All Fish Kill Reports and Updates are Passed through CCGROC***
2. ***The CCGROC will Notify the Provincial DOE and EC***
3. ***EC will Contact DFO, as Required***
4. ***EC will Coordinate Information Exchange***

2.3 Initial and On-site Assessment

Upon receiving a report of a natural or pollution-related fish kill, response staff from the provincial environment department and/or EC will review the reported information and consult with one another, as required, to determine which agency is the "lead government agency" and if DFO staff should be notified. Based on this review, response staff from the lead agency will contact the person reporting the kill to verify the facts, obtain additional details, if possible, and make an initial assessment of the severity of the situation.

Based on this information, a first responder from the lead agency will generally undertake an **initial on-site assessment**. If personnel from the lead agency are not available to respond, contact should be made with the resource agencies to determine if they have staff available in the area of the kill that could undertake an initial assessment. As the provincial environment departments and DFO have field staff in a number of regional or district offices they are often closest to the kill site and can provide the quickest response, when staff are available.

This initial on-site inspection will focus on:

- **determining the cause, extent, and severity of the kill,**
- **collecting initial field measurements and/or samples,**
- **identifying required mitigation and cleanup measures, and,**
- **documenting and communicating findings.**

For **small incidents** (handled by the first responder) and **large incidents** (involving an Incident Commander and Response Team), the assessment, sampling, monitoring, and mitigation functions are basically the same; however, the magnitude or level of effort will differ greatly (see Figure 1 and Section 3 for more detail).

Initial site assessments and sampling, if required, should be initiated without delay as contaminants and/or evidence can deteriorate rapidly.

Key Points

1. ***Review the Initial Incident Report***
2. ***Identify the Lead Agency***
3. ***Contact the Person Reporting the Kill***
4. ***Undertake an On-site Assessment as soon as Possible***
5. ***Determine the Cause and Severity of Kill***
6. ***Collect Initial Field Measurements and Samples***
7. ***Recommend Additional Follow-up actions***
8. ***Document and Communicate Findings***

2.4 Safety Considerations

The health and safety of field staff and the general public is the **primary consideration** in any fish kill response. Each of the organizations involved in the development of this guide must ensure that their response staff are properly trained and equipped to safely undertake field-response activities.

As fish kills can result from a variety of causes, including exposure to toxic and harmful substances, and occur in a variety of locations, specific safety and health procedures should be developed by each organization to guide the activities of their field staff. As each fish kill is different, procedures will have to be evaluated and adapted by field staff on a case-by-case basis to meet the specific needs of an event.



(Source: Environment Canada)

Where the cause of a fish kill is unknown, it should be assumed that the area **may be contaminated with a hazardous material** until proven otherwise. Kills involving hazardous materials require special safety precautions, equipment, and training, which are not

addressed in these procedures. Responders should refer to the policies and procedures of their organization for guidance on this issue. Note: Fisheries Officers in the Maritimes Region will not respond to kills relating to chemical spills.

Various references [Material Safety Data Sheets (MSDS), field manuals, texts, container labels, Pesticide Control Product numbers] and agencies (CANUTEC, Poison Control, hospitals) are available to assist in developing safety plans specific to a particular case.

In incidents involving hazardous materials or wastes, which could affect human health or the commercial fishery, contact should be made with the appropriate Department of Health or the Canadian Food Inspection Agency.

In some cases, access to the site must be restricted for public safety. Precautionary arrangements may involve requesting assistance from the local police to establish exclusion zones, or contacting the local media to issue public announcements. See Appendix C for additional field-safety considerations.



(Source: Southeast Environmental Association)

Key Points

1. ***Responders must be Properly Trained and Equipped***
2. ***Safety Procedures should be Adapted for Each Incident***
3. ***Assume Hazardous Materials are Present until Proven Otherwise***
4. ***Restrict Access to Site, as Required***

2.5 External Communications

Natural die-offs and fish kills can attract much public and media attention. Each agency involved in the development of this guide has, or is responsible for developing, procedures for external communications. Generally, the **lead government agency** will appoint a **spokesperson(s) or communications lead,** based on the severity of the kill, to coordinate and address communication requirements. The **resource agencies** may also appoint spokespersons to work with the lead agency in addressing requests for information relating to their mandate or area of expertise.

It is important that external communications are carried out in an informed, timely, and coordinated manner. Following from this, Environment Canada will coordinate the exchange of information between the provincial DOE and DFO and ensure summary reports are prepared and

circulated for use in briefings. In addition, updates should be provided to other agencies when one agency has information relating to a kill, which may result in a multi-jurisdictional response. These updates will allow development of a communications plan and provide the appropriate factual information to the public in a timely and responsible manner.

Some **points to consider** when **coordinating external communications** include:

- a spokesperson or communications lead will be appointed by the lead government agency,
- each agency will follow its own procedures for dealing with external communications,
- the lead agency should discuss communication requirements with the responsible party (if known),
- the communications lead will discuss the facts and communication requirements with field response staff,
- the communications lead will contact and discuss the communication requirements with partner resource agencies (usually the Communications Director),
- interagency discussions will be held and a coordinated communications plan developed and agreed upon,

- a single point of contact will be established for media calls; however, particular questions relating to mandates or areas of expertise will be referred to resource agencies, as required,

- media products (media lines, media advisories, news releases, speaking notes) will be developed by the lead agency and shared with resource agencies prior to release, and,

- a procedure will be put in place to ensure partners are updated throughout the event; the communications lead will check with response staff and communications counterparts to ensure that similar information is being shared with other agencies.

Field response staff will often be approached for information relating to a particular kill. They should follow the procedures developed by their agency for dealing with external communications. Comments will usually be confined to their role, their activities, their field of expertise or speciality, and the observable facts of the case. Opinions or speculation about the cause or seriousness of the case should be avoided as this information could prove to be incorrect and may compromise subsequent legal actions.

In some cases response staff may have to request assistance from the public or media to protect public safety, control access to the site, obtain background information about the kill, and to ensure the integrity of evidence. Again, these requirements should be coordinated by the lead agency and their spokesperson.

Key Points

1. ***A Spokesperson should be Appointed by the Lead Agency***
2. ***A Coordinated Communication Plan should be Prepared***
3. ***Interagency Exchange of Information and Updates***
4. ***Factual and Timely Information is Provided to the Public and Media***



(Source: Environment Canada)

2.6 Environmental Damage Assessment

An Environmental Damage Assessment (EDA) is a multi-stage process that identifies and quantifies the damage to an ecosystem caused by a pollution event. Where possible, the process assigns a monetary value to any environmental damage or injury.

The EDA concept supports the **polluter pays principle** in that the polluter is held financially responsible for the damage they have caused and for the costs associated with repairing that damage. The information compiled during damage assessment surveys can be used to support enforcement actions and to seek compensation for damage though the courts. Several pieces of federal (e.g., *Fisheries Act* and *Canadian Environmental Protection Act*) and provincial legislation contain provisions, which support this approach. Compensation received through this process can be directed to a special holding account, such as the Environmental Damages Fund.

Following a fish kill incident the **lead agency or resource agencies** may conduct field assessment surveys to evaluate environmental damage. These surveys must be scientifically and technically sound and legally defensible to stand the tests of cross-examination.

In general, an environmental damage assessment of a fish kill may include:

- designing a field sampling plan;
- collecting and analyzing field data relating to:

1. identification of the source and cause of the kill,
2. identification of the area of impact,
3. collection of details relating to the dead fish (e.g., total number, species, size, age classes),
4. determination of local conditions (e.g., hydrological, geological, and meteorological),
5. collection of water quality measurements (e.g., DO, pH, temperature, salinity), and.
6. collection of samples (e.g., water, fish, sediment, biota) for chemical and toxicity analyses

- analysis and compilation of the data collected into a technical report; and,

- calculation of the economic cost of the damage.

Many of these assessment activities will follow the principles and procedures outlined in other sections of this guide. In some cases, more in-depth studies (e.g., fish density surveys, macro-invertebrate community studies) may be necessary to assess the long-term impacts or damage caused by an event. Damage assessment surveys can also help guide the selection and costing of appropriate restoration options.

Assistance and advice in designing and undertaking an EDA can be obtained from technical experts at Environment Canada, DFO, and provincial agencies. A number of protocols have been developed and are available to guide responders in conducting these specialized assessments.

Key Points

1. ***Collect Data to Determine Environmental Damage***
2. ***Use Data to Identify Restoration Requirements***
3. ***Use Data to Support Enforcement Actions Requesting Compensation***

2.7 Enforcement

Every fish kill incident may potentially be a violation of federal or provincial acts and regulations and may result in a prosecution. In some cases, several statutes may be violated in a single case and hence inter-agency consultations will be required to plan and coordinate enforcement activities. Generally, enforcement and the coordination of enforcement activities, will be organized by the lead government agency and follow the principles described in Section 2.1, herein.

Response staff conducting the initial and on-site assessments should gather all information and evidence with sufficient care and accuracy such that it can be shared with enforcement staff and used in any subsequent legal investigations and prosecutions. Staff should keep thorough notes of their activities, observations, and conversations relating to a kill. Any physical evidence should be properly collected, labelled, secured, handled, and transported, and chain-of-custody

records should be maintained according to the procedures developed by each agency.

Details on enforcement issues can be found in other references or are available from Departmental enforcement staff.

Key Points

1. ***The Lead Agency should Coordinate Enforcement Activities***
2. ***All Information and Evidence should be Properly Collected and Secured***
3. ***Thorough Notes should be Maintained***

3 Field Assessment

3.1 Objectives

As most natural and pollution-related fish kills are observed after the fact, it is important to carry out field assessments as quickly and efficiently as possible such that meaningful information and samples can be collected. **Field assessments** should focus on the following **objectives**:

- identifying the lead government agency and responsible party (Section 2.1);
- identifying any human health and safety risks (Section 2.4);
- identifying the cause, extent, and severity of the kill (Section 3.3);
- collecting field observations, water quality measurements, and samples to verify facts (Sections 3.2, 3.5, and 3.6);
- identifying and implementing mitigation and cleanup measures, where possible (Section 3.7);
- documenting findings and communicating them to partners (Section 2.2); and,
- initiating external communication and enforcement actions, where appropriate (Sections 2.5 and 2.7).

3.2 Initial Site Assessment

Prior to departing for the field, a variety of preparations should be made by response staff, including:

- a quick review of the administrative activities discussed in Section 2 of this guide;
- reviewing maps and photos of the affected area;
- contacting the person reporting the kill, the responsible party (if known), people familiar with the area or technical experts for information;
- reviewing recent weather events;
- identifying, assembling, and calibrating field equipment (Appendix D); and,
- planning and implementing appropriate safety measures.

Upon arrival at the site, it is important to make observations and collect field measurements and samples, if required, quickly and efficiently, as contaminants and/or evidence can rapidly deteriorate or disappear. Background information can be collected from a number of sources including conversations with local residents or officials familiar with the area (e.g., Fisheries Officers, Provincial Inspectors), walking or driving around in a car or boat to visually examine the area, and identifying land, water, and human use activities in the area. The information required can include the:

- location and extent of the kill;
- type of water body (freshwater, marine or brackish);
- number and species of dead and dying fish;
- size range and condition of dead fish;
- type of live fish species remaining in the area;
- physical appearance, unusual characteristics or behaviour of fish;
- size, flow rate, volume, of the water body;
- recent weather conditions (which could alter flow rates, water temperature, or salinity);
- recent soil disruption, waterway alterations, or dredging;
- local water use, dams, or other water obstructions;
- appearance, colour, and odour of the water;
- slope, drainage, soil type, and vegetation cover in surrounding area;
- presence and condition of other organisms (plants, excessive plant growth, invertebrates) in the area;
- proximity to natural areas, private residences, farms or livestock, industry, fish plants, etc.;
- type of fishery in the area (commercial or recreational); and,
- any evidence of hazardous materials used, discharged, or spilled in the area.

All information collected during site surveys should be recorded on the form provided in Appendix B and in the responder's field notes.

3.3 Fish Identification and Causes of Kills

The marine and freshwater fish species most frequently involved in natural or pollution-related fish kills in the Atlantic Region include:

American Eel	Mummichog
Atlantic Salmon	Rainbow Trout
Atlantic Tomcod	Shad
Brook Trout	Smallmouth bass
Brown Bullhead	Smelt
Brown Trout	Striped bass
Burbot	Threespine Stickleback
Cunner	White Sucker
Gaspereau or Alewife	Yellow Perch

Appendix M provides species descriptions, photos, and sketches (sketches courtesy of DFO, Newfoundland and Labrador Region) to assist in identifying these species during a kill.

