Fish Kill Reporting and Investigation Manual

For use in investigation of possible breaches of the ***Environmental Protection Act 1994*** and ***Fisheries Act 1994***

November 1998

QUEENSLAND GOVERNMENT

Department of Environment and Heritage

Contents

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Introduction

This manual is a guide for staff of agencies with a role in responding to reports of fish kill incidents in Queensland waters.

The Department of Environment and Heritage (DEH), under its lead agency role for all environmental management matters in Queensland, is required to respond and investigate fish kill incidents. Other key agencies involved in fish kill investigations are local governments, the Department of Primary Industries (DPI) including the Queensland