Fish kills can be linked to a number of possible causes such as:

- lack of oxygen,
- water temperature,
- pH stress,
- salinity changes,
- rain and runoff,
- turbidity,
- sediment disturbance,
- acid sulphate drainage,
- excessive plant growth,
- toxic algae,
- parasites and diseases,
- exposure to hydrogen sulphide,
- ammonia,
- gas-bubble disease,
- life-cycle related,

- fishing by-catch, or
- contamination by chemicals.

Appendices E and F provide a brief description of each possible cause and a key to help interpret the situation and identify the cause of the kill.



(Source: Environment Canada)

3.4 Sampling Locations

In the initial stages of a site assessment, field measurements, and samples (water, sediment, fish, etc) are often collected in a very ad hoc manner. As more details are collected about the significance and possible cause(s) of the kill, a more formal sampling plan may need to be developed and appropriate sampling locations will have to be identified (EC, 1995). This approach will allow data collected from different sites to be compared.

Some general factors to consider in **selecting sampling locations** include:

- establish a minimum of four sampling locations;

- establish a **control site** in a clean area of the water body or in a nearby clean water body with similar features to the affected area;
- sample **upstream** of the affected area;
- sample **within** the affected area;
- sample **below** the affected area; and,
- if possible, sample the **raw contaminant** where a chemical or effluent is suspected.

In larger water bodies or coastal areas, the sampling plan will have to be modified to include samples collected from within the affected area, outside the affected area, at a control site, and from the raw contaminant, where appropriate. Collecting samples at various water depths may also be required.

In more significant cases or where damage assessment surveys are warranted detailed sampling plans may be required to allow for statistical or economic analysis of results. Usually this is a specialist function undertaken by qualified staff from one of the partner agencies.

3.5 Field Measurements

Following the initial site assessment, **basic water quality measurements** should be taken, including temperature, dissolved oxygen, pH, turbidity, conductivity, and salinity. These parameters are essential for fish health and variations from normal levels can be indicators of physical problems or contamination. Where possible, these measurements (in particular pH, DO, temperature, and conductivity) should be collected in the field *(in-situ)* as changes can occur while samples are being delivered to the lab.

In collecting field measurements, it is essential to use appropriate apparatus, which is working properly and is routinely calibrated. The basic parameters and associated equipment include:

- **Temperature** - measured in the field with a thermometer or digital thermistor.

- **Dissolved Oxygen -** measured in the field with a DO meter or a "Winkler" titration.

- **pH -** measured in the field with pH or litmus paper or a pH meter.

- **Turbidity -** measured in the field with a meter or in slow flowing waters with a secchi disk. Where no apparatus is available, visual observations of water colour and clarity should be recorded.

- **Conductivity/Salinity -** measured in the field with a meter.

Information on the equipment used for fish kill assessments is found in Appendix D. Additional details about field measurements and their relevance to fish health are provided in Appendix E.

3.6 Sample Collection

Based on the findings of the initial site assessment and field measurements, it may be necessary to collect **water, fish, sediment, vegetation** or other samples. These samples can be used in toxicity tests, or to measure the level of a contaminant, if present. Procedures for properly collecting, handling and

preserving various types of samples are provided in Appendices G–K.

It is important to discuss sampling requirements with technical advisors from the lead agency and from the laboratory that will be conducting the analysis. These discussions will help ensure that appropriate samples are collected, proper procedures and equipment are employed, and that the laboratory has the capacity to undertake the required analysis in a timely manner. As samples can deteriorate rapidly (in particular fish samples) it is essential that they be promptly and properly shipped to the laboratory for analysis.

It should be noted that in some cases sample analysis will have to be carried out by a certified laboratory (e.g., the Canadian Association for Environmental Analytical Laboratories). This requirement should be discussed with technical advisors from the lead agency and from the laboratory that will be conducting the analysis.
As a general rule, some clues about the possible cause(s) of a kill are needed from field observations and measurements to focus sample collection and analytical efforts. Without this type of information samples may be useless as it is too expensive and not practical for the lab to analyze for all possible parameters. In some cases, however, it may be worth collecting and preserving a few representative samples and placing them in an archive in the event new information or clues arise.

Contact should be made with the laboratory before sending samples to ensure the desired analysis can be carried out within the required time lines and that chain-of-custody can be maintained. Appendix L provides a list and contact numbers for a few of the labs in eastern Canada. Plan ahead, since sample analysis can take

days or weeks to complete, depending on lab priorities and the parameters requested.

It should be noted that the information and samples collected may be used as legal evidence, hence, all information should be documented, measurements and samples should be collected following standard methods and chain-of-custody records should be maintained. Legal samples should be delivered to the laboratory by response staff or shipped by courier, and waybills maintained to verify chain-of-custody. If a courier is used, the samples should be sent in locked containers (e.g., a tool box or cooler), and the key shipped separately. Containers that cannot be locked can be sealed with tape and marked appropriately to verify that they have not been opened.

Additional details on collecting and shipping legal samples, chain-of-custody, evidence gathering, and note-taking can be obtained from departmental enforcement staff.

3.7 Mitigation, Cleanup, and Restoration

(a) Mitigation. The **primary goals** of any fish kill **mitigation strategy** include:

- **preventing** the contaminant from entering a water body, or
- **minimizing** the amount of **damage** caused, if the contaminant enters a water body.

Implementing a mitigation strategy is not always possible due to safety considerations, the wide range of potential causes of fish kills (natural die-off, disease) or

the time required to deploy staff and equipment to the site. The first sign of a problem is often dead or dying fish in or on the water, hence the damage is done before action can be taken.

In some instances, however, such as those relating to man made causes, field personnel may respond to a fish kill that is on-going and where there is a readily identifiable cause. In these cases, prompt but safe actions can significantly limit further contamination and environmental impact. Some basic techniques can include:

- controlling or shutting off the source of a contaminant,
- containing, recovering, diverting and/or neutralizing the contaminant, or
- addressing habitat alterations or illegal fishing activities.

For example, a number of pesticide spills have occurred on agricultural fields, which drain into a water body. In several cases, control actions included digging containment ditches, constructing dykes or dams, or diverting the pesticide flow away from the adjacent water body.

A number of other references are available which describe mitigation strategies. Two such references, which are available from Environment Canada, are *The Basics of Oil Spill Cleanup* (second edition) (Fingas, 2000) and *Field Guide for the Protection and Cleanup of Oiled Shorelines* (second edition) (Owens, 1998).

(b) Cleanup. For the purpose of these procedures, "**cleanup"** refers to the collection and disposal of fish carcasses only, and not the containment and removal of contaminants from a water body.

It may be necessary to undertake a cleanup program followed by appropriate disposal of fish carcasses in cases where the dead fish represent a health risk to the public or other fish, place an organic load on the water body, are unsightly or a nuisance, or if there is a need to prevent the subsequent contamination of scavengers or wildlife. Conversely, in some cases, a cleanup may not be necessary due to the limited number of fish involved, remoteness of the area, the rapid decomposition of the fish, or their quick removal by scavengers.

In smaller incidents, involving a limited number of fish, response personnel may collect all of the carcasses for lab analysis, length measurements, determination of age classes, or disposal. In larger incidents, the responsible party or lead agency may initiate a cleanup involving work crews and a variety of equipment to collect the carcasses and transport them to disposal sites. A common approach is to net or pick up dead fish and place them in plastic bags or containers. The bags should only be filled to the point where they can be easily managed by staff or available equipment. It may be appropriate to establish collection sites that are easily accessed along a water body where field personnel can drop off collected wastes. In larger water bodies, boats can be used as work platforms and collection points. Once the fish have been collected the lead agency should consult local authorities (municipality, or province) to discuss appropriate disposal methods and sites.

Field personnel should consider safety issues when collecting dead fish (see Section 2.4). Personnel should be equipped with the appropriate personal protective equipment for the season, weather conditions, operational setting, and properties of any contaminants that may be present.



(Source: Southeast Environmental Association)

Keeping records of the species and number of fish killed in an incident may be useful for damage assessment and enforcement purposes.

(c) Restoration. Restoration may have to be considered by the lead agency or responsible party following a significant fish kill event. Usually this will involve restocking or replacing the fish that were lost. If fish restocking is to take place, attempts should be made to ensure that fish of the same genetic stock are used. In some cases, this may require the collection of fish spawn from the affected system and rearing in a hatchery until the fish are old enough to be released (1–2 years). Permits may be required for restocking and

DFO or provincial agencies will need to be consulted. In addition, fish hatcheries should be consulted to determine if they could undertake this type of program.

In cases where physical damage has been inflicted on a stream, habitat restoration activities such as, water quality enhancements, bank stabilization, or vegetation replacement or planting, may be considered to bring the aquatic and riparian environment back to its pre-incident condition. Fisheries officials and local community groups may have the expertise required in undertaking such activities and therefore, should be consulted.



(Source: Environment Canada)

References

American Fisheries Society, The Pollution Committee, Southern Division, and Socioeconomics Section, 1992. Investigation and Valuation of Fish Kills. American Fisheries Society Special Publication 24. 96 pp.

CCME (Canadian Council of Ministers of the Environment), 1999, Canadian environmental quality guidelines, Canadian Water Quality Guidelines for the Protection of Aquatic Life. Chapter 4.

Department of Environment and Heritage, Queensland Government, 1998. Fish Kill Reporting and Investigation Manual. For use in the investigation of possible breaches of the Environmental Protection Act 1994 and Fisheries Act 1994. 28 pp.

EC (Environment Canada), 1993. Fish Kill Response Procedures for the Atlantic Provinces, Internal Document, 22 pp.

EC (Environment Canada), 1995, "The Inspector's Field Sampling Manual: A Sampling Manual and Reference Guide for Environment Canada Inspectors", Environment Canada, Ottawa, Ontario, ISBN-0-662-23513-4.

EC (Environment Canada), 1995. "The Inspector's Safety Guide: A Field Guide for Environment Canada Inspectors". Environment Canada, Ottawa, Ontario, ISBN 0-662-23533-9.

Fingas, M., 2000, *The Basics of Oil Spill Cleanup,* 2nd edition, Lewis Publishers, Boca Raton, Florida.

DFO (Fisheries and Oceans Canada), Marine Environment and Habitat Management, Newfoundland and Labrador Region, 2003. Fish illustrations and species descriptions. Internal Document.

Keenan, R., 2001, Field Sampling Protocol for Water, Sediment, Macroinvertibrates and Fish. For use in small rivers and streams. Southeast Environmental Association, 42 pp.

Meyer, F.P, and L.A. Barclay, 1990. Field Manual for the Investigation of Fish Kills. US Fish and Wildlife Service, Resource Publication 177, 120 pp.

NCDENR (North Carolina Department of Environment and Natural Resources). Undated. Fish Kill Field Investigation form. Division of Water Quality, Environmental Sciences Branch, www.esb.enr.state.nc.us/forms/fishkillform.doc.

Owens, E.H., 1998, Field Guide for the Protection and Cleanup of Oiled Shorelines (second edition), prepared by Owens Coastal Consultants for the Environmental Emergencies Section, Environment Canada, Atlantic Region, Dartmouth, Nova Scotia.

Pierce, R.A., T.W. May and V.C. Suppes. 1996. Collection and Submission of Samples for Fish-Kill Investigation and Toxic Substance Analysis. University of Missouri. Agricultural Publication G9402.

Prince Edward Island, Fisheries Aquaculture and Environment, 2002. Environmental Emergency Response Procedures on Prince Edward Island. 53 pp.

USEPA (United States Environmental Protection Agency), 1996, Environmental Investigations Standard Operating Procedures and Quality Assurance Manual. USEPA, Region 4, Athens, Georgia, 369 pp.

Appendix A

Information Required from Individuals Reporting a Fish Kill

- Date and time?
- Caller's name/phone number/address?
- Description of the problem?
- Source or cause of the problem?
- Human activities in the area?
- Location of the problem/directions to site?
- Appearance of the water?
- Identification of the type and amount of any hazardous materials involved?
- Has the product entered a water body?
- The name of impacted water body?
- Number, type, and size range of dead or dying fish?
- Recent weather conditions?
- Are live fish or invertebrates present?
- Have remedial or containment actions been initiated?
- Any safety issues?

Appendix B

Fish Kill Field Assessment Form

(Adapted from; NCDENR, DWQ, Environmental Sciences Branch)

First Responders Details

Assessment Date and Time:		Case File Number:
Responders Name:		
Organization/Agency:		
Address:		Phone:
e-mail:		
Reporting Party:	Address:	Phone:
Advisors:	Address:	Phone:

Kill Event Location

Waterbody:	Attach map describing area of event
Province/County:	Nearest Town/Landmark:
Tributaries or Coastal waters affected:	
Latitude:	Longitude:

Fish Kill Details

Date Event Began (First reported):	Time:
Is kill event: in progress □	completed □
Area covered by kill:	River (metres): Lake/Estuary/Coastal (km^2):
Event Duration:	Days: Hours:

Finfish Species Affected

Species:	Size Range:	Approx. Number:
In Distress/Dying □ Dead □ Decayed □		Percent observed with sores or lesions:
Species:	Size Range:	Approx. Number:
In Distress/Dying □ Dead □ Decayed □		Percent observed with sores or lesions:

Other Organisms Affected:	
Total Finfish Mortality:	Total Mortality of Other Organisms:

Fish Health Observations

Lesions/sores □ Injuries □ Flared gills □ Tumours □ Gasping □ Loss of Equilibrium □ Erratic Behaviour □ Attempt to leave water □ Other □ Describe:

Physical Observations and Field Measurements

Weather:	Water/Sea Condition:	Air Temp:	Precipitation (past 24 h):
Wind Direction:	Wind Speed:	Secchi Depth:	
Bottom Depth:	Prior Weather (3–4 days):		
Outfalls Present: Y □ N □ Describe:			
Spills in Area? Y □ N □ Describe:			
Activity in Area:			

Depth (m)	Dissolved Oxygen (mg/L)	%Saturation	pH	Temp. (ºC)	Conductivity	Salinity (ppt)
Surface						
1.0						
2.0						

Visual Characteristics

□ Discoloured water	Describe:
□ Flecks, □ Balls, □ Filaments	Describe:
□ Surface film	Describe:
□ Other	Describe:

Biological and Chemical Samples Collected

Fish (Describe):	Iced, Preserved?
Station:	Sample No.:
Contact for Results:	Phone:
Algae/Plants (Describe):	Iced, Preserved?
Station:	Sample No.:
Contact for Results:	Phone:
Bioassay Samples (Describe):	Iced, Preserved?
Station:	Sample No.:
Contact for Results:	Phone:

Chemical Samples: Water □ Sediment □ Tissue □ Other □ Metals □ Pesticides □ Nutrients □ Chlor A □ Other □ Describe:	
Station:	Sample No.:
Contact for Results:	Phone:

Photographs and/or videos: Y □ N□

Where on file? Name:	Phone:

Additional Comments or Observations:

Attachment Checklist:

Document Attached		Document Attached	
Photographs:	□	Samples collected	
Statements:	□	Water:	□
Field Observation:	□	Biota:	□
Limnological report:	□	Sediment:	□
Chain-of-custody form:	□	Fish:	□
Lab results:	□	Others:	□

Agencies Notified	Date/Time	Contact Tel #
CCG:	□ /	
EC:	□ /	
DFO:	□ /	
Provincial Agencies:	□ /	
Other:	□ /	

Completed forms should be sent by e-mail or faxed to:

Environment Canada at
sinclair.dewis@ec.gc.ca or fax: 902-426-9709;
georges.long@ec.gc.ca or fax: 506-452-3003, or
graham.thomas@ec.gc.ca or fax: 709-772-5097.

Appendix C

Field Safety Considerations

The following brief summary of safety considerations should be considered when planning and undertaking fish-kill assessments. Response staff will have to adapt these considerations to the field conditions at the time of the kill, weather conditions, method of travel (foot, car, boat, airplane), location and cause of kill, etc.

Note: This is not an exhaustive list and a number of other references (e.g., EC, 1995) are available on this topic.

Some safety considerations include:

- Before entering the site, try to determine if hazardous materials are involved, and if so, identify the specific chemical in order that appropriate personal protective equipment can be selected and precautions can be taken. Responders should refer to the policies and procedures of their organizations for guidance on these issues.

- Wear appropriate protective clothing and equipment for the situation and weather conditions (e.g., gloves, boots, helmets, eyewear, coveralls, or chemical suits, etc.) as indicated by the appropriate MSDS or other guidance documents.

- Wear proper footwear (e.g., felt soles) in slippery areas (mud, algae covered rocks, etc.).

- Know the limitations of personal protective equipment (PPE).

- Properly clean all safety equipment after use.
- Undertake appropriate decontamination when PPE has been in contact with hazardous materials.
- Do not smoke, eat, or drink in the affected area and always wash hands thoroughly immediately after leaving the area.
- Consider safety issues relating to the specific mode of transport (motor vehicles, boats or ships, trailer towing, aircraft, ATV, snowmobile).
- Generally, field response staff should use the buddy system, especially in remote areas, around water or where hazardous materials may be involved.
- If working alone in rural or remote areas always take appropriate communications equipment (cell phone, two-way radio), and contact lists; notify other staff of your travel plans and timetable.
- Carefully read container labels, MSDS, and follow instructions, where appropriate.
- When going on a private or industrial site, always ask permission and follow any specified company or site safety requirements.
- Always have access to a first-aid kit and know the location of the local hospital and/or ambulance in case of accidents or sudden illness.
- When working in unfamiliar terrain, be careful of slips, trips, or falls.

- Consider moving hazards (traffic, moving machinery), working from heights (ladders, platforms, walkways), falling objects, excessive sound levels, electrical shock, and confined spaces.

- Care should be taken when working around or walking on ice.

- Approach the area from a safe access point (avoid steep embankments, heavy brush, etc.).

- Approach the site from upwind unless it can be determined that there is no airborne health threat.

- Always wear a personal floatation device where there is risk of falling in water.

- Wear sunglasses, sunscreen, or insect repellent, as required.

- Take precautions when working in areas where dogs may be present.

- Site control measures may be warranted in certain circumstances to protect the safety of others (usually these measures will require the assistance of others for implementation, e.g., local police).

- Implement specific precautions when using sampling equipment such as electro-seining equipment to collect fish.

Appendix D

Equipment for Fish Kill Assessments

The following list identifies some of the equipment that may be appropriate for on-site fish-kill assessment. Some of this equipment may be obtained by contacting the provincial environment departments, Environment Canada (EC), and the Fisheries and Oceans Canada (DFO) staff identified in this document.

- boots (chest high waders) and appropriate clothing for weather;
- shoulder length gloves/disposable gloves;
- other appropriate Personal Protective Equipment (PPE) for specific chemicals (see MSDS);
- cell phone or other communications equipment;
- GPS and maps;
- field thermometer (-20 to +50ºC); calibrated portable pH meter(s) or litmus paper; calibrated dissolved oxygen meter;
- other instruments such as salinometer, conductivity meter, secchi disk;
- fish kill/pollution incident report forms (see Appendix C);
- fish identification (see Appendices F and M);
- notebook (waterproof), pencils, pens, tape measure, labels/labelling tape;
- camera and film;
- laboratory-cleaned Nalgene (wide mouth) bottles, 500-mL size, washed with distilled water;
- laboratory-cleaned glass bottles with Teflon-lined tops, 475-mL size, acetone, or hexane washed;
- plastic freezer bags and ties, 4-litre size, extra heavy-duty garbage bags;

- aluminum foil (heavy-duty) sweep nets and forceps (various sizes);
- box with lock to hold equipment;
- cooler, fitted with hasp and padlock for shipping samples;
- freezer packs and crushed ice (Note: re-ice samples before shipment);
- 20-litre plastic pails (for bioassay samples) or collapsible food-grade water containers;
- preservatives (see Appendices G–K);
- sweep nets for fish or grab samplers for water, sediment, and benthic sampling.

Appendix E

Determining the Cause of A Fish Kill

(Adapted from the Department of Environment and Heritage, 1998 and CCME, 1999)

A fish-kill assessment should focus on collecting data to answer **two basic questions**:

- **What is the cause of the kill** - natural or otherwise**?**
- **What is the sequence of events that lead to the kill?**

In some cases, observations and data collected during the initial assessment will provide answers to these questions while in others, answers will depend on the results of chemical, sediment, or tissue analyses. Unfortunately, in some cases, no satisfactory answer will be available without additional detailed expert investigation, justified only by the scale of the incident.

A variety of factors can be involved in a fish-kill incident such as local weather conditions before the fish kill, the time of day when the incident occurred, the time of year, whether the deaths occurred suddenly or over an extended period, whether fish of only a particular size range or species are involved, or if the area has a history of similar events.

The following subsections briefly describe 17 of the major causes of fish kills and related environmental conditions in the region that can affect fish. Appendix F provides a “key” or checklist, which may also assist response staff in identifying the cause of a kill.

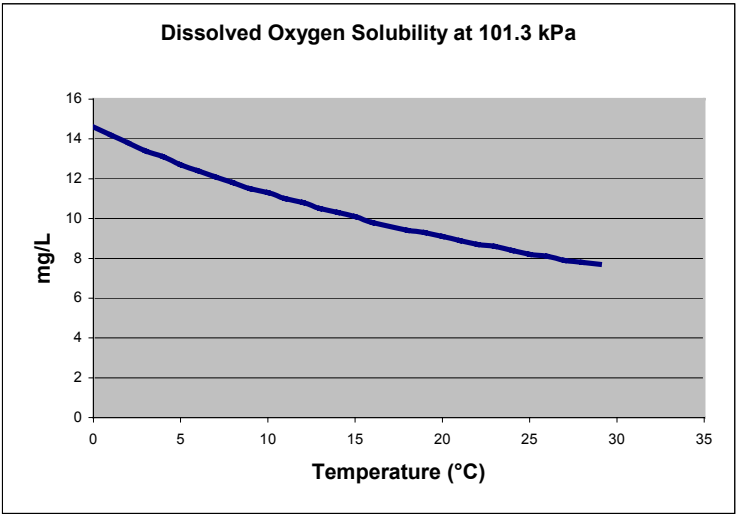
1. Lack of Oxygen. Dissolved oxygen (DO) (the amount of oxygen dissolved in the water) is usually measured in milligrams per litre (mg/L), parts per million (ppm), or percent saturation. Oxygen is essential for the respiration of most marine and freshwater organisms and low levels can result in suffocation. Tolerance levels of fish to low dissolved oxygen levels vary with the species. Some species are sensitive to low levels (trout and salmon) while others (suckers and eels) are able to survive in low oxygen conditions for many hours.

Low oxygen levels are one of the more common causes of fish kills in the Atlantic region. Levels of oxygen can be measured in the field using a meter and probe or Hach kit, or in the lab using a meter or by titration. Natural dissolved oxygen levels in water can vary greatly based on a number of factors such as water temperature, salinity (solubility of oxygen in water is inversely related to temperature and salinity), water depth (levels are usually highest in surface waters), water circulation, time of day, weather conditions, and time of year.

The Canadian Environmental Quality Guidelines (CCME, 1999) recommend that the minimum concentration of dissolved oxygen in marine and estuarine waters should be 8.0 ppm. The CCME (1999) identifies, that for the protection of aquatic life, dissolved oxygen levels should not fall below 5.5 ppm in warm water or 6.5 ppm in cold water. Generally, dissolved oxygen levels below 3 ppm are of concern, in either fresh or marine water, as they can result in obvious signs of stress or the death of fish. No upper limit can be provided as oxygen saturation relates to water temperature and salinity.

Some of the potential causes of dissolved oxygen depletion can include:

- increases in water temperature, which the reduce oxygen-carrying capacity;
- discharges and decomposition of organic matter (e.g., sewage, fish plant washwater or untreated pulp mill effluent) or nutrients (e.g., farm land runoff) which stimulate the growth of aquatic plants, algae, or bacteria, and consumes oxygen;
- natural die-off of aquatic plants or algae, which consumes oxygen;
- night time, when aquatic plants consume rather than produce oxygen;
- natural springs, tranquil, low flow, or ice-covered waters where there is limited oxygen uptake; and,
- chemical reactions which consume oxygen (such as dissolved iron flocculating in waters affected by acid sulphate drainage).



2. Water Temperature. Water temperature is another important physical factor affecting marine and freshwater fish. Temperature can vary considerably depending on location, depth, spring inputs, ice formations, upwellings, currents, sedimentation, and seasonal variability. Human activities that affect temperature can include chemical, petrochemical, pulp and paper industries, municipal sewage, thermal generating stations, and physical alterations of the water body.

Fish can be affected by water temperature fluctuations, gradients, and ranges in addition to the frequency, intensity and duration of changes. The CCME (1999) guidelines stipulate that human use should not cause changes in ambient temperature that exceed ± 1° C at any time, location, or depth. The maximum rate of human-related temperature change should not exceed 0.5° C per hour.

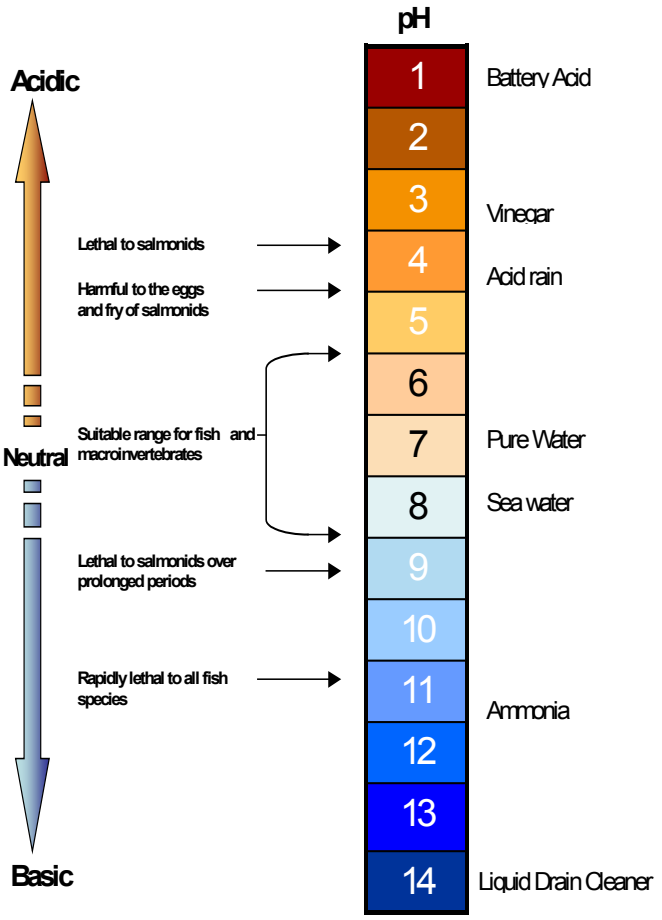
In assessing the cause of a fish kill, the background or normal temperature levels should be established, by taking measurements with a thermometer or digital thermistor. Measurements should also be taken at control sampling stations or from a similar adjacent water body, and compared to the temperature readings with those from the affected area. Significant differences in these temperature readings may be cause for concern and may require further investigation.

3. pH Stress. The pH is the negative logarithm (base 10) of the chemical activity of the hydrogen ion in solution. The pH scale indicates a neutral solution at pH 7.0, an acidic solution below 7.0, and an alkaline (basic) solution above 7.0. A unit change in pH corresponds to a tenfold change in the hydrogen ion concentration.

The pH in marine and estuarine waters (usually between 7 and 8.5 worldwide) is usually quite stable due to the buffering capacity of the salt water. Conversely, fresh water is more susceptible to pH change as it generally does not have this buffering capacity. Fluctuations in pH of water can result from industrial activities, acid precipitation caused by emissions from industries and vehicles, direct effects of acid (through acid soils or mine drainage), or releases of alkaline substances such as lime or fresh concrete. In addition, pH changes can also affect the chemical form and toxicity of other substances such as ammonia.

The CCME (1999) guidelines suggest that pH in marine and estuarine waters should range within 7.0–8.7. Within this range, the pH should not vary by more than 0.2 from the natural expected pH at that time. There is no definite pH range within which fish are unharmed and outside which they are damaged; rather, there is a gradual deterioration of water quality as pH values are removed from the normal range. Most fish, have limited tolerance to abnormal or sudden changes in pH.

In assessing the cause of a fish kill, the background or normal pH levels should be established by taking measurements using a meter or pH paper at control sampling stations or from a similar adjacent water body, and comparing them with measurements from the affected area. Significant differences in measurements or incidences, or where levels are below 4.5 or above 9, may be cause for concern.


pH
Acidic
Neutral
Basic
Lethal to salmonids
Harmful to the eggs and fry of salmonids
Suitable range for fish and macroinvertebrates
Lethal to salmonids over prolonged periods
Rapidly lethal to all fish species
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Battery Acid
Vinegar
Acid rain
Pure Water
Sea water
Ammonia
Liquid Drain Cleaner

4. Salinity Changes. Salinity is a measure of the concentration of total dissolved solids or salts in water. Salinity can range from 28–32 parts per thousand (ppt) in coastal areas to ≤1 ppt in fresh water. Levels can vary greatly due to river and groundwater inputs, evaporation rates, freshwater runoff from rainfall, and tidal and ocean currents. Salinity affects several physical and chemical properties of water including the freezing point, specific gravity, and osmotic pressure.

Rapid salinity reductions can result from major precipitation events and can cause fish kills in estuaries. Similarly, breaches in sand barriers at the mouths of rivers can cause the deaths of fish through the sudden intrusion of saline water into a comparatively freshwater environment. The evaporation of confined water bodies can raise salinity levels beyond the tolerance level for some fish.

The CCME (1999) guidelines stipulate that human use should not cause the salinity of marine or estuarine waters to fluctuate by more than 10% of the natural level. In assessing the cause of a fish kill, the background or normal salinity levels should be established, by taking measurements with a meter at control stations or from a similar adjacent water body, and comparing them with those from the affected area. Significant differences in measurements may be cause for concern and further investigation may be required.

5. Rain and Runoff. Rainfall runoff can carry a variety of organic and inorganic materials into adjacent waterways, including sediments, organic debris, nutrients, acid drainage, winter road salt, and other toxic

materials such as oil and grease, pesticides, and heavy metals.

A variety of changes or effects can occur in the receiving waters resulting from runoff including increased flow rates, fluctuations in water temperature, pH, salinity, and turbidity, reduced dissolved oxygen levels, and the flushing of potentially toxic levels of a substance. All of these situations can result in adverse impacts on local fish species.



(Source: Southeast Environmental Association)

These potential causes of pollution can vary greatly in nature. Field assessment activities usually start with a thorough survey of the affected water body and surrounding land-use practices. Field observations can be supplemented with field measurements of water temperature, dissolved oxygen, pH, and possibly salinity, conductivity, and turbidity in an attempt to narrow down possible causes. Screening techniques like a Microtox analysis (see Appendix I) can be used to determine if a

water sample is toxic and to identify the need for further analysis.

6. Turbidity. Turbidity is a measure of water clarity. It provides a relative indication of the suspended solids such as clay, sand, silt, organic and inorganic matter, and plankton and other micro-organisms in the water column. Increases in turbidity limit light penetration and can reduce photosynthesis and directly influence biological production in a water body. Greater absorption of solar energy can also result in warmer surface water.

Turbidity or suspended solids can affect fish in several ways including:

- clogging the filtering organs of some immature stages;
- causing physical injury to eyes and gills by abrasion;
- restricting food availability;
- restricting normal movements and migrations; and,
- inhibiting egg development.

Turbidity is measured using a Secchi disk in lakes or slow flowing rivers. In shallow or faster moving waters turbidity is measured using a hand-held turbidity meter . Typically, turbidity is measured in Nephelometric Turbidity Units (NTUs), which is a measure of the scattering of light caused by suspended particles as they pass through the water column. In assessing the cause of a fish kill, the background or normal levels should be established by taking measurements with a meter at control sampling stations or from a similar adjacent water body, and comparing them with the affected area.

Changes in turbidity greater than 10% indicate a possible need for further investigation.

7. Sediment Disturbance. On occasion, large quantities of nutrient-rich organic matter can accumulate on the bottom of a water body. This may not initially cause a problem where contact between the water and the organic matter is limited; however, if the sediments are disturbed by increased flow or turbulence, this material can become mixed into resuspended in the water column. The result may be an increase in bacterial decay and oxygen depletion or the release of the water-soluble toxicants such as ammonia and sulphide.

Dissolved oxygen levels can be measured in the field with a meter; however, specific toxicants will require water samples to be collected for lab analysis.

8. Acid Sulphate Drainage. Disturbing or draining acid soils or substrates such as pyritic rock, natural bogs, coastal wetlands, or old mine sites can result in acid sulphate drainage. The oxidation of naturally occurring iron sulphides in these soils and sediments, after mechanical disturbance, can produce sulphuric acid, which can drain into a water body following a precipitation event or tide change. The immediate effect of this acid runoff is to lower the pH. In addition, acidic conditions can dissolve metals such as aluminium, iron, and cadmium from the sediments, which can result in fish deaths from metal toxicity. Acid drainage can be more of a concern in fresh water, which has a less buffering capacity than salt water.

When pH returns to normal further downstream, the excess iron dissolved in the acidic water flocculates forming a cloudy, rust-coloured substance, which can

coat the substrate or vegetation and block fish gills. This flocculation process also consumes dissolved oxygen, which can lead to fish suffocation.

Measuring the pH or collecting water samples for metal analysis are the usual methods for monitoring acid runoff. Flushing of acidic waters can be very irregular, driven by storm events and tidal cycles, and pH measurement at a later date may reveal nothing abnormal. Also, acid drainage waters are often deceptively "clean" in appearance since a by-product of acidification is reduced turbidity.

9. Excessive Plant Growth. Aquatic plants and algae, produce oxygen by photosynthesis during the day and consume oxygen by respiration during the night, similar to terrestrial plants. When the daytime photosynthesis cannot counterbalance the night-time loss, DO levels may decline to levels lethal to fish. Levels may become lowest just before dawn, when photosynthesis resumes. Dissolved oxygen levels can be measured in the field using a meter or Hach kit, or in the lab by titration.

Excessive organic (e.g., sewage or fish plant wastewaters) or nutrient (e.g., farm runoff) loadings in a water body can result in increased plant growth or algal "blooms" (green water), and can result in oxygen depletion, particularly at night. These events are more common during warm water conditions when plants are at the highest growth stage of their life cycle.

The die-off of excessive plant growth (including algae) results in the decomposition of large amounts of organic matter and can further reduce oxygen levels. In this case, the oxygen is consumed by the bacteria associated with the decomposition process.

10. Toxic Algae. A number of blue-green algae and dinoflagellate species are potential producers of toxins under certain conditions. These plant species may be acutely toxic to fish when they are numerous in the water column at certain times of the year, such as the late summer.

Evaluating fish kills relating to toxic algae is a specialist function usually undertaken by qualified staff.

11. Parasites and Diseases. Fish can be subject to a variety of natural bacterial, viral infections, and parasitic infestations. These are usually a secondary cause of mortality in fish, which are already stressed by other environmental factors such as poor water quality or overcrowded conditions.

Lesions and haemorrhages (bleeding) are sometimes indicators of the presence of disease. In a disease outbreak, the number of fish affected can increase dramatically over days or weeks. Histopathological examination of fresh or appropriately preserved tissue samples by technical staff from DFO is required to determine the presence of a disease (Appendix J).

12. Hydrogen Sulphide (H_2S). Hydrogen sulphide can be produced from the bacterial decomposition of organic material or the disturbance of anoxic sediments in the aquatic environment. It can be released by natural turbulence or by man-made activities like dredging. Hydrogen sulphide is highly toxic to fish and usually larger fish are the first to be affected.

Hydrogen sulphide can be identified by its very characteristic smell (rotten eggs) and can cause a decrease in dissolved oxygen levels. A pathological sign

in fish is dark brown gill filaments due to the formation of sulfhaemoglobin.

13. Ammonia. Ammonia is an important component of the nitrogen cycle and can be found in the environment in two forms, un-ionized as NH_3 and ionized as NH_4. The main factors that influence the equilibrium or form of ammonia are pH and temperature. The un-ionized form is known to be more toxic to fish as it able to diffuse across biological membranes more readily than other forms.

Ammonia commonly enters the environment as a result of municipal, industrial, agricultural, and natural processes. Natural sources include the decomposition of organic matter, gas exchange with the atmosphere, forest fires, animal waste, and the discharge of ammonia by biota. Monitoring ammonia levels during a fish kill will require the collection of water samples (Appendix G).

14. Gas Bubble Disease. Gas bubble disease is characterized by the presence of bubbles in fish blood vessels. These bubbles are easily visible in the fins, head, gills, and behind the eyes of affected fish. Death results from blockage of the blood supply to vital organs.

The cause of gas bubble disease is supersaturation of dissolved gases in the water usually associated with turbulent or high energy conditions, such as near spillways or water discharges from power stations.

15. Life-cycle Related. Some fish species make seasonal migrations from salt water to fresh water (anadromous) to spawn (e.g., Atlantic salmon, striped bass, gaspereau). In some cases, their journey can expose fish to stressful conditions, such as changes in

water temperature and salinity, or physical damage, relating to turbulent waters or man made structures such as power dams. These changes and impediments can result in fish kills, which are often confined to a single species or family (e.g., gaspereau or blue-back herring).

Gaspereau (or Alewife), as an example, are frequently involved in kills and mass die-offs during their migrations in the spring and early summer each year. Studies indicate that the fish appear to be unable to acclimate to rapid increases or fluctuations in temperature.

Smelt are another species frequently involved in natural die-offs in the spring. These die-offs are likely due to the stresses associated with temperature fluctuations, migration, and spawning.



(Source: Environment Canada)

Striped bass mortalities have been noted in the winter following high freshwater discharge events (rain, snow melt). These fish over-winter near the fresh- and saltwater interface and may be affected by changes in salinity or temperature. Local or technical knowledge (DFO or provincial Natural Resources) can be helpful in understanding these cases.

16. Fishing By-catch. In areas where commercial or recreational fishing occur, dead or discarded fish can occasionally be found in the water or along the shoreline. These fish often have physical injuries, are undersized commercial or recreational species, or are simply unwanted coarser species. In marine commercial fishing areas unwanted by-catch may be discharged over the side of fishing boats. Local knowledge about recent fishing activity in the area can be helpful in these cases.

17. Contamination by Chemicals. There is a wide range of chemicals in common use in eastern Canada that can be involved in spills or chronic discharges. Fish kills resulting from chemicals can often be sudden and unexpected and leave little or no physical evidence.

In assessing and identifying the cause of fish kills where chemicals are suspected, it is important to thoroughly evaluate land or water use practices in the surrounding area or in upstream or up-current areas. Human activities that can release chemicals include municipal sewers and runoff, pulp and paper mills, fish and food processing plants, chemical and petrochemical plants, and farming operations, to name a few. It is also important to talk to people familiar with the area, who may be aware of recent spills or unusual activities. Physical measurements such as dissolved oxygen, temperature, pH, salinity, and turbidity should also be

collected in an effort to identify the possible cause. In some cases, water samples can be collected and screened using Microtox analysis to determine if the sample is toxic. Further analyses may then be needed to identify the actual toxicant. As well as analyzing the affected fish, these analyses may include sediments or vegetation, which can accumulate and retain chemical residues after the incident.

As there is a wide range of analysis that regional labs can perform. Information from field observations and measurements should be used to select which parameters will be measured. Pesticides and herbicides commonly used in urban and agricultural areas can cause fish kills. The seasonal nature of their use should therefore be considered.

Appendix F

Fish Kill Interpretation Key
(Adapted from Meyer and Barclay, 1990)

Directions for using this Key.

Each item has a number on the left side and another on the right side of the page. Always start at left number 1, read the two associated statements and decide which one is **true** and which is **false**. The number to the right of the true statement will direct you to the next appropriate number on the left and group of statements to be considered. Work down through the numbers until the key indicates a possible cause (in bold print) of the kill.

For example, left number 1 asks if the kill occurred in the past 24 hours, or if the time is unknown or longer than 24 hours. If the kill occurred in the past 24 hours the number on the right directs the reader to left number 2. If the time is unknown or longer than 24 hours the number on the right directs the reader to skip to left number 16.

Fish Kill Key

1 Kill occurred in less than 24 hours……..2
Not known when kill occurred, or kill continued for longer than 24 h hours……..16

2 Kill occurred between midnight and sunrise…..……..…3
Kill occurred at times other than between midnight and sunrise……..…8

3 Water dark in colour, musty odour ……...4
Water conditions normal in colour and odour……....6

4 Some fish alive..……..…5
All fish dead …….…….....16

5 Large fish dead, some small fish alive ..……..…6
Small fish dead, some large fish alive...……....18

6 Dissolved oxygen less than 2 mg/L (ppm)……....7
Dissolved oxygen 2 mg/L (ppm) or more .....……9

7 Algal cells absent or dead if present ……..……..8
Algal cells present and alive ……....10

8 Dead algal cells abundant – ***Oxygen depletion due to organic breakdown***
Algal cells absent – ***Oxygen depletion due to lack of production***

9 Kill occurred during daylight hours ……....10
Kill occurred at other times as well……..…..23

10 pH above 9.0 ……...11
pH not above 9.0 ……..…....14

11 Dissolved oxygen high, often saturated or near saturation ……....12
Dissolved oxygen low or near normal for temperature concerned ……..……..…….....13

12 Heavy bloom of one or more species of blue-green algae – ***Toxic algal bloom***
Heavy bloom of dinoflagellate algae – ***Toxic algal bloom***

13 Vegetation dead, and appears burnt ……..……..14
Vegetation normal……..……15

14 Ammonia concentrations near zero ……..……15
Ammonia concentrations high – ***Anhydrous ammonia discharge***

15 pH 6.0 to 7.0 – ***Oxygen depletion***
pH below 6.0 – ***Low pH/heavy metal poisoning/acid sulphate drainage***

16 Some fish still alive……..……17
All fish dead ..…….……..…23

17 Kill size selective..…….……...18
Kill not size selective..…….....25

18 Large fish dead, but some small fish alive……..…….6
Small fish dead, but some large fish alive..……..…19

19 Zooplankton and aquatic insects alive ……..……...7
Zooplankton and aquatic insects dead……..20

20 Algal cells alive……..……21
Algal cells dead or absent – ***Potentially toxic herbicidal substance present***

21 Fish showing convulsive or other abnormal behaviour……..…... 22
Fish behaviour normal ……..……..…..24

22 Fins in normal position ……...……..……..……23
Pectoral fins thrust to extreme forward position – ***Organophosphate poisoning***

23 Kill occurred throughout the day – ***Pesticide poisoning***
Kill occurred during daylight hours – ***Toxic algal bloom (see also 11)***

24 Recent seasonal water temperature change – ***Temperature kill (natural causes)***
Recent major temporary water temperature change – ***Temperature kill (natural causes)***

25 Species selectivity evident.....……..26
No species selectivity evident – ***Very high concentration of potentially toxic substance***

26 Lesions evident on fish …….....…….....27
No lesions on fish – ***Low toxicity or low concentration of potentially toxic substance (see also 23)***

27 Organisms in lesions visible to naked eye .....…….....28
No organisms visible .....…….....29

28 Organisms resemble copepods or have jointed body parts – ***Parasitic infestation***

29 Lesions not hemorrhagic .....…….....30
Lesions hemorrhagic – ***Possible bacterial or viral disease***

30 Lesions as small discrete bodies or masses in tissues……..…31
Lesions appear as grey, yellow, or white areas on body – ***Bacteria or fungus present***

31 Lesion or mass filled with cellular material – ***Cysts caused by parasitic infestation***
Lesion or mass filled with gas .....……..……...32

32 Bubbles of gas present in gills, fins and behind eyes – ***Gas bubble disease***
Odorous gas in large bubbles in necrotic lesions – ***Bacterial disease***

Appendix G

Sample Collection Procedures

1. Water Samples. There are several types of water sampling strategies that can be used during fish kill investigations such as collecting grab samples, composite samples, or depth- and width-integrated samples (for more detail see USEPA, 1996). There are two basic goals when collecting samples:

- ensure the water collected **is representative** of the environmental conditions in the water body at that time; and,
- ensure there is **no cross-contamination**.

Several sample collection considerations include:

- ensure the person sampling the water is wearing appropriate protective clothing (e.g., gloves, boots, rain gear);
- all sample containers should be washed and cleaned following recognized laboratory procedures;
- the appropriate size and type of sample containers must be used for each parameter (see Appendices H–K);
- sampling rods or core tubes may be used to collect samples from stream banks or substrate;
- to prevent contamination, do not open the container until the sample is to be collected;

- wade into the water and face upstream, working from downstream to upstream sampling stations;

- wait until the disturbance you have created washes away or settles before collecting a sample;

- dip bottle into the water, ensuring the bottle mouth is facing upstream;

- remove the cap and triple rinse the bottle before collecting the actual sample;

- replace the watertight cap underwater (some parameters like BOD require that no air is trapped in the container);

- in larger and deeper waters or coastal areas boats will usually be used as a sampling platform and sampling apparatus (e.g., Kemmerer and Alpha samplers) will be employed to collect water samples at various depths; water samples will subsequently be transferred from the sample collection apparatus to sample bottles keeping in mind the procedures mentioned previously;

- in some cases, contaminant samples will be collected from a variety different of sources (e.g., buckets, drums, trucks, storage tanks) or from run-off ditches or large puddles. The procedures mentioned previously should be adapted for this application;

- when collecting samples of standing water (e.g., ditches or puddles) attempt to ensure that no sediment is collected in the sample;

- properly label each sample including the date, time, and location; and,

- after collection, all samples should be properly preserved and stored (see Appendices H–K).

2. Toxicity Samples. Toxicity tests are performed to measure the harmful (either lethal or sublethal) effects of a substance on living organisms. If the cause of a fish kill is unknown, potential sources could be sampled and the toxicity screened using a "Microtox" test, or using organisms such as the crustacean, *Daphnia magna*. Only a small sample volume is required in these toxicity tests to determine if a sample contains a toxic or harmful substance. If a sample proves to be toxic it can then be examined in more detail using more specific and expensive analyses.

Water, chemicals, effluent, and sediment samples can also be collected for LC50 (median lethal concentration)* or "Pass/Fail" tests (lethal time to kill 50% of test on a variety of different organisms, usually tested on undiluted samples). Samples should be collected in a manner similar to water samples (Appendix G, Section 1). The required volumes, containers and preservatives are provided in Appendix I.

Following a fish kill, it may be hours or even days after the fish were exposed to a toxic substance before a responder is able to collect samples. The water collected at that time may not be representative of the water that caused the mortalities. In certain cases, such as with pesticide exposure, some residue may accumulate in

* LC50 = the concentration of a material or substance that is estimated to be lethal (kill) to 50% of the test organisms.

the sediment (as pesticides bind to sediment particles) and persist there longer than in the water column. In addition to water samples, therefore, sediment samples may be collected for chemical analysis or sediment bioassays in such areas as the site of the kill as well as upstream and downstream. See Section 4 of this appendix for further details.

3. Fish Samples. Collecting fish samples for performing an autopsy, tissue analysis, or searching for disease-causing pathogens or parasites can be important for identifying the cause of a kill. Several sample collection considerations include:

- collect only living, moribund, or recently dead fish from the kill site for analysis;
- when collecting fish, it is important to note the behaviour of living and moribund fish and note any signs of damage, lesions, or discoloration;
- fish samples may also be collected from unaffected sites to measure background levels of contaminants in tissues for comparison;
- ensure fish samples are fresh by looking at the colour of gills (colour should be deep red); **decaying fish are of no use for analytical testing;**
- if a hazardous material is suspected, two samples should be collected, one for organic (pesticides), and a second for inorganic (metals) analysis;
- occasionally, subsamples of tissues (e.g., brain, blood, gills) will be collected for special analysis;

- fish scales may also be collected to determine the age class of the fish;

- all samples should be properly labelled (including the date, time and location), taped shut (initial the tape), and stored following collection (see Appendix J). Often, this will involve cooling (to approx. 4 ºC) or freezing.



(Source: PEI Environment Energy and Forestry)

In addition to collecting fish samples, it may be important to collect the dead fish in the affected area to identify the number of fish involved, the species, size, and age classes affected and to arrange for appropriate disposal. This information is important in determining the severity of the event and can be used to estimate environmental and economic impacts. Where safe to do so, dead fish samples can be collected by hand or by using dip nets.

Live fish may also be collected to identify the remaining numbers, species size, and age class. This type of survey may necessitate the use of electro-fishing equipment, which requires specialized skill, and is undertaken by qualified staff from DFO or other organizations. Electro-fishing only stuns the fish, and once the appropriate data are collected, the fish can be released. Techniques for measuring the size of fish can be obtained from DFO or other organizations.

4. Sediment Samples. Analyzing sediment samples can be an important method of identifying a toxic substance, which, after a period of time, may no longer be detectable in water samples. When certain toxic chemicals enter a watercourse, they may partition out of the water column and settle or attach to sediments on the bottom. The thin surface layer of sediment is usually where chemicals settle or attach and, therefore, it may be an important area to sample. Several sample collection considerations include:

- sediment samples should be collected in containers and preserved as outlined in Appendix K;

- soil samples can also be collected along the shores of a waterway using the techniques described in this section;

- usually, sediment samples are collected after field measurements and water samples have been collected and at the same locations (below, within, and above the affected area);

- areas of low turbulence, such as downstream of a riffle, are ideal sampling sites as there is a reduction

in current flow and sediments have an opportunity to accumulate;

- sampling equipment for sediments can include stainless steel or plastic/Teflon scoops or utensils, Teflon core tubes, or grabs (such as stainless Ekman dredges);

- all sample bottles and equipment should be cleaned before use following specified lab procedures;

- clean sample bottles should not be uncapped until used;

- usually, utensils are individually wrapped in tin foil following cleaning and kept wrapped until used;

- to collect samples, start at the downstream location first and progress upstream;

- wade into the stream, face upstream and take a scoop of the surface bottom sediment; the bottle must be filled almost to the top with sediment and topped off with water from the site;

- in larger and deeper waters or coastal areas boats will usually be employed as a sampling platform and sampling apparatus (e.g., various types of dredges) will be used to collect sediment samples; samples will subsequently be transferred from the sample collection apparatus to appropriate sample bottles keeping in mind the procedures mentioned previously;

- samples should be properly sealed, labelled, and stored and transported or shipped to the lab as quickly as possible; and,

- trip blanks or field blanks should be used to ensure quality control of samples.



(Source: PEI Environment Energy and Forestry)

5. Macroinvertebrate Samples. Macroinvertebrates comprise a wide range of organisms that inhabit marine and freshwater aquatic ecosystems. Many of these organisms can be used as indicators of environmental conditions in a waterway as they are often affected by events similar to those that affect fish (Keenan, 2001). Sampling macroinvertebrates requires specialized techniques. These methods are not described in detail in this document.

As a general indicator in a freshwater system, rocks (cobble-sized) can be picked up in riffle areas, and overturned to look for the presence or absence of invertebrates attached to, or scurrying around the substrate. A larger number and variety of invertebrates will often indicate a healthier system. In a more contaminated area, very few, if any, invertebrates may be observed.

Appendix H

Environment Canada Water Sample and Preservation Requirements for Chemical Analysis

Parameter	Bottle Size and Container (minimum mL)	Preservation
BOD	250–1000, polyethylene	bottles filled completely, no air space, analyze immediately or freeze
Alkalinity	100, polyethylene	no preservation necessary, analyze immediately
Ammonia	150, polyethylene	1 mL H_2SO_4/L and freeze immediately
Carbon	100, polyethylene	keep cool, analyze immediately
COD	100, polyethylene	add 1 mL H_2SO_4 freeze immediately
Colour	100, polyethylene	keep cold
Conductivity	100, polyethylene	keep cold
Chloride	100, polyethylene	no preservation
Cyanide	1000, polyethylene	2 g NaOH/L and keep cold
Fluoride	100, polyethylene	no preservation
Formaldehyde	250, polyethylene	freeze
Humic Acid	250, polyethylene	no preservation
Lignin	250, polyethylene	freeze
Metals + Ca and Mg	500, polyethylene	2 mL HNO_3/L
Mercury	250, polyethylene	10 mL conc. HNO_3 + 0.125 g $K_2Cr_2O_7$
Nitrate-Nitrite	100, polyethylene	1 mL $CHCl_3$/L

Oil and Grease	100, glass	2 mL H_2SO_4/L
PAHs	1000, glass	keep cold
Pesticide	1000, amber glass, hexane-rinsed	keep cold
PCB	1000, glass, hexane-rinsed	keep cold
pH	100, polyethylene	keep cool, analyze immediately
Phenols	1000, glass	acidify to pH 4 with H_3PO_4 + 1 g $CuSO_4 \cdot 5H_2O$
Phosphate	100, polyethylene	add 1 mL $CHCl_3$/L and freeze
Resin Acids	1000, polyethylene	freeze immediately
Solids	1000, polyethylene	keep cold, freeze
Sulphate	100, polyethylene	no preservation
Sulphide	300, glass BOD bottle	fill bottle, make sure no air bubbles are present; if air is present, add 12 g NaOH, keep cold
Turbidity	100, polyethylene	keep cold

Chemicals:

$CHCl_3$	- chloroform
$CuSO_4 \cdot 5\ H_2O$	- copper sulphate
HNO_3	- nitric acid
H_3PO_4	- phosphoric acid
K_2Cr_2O	- potassium dichromate
NaOH	- sodium hydroxide
H_2SO_4	- sulphuric acid

Appendix I

Environment Canada Sample Requirements and Preservation for Toxicity Tests

Test	Volume Required	Container	Preservation	Comments
effluent and receiving water by Microtox *Photo-bacterium* EC50	500 mL	HDPE (plastic) or glass; soap and water washed and thoroughly rinsed for routine samples; **new containers for legal samples; rinse with sample**	fill container; cap tightly; keep cool (4° C); do not freeze; **do not add chemical preservatives** bring to lab ASAP	usually used as a screening test
effluent and receiving water by *Daphnia* (LC50 or pass/fail)	1 L	as above	as above	
effluent by fish (pass/fail)	usually 40 L	as above, 20-L plastic container	as above (keep cool, if possible)	pass/fail test at 100% conc.

effluent and receiving water by fish (LC50)	usually 80 L	as above	as above (keep cool, if possible)	multiple concent-ration test
sediment by various species	4 L	as above	as above	used for *CEPA – Part V* (disposal at sea)
chemicals and products by various species	1 L of pure compound usually sufficient	as above	as above	chemical and product spills

Appendix J

Environment Canada Recommendations for Handling and Preserving Fish Samples

Parameter Note: check fish gills to ensure sample is fresh	**Handling and Preservation**
Inorganics (e.g., metals)	- minimum three fish of each species - minimum 100 g of tissue sample - pack dry and individually sealed plastic bags - freeze quickly - ship in watertight cooler
Organics (e.g., pesticides)	- minimum three fish of each species - minimum 250 g of tissue paper - rinse fish with clean water - wrap in aluminum foil (dull side in) - freeze quickly - do not touch fish/foil with hands - ship in watertight container
Fish Disease and Parasites	**a) Live Fish** - place in sealed bags - partly fill bag with water - charge bag with oxygen - place on ice in watertight cooler **b) Dead Fish – Frozen** - individually packed in sealed plastic bags - freeze quickly - ship in watertight cooler **c) Dead Fish - Unfrozen** - place in sealed plastic bags - maximum of five small or one large fish per bag - pack in crushed ice (no ice in bag) - ship in watertight cooler

Appendix K

Environment Canada Sediment Sample and Preservation Requirements

Parameter	Minimum sample size and container	Preservation
Total solids	50 g, plastic or glass	freeze
Total volatile solids	50 g, plastic or glass	freeze
Oil and grease	100 g, glass	cool 4 ºC add HCl*; freeze
Total nitrogen	25 g, plastic or glass	freeze
BOD	50 g, plastic or glass	cool 4 ºC
PCB	100 g, glass	freeze
PAHs	100 g, glass	freeze
Pesticides	100 g, glass	freeze
COD	50 g, plastic or glass	cool 4 ºC

* HCl = hydrochloric acid

Appendix L

Laboratories in the Atlantic Region

Laboratory	Location	Contact	Analyses
Atlantic Veterinarian College	Charlottetown	902-566-0833 902-566-0864	fish pathology, pesticides, hydrocarbons
Environment Canada Labs	Moncton	506-851-2129 506-851-3486	organics, inorganics, and toxicology
PEI Analytical Laboratories	Charlottetown	866-368-5044	inorganics, bacteria
DFO Fish Health Unit	Moncton	506-851-6081 506-851-3259	fish pathology
Maxxam	Halifax Sydney	902-420-0203 902-567-1255	organics, inorganics
RPC	Fredericton	506-452-1212	organics, inorganics
NB Dept of Environment and Local Government	Fredericton	506-453-2477 506-453-3269 fax	contaminants in water, soil, sediment, air, and food

Note: In some cases sample analysis will have to be carried out by a certified laboratory (e.g., Canadian Association for Environmental Analytical Laboratories).

Appendix M

Fish Identification Guide

This appendix is intended to assist field personnel in identifying the species of fish involved in a fish kill or natural die-off incident. The 18 species most commonly associated with fish kills and natural die-off events in Atlantic Canada included in this identification guide are:

American Eel	Mummichog
Atlantic Salmon	Rainbow Trout
Atlantic Tomcod	Shad
Brook Trout	Smallmouth bass
Brown Bullhead	Smelt
Brown Trout	Striped bass
Burbot	Threespine Stickleback
Cunner	White Sucker
Gaspereau or Alewife	Yellow Perch

American Eel

Anguilla rostrata

Common Name
American eel, Atlantic eel, Freshwater eel, Yellow-bellied eel, Bronze eel, Whip.



(Source: DFO)

Life History
Eels are catadromous, which means they spend most of their lives in fresh water and return to the sea to spawn. The upstream movement of young eels occurs during the spring and the downstream movement of adults to the sea occurs during the autumn.

Size
American eels can grow to 127 cm and weigh up to 4.5 kg.

Physical Characteristics
A mature eel has an elongate, serpentine, or snakelike body with a pointed head and many teeth. The skin is thick and has a mucous coating, which acts as a protective barrier. A single gill opening is located just in front of the pectoral fin. There are no pelvic fins and the soft-rayed dorsal fins are continuous.

Yellow eels are adults in fresh water. Colour varies from yellowish to olive-brown and they are dark on the back and lighter on the belly. Silver eels are sexually mature eels, which darken to a bronze black hue on the back and are silver on the belly. Glass eels are the young larval stage called leptocephalus. Their bodies are transparent and shaped like willow leaves. They have a distinct black eye. Eels in the stage where they are adapting to fresh water are called “elvers”. They are darker in colour ranging from grey to greenish-brown.

Habitat Type
Adults usually reside in permanent streams with continuous flow. They seek cover in the daylight in undercut banks, and in deep pools, near logs and boulders. Young eels may reside in estuaries while they adapt to living in a freshwater environment.

Eels are a hardy fish and have the ability to survive in extreme conditions. They prefer fresh water but can tolerate high salinity. Eels can flourish in warm water as well as in sub-zero environments. They breathe in water like a fish but can also breathe through their skin, which allows them to

remain alive for hours out of water.

Potential Cause of Mortality
See Appendix E
Local examples:

- Commercial fishing activities, caught in traps and nets.
- Frozen while over-wintering in mud.

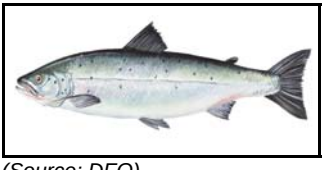


(*Source: Inland Fish Species of New Brunswick)*

Atlantic Salmon

Salmo salar

Common Name
Atlantic salmon



(Source: DFO)

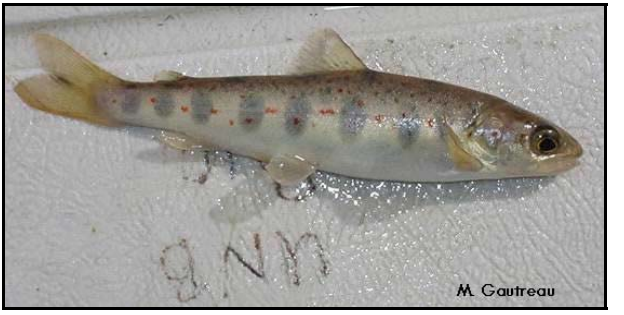
Life History
The Atlantic salmon is an anadromous species, living in fresh water for at least the first two or three years of life before migrating to the sea. Salmon live one or two years at sea before they return to freshwater systems to spawn. Atlantic salmon typically ascend rivers and streams during the late summer–early fall to spawn. Atlantic salmon do not die after spawning. Juvenile salmon parr spend most of their freshwater life in shallow riffles.

Size
Adults: Average 46–150 cm, and weigh up to 17.4 kg.
Parr: 5–15 cm

Physical Characteristics
Salmon colouration varies depending on the stage of development. Small "parr", which are older young salmon, have 8 to 11 pigmented bars, or parr marks along each side of the body, alternating with a single row of red spots along the lateral line. These markings are lost when the smolt age is reached. Saltwater salmon are silvery on their sides and silvery-white on their bellies.

Upon entering fresh water for spawning, adults loose their silvery appearance and become darker. As these salmon approach spawning, they become bronze and dark-brown, and sometimes reddish on the head.

Habitat Type
Salmon require cool, well-oxygenated water in rocky runs and pools of small to larger rivers and lakes. Adult salmon will seek out a stream with a suitable gravel, rocky substrate to spawn.



Salmon Parr *(Source: Inland fish species of NB)*

Potential Causes of Mortality

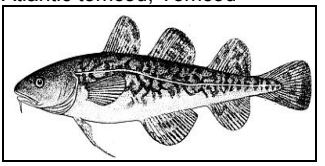
See Appendix E

Local examples:

- Pesticide run-off
- Habitat alteration and sediment inputs
- Low dissolved oxygen

Atlantic Tomcod
Microgadus tomcod

Common Name
Atlantic tomcod, Tomcod



(Source: NOAA)

Life History
The Atlantic tomcod spawns from November to February with peak spawning in January. Spawning occurs in shoal waters of estuaries or in the streams in either salt or brackish waters. Eggs are deposited, sink to the bottom, and stick together in large masses on seaweed or stones.

Size:
Rarely over 30 cm in length



(Source: Inland fish species of New Brunswick)

Physical Characteristics
The Atlantic tomcod is a close relative of the Atlantic cod, except it is much smaller. The body is elongated, and the upper jaw projects past the lower jaw. There is a barbell on the chin. The Atlantic tomcod is olive-brown, or muddy green in colour, with some yellow on the dorsal surface. The dorsal fins are mottled with dark spots or blotches while the belly is grey, yellow, or white.

Habitat Type
The tomcod can be found in salt water, brackish water and fresh water. In some regions tomcod have established populations in landlocked lakes. Typically inhabits coastal waters and estuaries with depth range of 10 m.

Potential Causes of Mortality
See Appendix E
Local examples:

- Thermal inversions
- Discarded by-catch
- Chemical pollution

Brown Trout
Salmo trutta

Common Name
Brown trout, Brownie, Sea-run brown trout



(Source: DFO)

Life History
Apart from moving upstream to spawn, adults tend to remain in the same area of a river, where they can be found day after day, even year after year. Others move to or from estuaries in the spring or fall. Brown trout are active at night.

Size
Typically, 2.3–3.2 kg, and up to 100 cm in length.

Physical Characteristics
Yellow-brown to tan in colour, brown trout may have numerous large black or brown spots on their sides, back, and dorsal fin. An adipose fin is located between the dorsal fin and tail fin. Sea-run brown trout closely resemble Atlantic salmon both in shape and colour. They can be distinguished by observing their teeth. Brown trout have two well-defined double rows of teeth, while salmon and other native salmonids only have a single row. Young brown trout have 9–14 dark narrow parr marks along their sides and some red spotting along their lateral line.

Habitat Type
Brown trout are a very elusive fish that seek cover more than other salmonids. They prefer medium-sized streams, with continuous flow and ample cover. In running waters they hide in undercut banks, in-stream debris, near rocks, and in deep pools. Adults tend to inhabit deep pools, while the young occupy both riffle and pool habitats. Sometimes they will inhabit lower reaches of streams that are not suitable for brook trout.

Brown trout can tolerate higher water temperatures and poorer water quality than most other species of trout and salmon.



(Source: Inland fish species of NB)

Potential Causes of Mortality
See Appendix E
Local examples:

- Low oxygen levels
- Chemical inputs
- Habitat disruption and siltation can be detrimental to this species, in particular the juveniles and eggs.

Brook Trout
Salvelinus fontinalis

Common Name
Brook trout, Sea trout, Salter, Speckled trout.



(Source: DFO)

Life History
Brook trout spend most of their lives inhabiting streams; however, some will move out to the sea in the spring as temperatures begin to rise. Those that descend a freshwater system may stay out to sea for up to three months, remaining close to the river mouths. During the fall "Salters" will ascend streams to spawn in the gravel substrate. Trout usually spawn in late summer or fall, typically during late September, October or November in eastern Canada. Trout nests built in the gravel and after spawning female covers eggs with pebbles.

Size
Average length 25–30 cm

Physical Characteristics
An adult brook trout has an elongate and slightly laterally compressed body and a large head. Colour varies depending on the stage of development. The back, upper sides, and top of the head are dark brown to black, becoming lighter sides and silvery-white on the underside. There are pale red spots surrounded with bluish halos on the side. At spawning time, the lower sides and undersides of males become orange-red. The anal, pelvic, and pectoral fins are a reddish colour with black pigmentation and white leading edges. Adults in salt water are silvery on the sides and dark blue or green on the back. Pale red spots may be visible on the sides as well as the white leading edge on the fins. When returning from the sea, these trout re-acclimate to their freshwater environment and regain their colours. Young speckled trout or parr have 8–10 dark vertical bars (called parr marks) on the sides.

Habitat Type
Brook trout require clear, cool, well-oxygenated water in creeks and small to medium-sized rivers and lakes. Since some populations of brook trout are anadromous, they can inhabit fresh water, brackish and marine environments. In streams, brook trout will seek cover near stream

banks, in woody debris, and deep pools.



(Source: Inland fish species of NB)

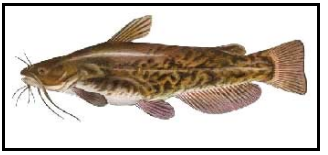
Potential causes of Mortality
See Appendix E
Local examples:

- Pesticide run-off
- Low dissolved oxygen
- High water temperature
- Habitat disruption and siltation can be detrimental to this species, in particular the juveniles and eggs.

Brown Bullhead

Ictalurus nebulosus

Common Name
Brown Bullhead, Catfish, bullhead catfish.



(Source: DFO)

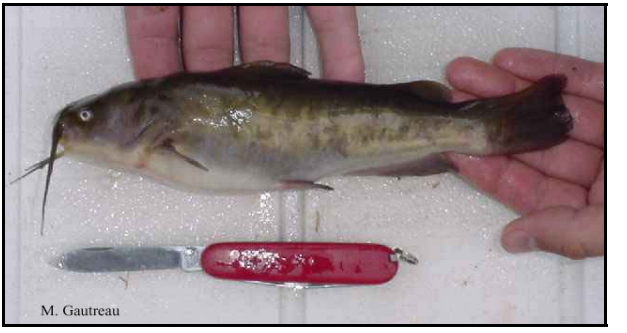
Life History
Bullheads spawn in the late spring when water temperatures approach 21°C. One or both parents excavate a shallow nest in a protected area of mud or sandy bottom. Spawning occurs in the daytime. Several thousand cream-coloured eggs are deposited in the nest. The parents care for the eggs by fanning them with their fins and physically stirring them up. After hatching, the young catfish are jet black and resemble tadpoles. They swim in a "school" and are protected by their parents for several weeks until they are about 5 cm long. The brown bullhead usually matures at age three and lives for 6–8 years.

Size
Typical size range 20–35 cm.

Physical characteristics
The brown bullhead is a moderate-sized fish. It has two dorsal fins including one adipose fin and a tail only slightly notched. Long barbels around the mouth are distinct physical characteristics of the bullhead. The head, body, and upper sides are yellow-brown, olive, or grey to almost blue-black.

The bullhead has sharp, saw-toothed, spines at the base of the dorsal and pectoral fins. These spines can be "locked" in an erect position. There are no scales but the skin has many taste glands.

Habitat Type
Brown bullheads usually live on the bottom in the shallow, weedy, muddy areas of lakes or large slow-moving streams. They can tolerate higher water temperatures and lower oxygen levels than many other fish species.



Potential Causes of Mortality

See Appendix E

Local examples:

- Disease

Burbot
Lota lota

Common Name
Burbott, Ling



(Source: DFO)

Life History
The Burbot is one of a few freshwater fish that spawns in the mid-winter under the lake ice. The general, period of spawning occurs between January and March depending on the latitude. In general, spawning occurs in shallow water between 30 to 120 cm or on gravel shoals in about 150 to 300 cm of water. Mating occurs at night and the spawning grounds are deserted during the day.

Size
Burbot average 40–60 cm in length. Maximum size 84 cm and 4.5 kg.

Physical Characteristics
Burbot have a long slender body with a round tail. Distinguishing features are the large barbell (whisker) on the tip of the chin and a long thin anal fin. Colour may vary across its distribution, but usually is yellowish to light brown or dark brown. The skin of the burbot appears smooth, but tiny imbedded scales are present.

Habitat
Burbot, also known as ling, are usually found in larger streams and cold, deep lakes and reservoirs.

Potential Causes of Mortality
See Appendix E

Cunner
Tautogolabrus adsperus

Common Name
Cunner, Perch, Sea Perch, Blue Perch



(Source: DFO)

Life History
Spawning occurs from late spring through early summer. At hatching, larvae are about 2 to 2.2 mm long, and upon reaching 15 mm, the young display the adult form.

Size
Usual size is between 15–25 cm in length.

Physical Characteristics
Cunners range in colour from mottled-reddish to bluish-brown on top, fading to slightly paler hues along their sides. These fish have a pointed snout and are moderately slender and deep in body shape. They have a single long dorsal fin and a very deep caudal peduncle. Their small mouth is lined with several rows of uneven cone-shaped teeth.

Habitat
Cunners are considered a coastal fish with most living within 8–10 km from shore. They are most often found around piers, rock jetties, and eel-grass beds. Cunners usually occur in schools or small groups.

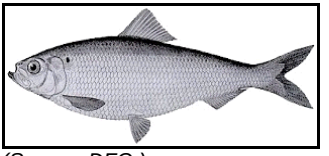


(Source Cornell University)

Potential Causes of Mortality
See Appendix E

Gaspereau
Alosa psuedoharengus

Common Name
Alewife, Gaspereau, White herring, Sawbelly, Kyak



(Source: DFO)

Life History
Gaspereau are anadromous, and thus use freshwater streams and lakes in the spring to spawn. Upstream migration typically begins in April and can last up to two months. Gaspereau seek out lakes and quite stretches of rivers to spawn. Larvae remain in the vicinity of spawning grounds for up to two weeks before descending streams to estuaries and the sea. Adults school with like sizes, apparently remaining near their natal estuaries. Despite the many thousands of eggs laid by spawning alewife, very few offspring actually survive. In some populations, as few as three "young-of-the-year" fish migrate downstream for each female that spawned.

Size
Usually 25–30 cm long and weighs up to 340 g.

Physical Characteristics
The body is strongly compressed laterally, and deep. The caudal fin is distinctly forked. Scales are large and silvery in colour and the back is greyish-green. The scales appear iridescent when freshly caught. A single black spot is evident at eye level, immediately behind the head.

Habitat Type
Throughout most of the year gaspereau travel the coast in large schools, staying at depths ranging from 5–145 m. In spring, they ascend coastal streams. Some landlocked populations ascend rivers and streams to spawn. As gaspereau are not jumpers, man-made barriers may pose a threat for spawning.



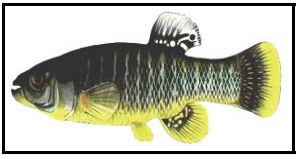
(Source: Inland Fishes of NB)

Potential Causes of Mortality
See Appendix E
Local examples:

- Die after spawning
- Trapped by man-made barriers in tidal streams
- Discarded as by-catch
- Sudden changes in salinity and temperature

Mummichog
Fundulus heteroclitus

Common Name
Mummichog



(Source: www.njscuba.net)

Life History
Mummichogs emerge from their mud burrows in the spring as the water begins to warm. The female deposits her eggs in the marsh on the high spring tide. About two weeks later, on the next spring tide, the eggs hatch and the young return to tidal ditches and pools.

Size
Average length is about 7 cm.

Physical characteristics
The body is generally robust but elongate, somewhat flattened at the back of the head. Colour may vary depending on environmental conditions, but the overall colour is olive-brown to olive-green. In spawning season, from April to September, the male's coloration becomes more striking turning a darker greenish-brown with bright blue spots. Their bellies may range from white to orange. Females are more pale in colour, from olive to green, with a pale underside.

Habitat Type
Mummichogs can be found in brackish waters, in salt marsh flats, estuaries, and tidal areas, especially where there is submerged vegetation. They are capable of tolerating highly variable salinity and temperatures. They may be the only species found in oxygen-deprived coastal streams.

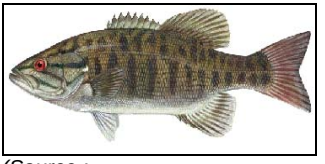


(Source www.njscuba.net)

Potential Causes of Mortality
See Appendix E

Smallmouth Bass
Micropterus dolomieui

Common Names
Smallmouth bass, black bass, brown bass



(Source : www.dnrec.state.de.us)

Life History
Spawning takes place over a period of 6–10 days usually between late May to early June in shallow (usually 30–90 cm deep) protected areas of lakes and rivers, when the water temperature is 16–18 ºC.

Size
Usually they grow to about 17–28 cm in length.

Physical Characteristics
Colour varies with size, condition, and habitat. In clear, vegetated water or stained water they are darker with pronounced contracting markings. Dorsal surface of the back and head are brown, golden-brown through olive to green. There are 8–15 narrow, vertical bars on the sides and dark bars on the head that radiate backwards from the eyes. It has a relatively large head, with a large red, orange, or brown eye, and protruding lower jaw. The two dorsal fins are joined; the front one is spiny and the second one has one spine followed by soft rays. The pelvic fins sit forward on the body below the pectoral fins. A single spine is found on each pelvic fin, and the front of the anal fin. Young fish have more distinct vertical bars or rows of spots on their sides and the caudal or tail fin is orange at the base followed by black and then white outer edges.

Habitat Type
Smallmouth bass inhabit clear, quiet waters with gravel, rubble, or rocky substrate. They live in mid-sized streams that have deep pools and shade. Smallmouth bass tend to seek cover and avoid the light. They hide in deep water, behind rocks and boulders, and around underwater debris and crevices. They prefer temperatures of 21–27ºC, and as temperatures fall, they become less active and seek cover in dark, rocky areas. In

the winter they cease feeding, remain inactive on the bottom, and stay near warm springs when possible.

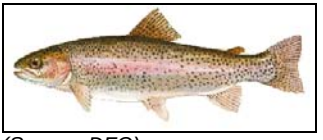
Potential Causes of Mortality
See Appendix E



(Source: Inland Fish species of NB)

Rainbow Trout
Oncorhynchus mykiss

Common Name
Rainbow Trout



(Source: DFO)

Life History
Different populations of rainbow trout may have very different life history patterns. Rainbow trout may live in lakes or ponds, in streams, or they may be anadromous, spending part of their lives at sea before returning to fresh water to reproduce. Rainbow trout spawn in the spring usually from March to May in small tributaries of rivers, or inlets of lakes. Spawning can also take place in the early fall or winter. Spawning occurs in shallow riffles with gravel bottoms. They usually return to the streams in which they were hatched. Rainbow trout that migrate to sea (steelhead) spend from 1 to 4 years in fresh water before transforming into smolts to prepare for life in salt water. They migrate to sea in spring and remain there for a few months to several years before returning to fresh water.

Size
Usual size ranges from 15–40 cm in length.

Physical Characteristics
The body is elongate with a pinkish red stripe along the lateral line and small black speckles on the sides, back and upper fins, and tail. Colour varies from olive-green to bluish on the back and silver on the sides. The mouth is large and contains strong teeth on jaws, tongue, and roof. Adults in salt water: sea-run rainbow trout (steelhead) are more silvery in colour, may lack the rosy stripe, and show less spotting on the sides. Young rainbow trout (parr): have 5–13 well-spaced dark parr marks on the sides and show less spotting on the body than adults. Rainbow trout may look very similar to Atlantic salmon and brown trout, but can be distinguished by the regular rows of spots on the tail, the lack of any coloured spots, and the absence of red in the adipose fin.

Habitat Type
Rainbow trout prefer water temperatures of 12–18 °C and do well in clear, cool, deep lakes, or cool, clear moderately flowing streams with abundant cover and deep pools. Young rainbow trout seek cover and prefer slow-moving shallow stream areas where rubble, rocks, in-stream debris, and undercut banks provide shelter. Older trout move into faster and deeper stream waters.

Potential Causes of Mortality
See Appendix E
Local examples:

- Pesticide run-off
- Siltation



(Source: Inland fish species of New Brunswick)

Striped Bass
Morone saxatilis

Common Name
Striped Bass, Striper, Striper bass



(Source: unknown)

Life History
After moving upriver the previous fall, Striped bass spawn in May and June, usually at water temperatures of 14–22 °C. Upstream distances can vary from a long journey inland to spawning just above the head of tide. Striped bass sometimes spawn in brackish waters. During their saltwater life, many striped bass make long sea migrations. However, not all fish migrate and some populations do not migrate at all. Some fish remain in the estuary of their home rivers.

Size
Usually 40–50 cm in length

Physical Characteristics
Body is elongate, and is dark olive-green, to steel-blue or black above, paling on the sides to silvery, sometimes with brassy reflections, becoming white on the belly. There are 7 or 8 predominant horizontal dark stripes along the sides. The first dorsal fin (on the back) is spiny and the second has one spine followed by several soft rays. A single spine lies at the front of each pelvic fin and three short spines precede the anal fin. Young often lack stripes and have 6–10 dusky bars on the sides.

Habitat Type
Striped bass are schooling fish, living in the sea and returning to fresh water to spawn (anadromous). Spawning is most common in steady-flowing, turbid rivers that have low slopes and large estuaries.



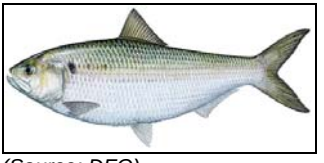
(Source: NOAA)

Potential cause of Mortality
See Appendix E
Local examples:

- Thermal shock
- Breeding stress
- Changes in salinity

American Shad
Alosa sapidissima

Common Name
American Shad



(Source: DFO)

Life History
Each spring, schools of shad, using their sense of smell, begin to migrate up coastal rivers and tributaries when water temperatures reach 12 °C. Spawning in the Maritimes occurs during June and July in water temperatures of 13–20 °C. Migration stops in temperatures over 20 °C. American shad do not usually travel upstream as far as the alewife. They spawn in rivers at night in mid-water areas with a wide range of bottom types. Young shad spend their first summer in the river feeding on insects and crustaceans. At sea, shad live in schools moving to areas with bottom temperatures that are 7–13 °C. They stay near the bottom during the day, dispersing at night to all depths. Immature and spawned-out adults remain offshore in areas like the Bay of Fundy until winter, when they move farther out to sea seeking preferred water temperatures.

Size
Reach an average length of 45–50cm

Physical characteristics
Body is elongate, strongly compressed laterally, and rather deep. The overall colour of the shad is a silvery, with a blue or blue-green lustre on the back. The sides are bright silvery. There is a large black spot on the shoulder close behind the edge of the gill cover. The fish has no lateral line, and a row of scales known as scutes form a sharp “sawbelly” edge along the midline of the belly.

Habitat Type
American shad spend most of their life at sea, returning to freshwater streams to breed. They avoid cold water temperatures. Non-spawning adults are found in schools near the continental shelf waters in spring, summer, and fall. During the spring and summer, shad are found in rivers and streams.



*(Source : **www.dnr.state.md.us**)*

Potential Causes of Mortality
See Appendix E
Local examples:

- Discarded as by-catch

Rainbow Smelt
Osmerus mordax

Common Name
Rainbow Smelt



(Source: DFO)

Life History
The rainbow smelt is an anadromous schooling fish. Smelt move into estuaries in the fall and to streams after the spring thaw. Spawning occurs from February to June. After spawning the adults return to the estuary during the day but may return upstream to spawn again on subsequent nights. Some fish die after spawning. Those that survive leave fresh water after spawning to spend the summer in coastal waters. Smelt fry are 5–6-mm long when they hatch, and drift downstream to brackish water. Land-locked smelt populations remain in freshwater lakes.

Size
Typically reach 15–20 cm.

Physical Characteristics
Rainbow smelt have very slender bodies, and prefer dark, cool waters. When viewed under water, they appear primarily silver with light-green backs, and have an abundance of pink, purple, and blue along their incomplete lateral line. The belly of this fish is white. Rainbow smelt have a long, pointed snout, a mouth full of teeth, an adipose fin, and a deeply forked caudal (tail) fin.

Habitat Type
Rainbow smelt are a pelagic species and travel in schools within a couple of kilometres of the shore. Their shore movement patterns are associated with changes in seasonal water temperatures. Some populations inhabit land-locked lakes. They prefer temperatures of 6–14 °C and stay close to shore, seeking cover in eelgrass beds or in the mud.



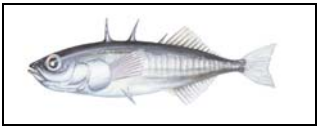
(Source: Inland fish species of New Brunswick)

Potential Causes of Mortality
See Appendix E
Local examples:

- Spawning stress
- Trapped in tidal pools and streams
- Elevated water temperatures
- Discarded as by-catch

Three-spine Stickleback
Gasterosteus aculeatus

Common Name
Three-spine stickleback



(Source: DFO)

Life History
The three-spine stickleback spawns in fresh water, generally in June or July.

Size
Approximately 5 cm in length.

Physical Characteristics
The three-spine stickleback has a very slender caudal peduncle and squarish tail fin. It is a stout fish, being about 1/4 as deep as it is long. It's most distinguishable characteristic is the number of dorsal spines, of which there are usually three, occasionally four, and rarely five. The first two spines are usually much larger, and each has a small triangular fin membrane. Three-spine stickleback are deep greyish, olive, or greenish-brown above, or sometimes blue. They are paler and often have silvery reflections on the sides and silvery bellies. The fins are pale, but fin membranes often are red. During breeding season, males turn a reddish-colour along the belly. In females, the whole body, except the top of the back, may be reddish. Also at this time, the back turns brownish with transverse bands, and the sides develop brassy reflection.

Habitat Type
The stickleback can live in shallow brackish water, and at sea, but is chiefly a fish of inland streams and ponds. Usually inhabits vegetated areas in streams, or estuaries with mud or sand bottoms.

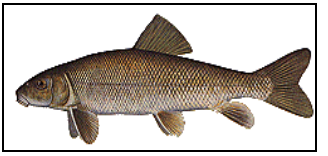
Potential Causes of Mortality
See Appendix E
Local examples:
- Pesticide run-off
- Elevated water temperature



(Source: Inland fish species of New Brunswick)

White Sucker
Catostomus commersoni

Common Name
White Sucker



(Source: unknown)

Life History
White suckers spawn in the spring, usually from May to June, migrating upstream to spawning areas (small streams and tributaries) when water temperatures are 10–18 °C. Suckers typically spawn in shallow gravel riffles where the water is up to 30 cm deep and where the flow is moderate. Lake populations of white suckers with limited access to streams will occasionally spawn on gravel shoals where there are waves. The young remain in the gravel for one or two weeks and then migrate downstream, at which time they are 12–17 mm in size. Sometimes only 3% of white sucker eggs survive to this stage. Young suckers in lakes are found along shorelines with sand or gravel bottoms. In streams they prefer sand and gravel shallow areas with moderate currents.

Size
Average size is 46 cm but they can grow to 63 cm and weigh more than 3.2 kg.

Physical Characteristics
The white sucker is a robust cylindrical, torpedo-shaped fish, round to oval in cross section. The fish is distinguished by its sucker-like mouth, which is located on the underside of its blunt, rounded snout. The mouth has thick lips covered with little fleshy bumps (papillae). The colour on the back, top of the head, upper sides to below the eye are grey, copper-brown, through brown to almost black on the lower sides and ventral surface of the head. The belly is cream to white.

Habitat Type
The white sucker can adapt to a wide range of environmental conditions but generally lives in the warm, shallow waters of lakes and quite rivers. In streams they are most abundant in pool areas with

ample underwater debris. In lakes they are found in the upper 6–9 metres, moving to the shallows to feed.



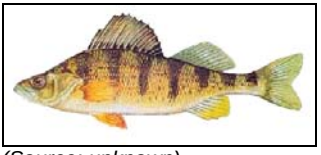
(Source: Inland fish species of NB)

Potential Causes of Mortality
See Appendix E
Local examples:

- Extreme dissolved oxygen and pH fluctuations
- Discarded as by-catch

Yellow Perch
Perca flavescens

Common Name
Yellow Perch



(Source: unknown)

Life History
Yellow perch spawn from April through July at water temperatures ranging within 9–12 °C. Young perch grow quickly and remain near the shore during their first summer, swimming in large schools that often include other species. Adults move in schools farther offshore than the young. They move between deeper and shallow water in response to changing food supplies, seasons, and temperatures.

Size
Typically less than 30 cm in length.

Physical Characteristics
Yellow perch have an elongate body, with green to olive-brown or golden-brown back. Their sides are yellow to yellow-green, with dark vertical stripes (usually 7). The lower fins are usually red to orange.

Habitat Type
The yellow perch is a schooling, shallow water fish that can adapt to a wide variety of warm or cool habitats. These fish can be found in large lakes, small ponds, or gentle rivers but are most abundant in clear, weedy lakes that have muck, sand, or gravel bottoms.

Potential Causes of Mortality
See Appendix E



(Source: Inland fish species of New Brunswick)

References

Department of Maine Marine Resources: Species Information. www.maine.gov/dnr/rm/speciesinformation.htm

Froese, R. and D. Pauly (eds.), 2004. *FishBase*. World Wide Web electronic publication.www.fishbase.org, version (12/2004).

Inland Fishes. Government of Newfoundland and Labrador. 20 February 2005 http://www.gov.nl.ca/env/wildlife/ourwldlife/animals/inlandfish

Inland Fishes of New Brunswick. Curry, R. A. and G. P. Yamazaki. Dec. 2001. University of New Brunswick, Biology Department. 20 February 2005 www.unb.ca/fredericton/science/biology/fish_key

NOAA. www.nefsc.noaa.gov/lineart/

Nova Scotia Department of Agriculture and Fisheries. Species Factsheets. 2001 http://www.gov.ns.ca/nsaf/sportfishing/species/brn.htm

Page, M. and B.M. Curry. 1991, *A field Guide to Freshwater Fishes*. Houghton Mifflin Company. Boston, MA, 432 pp.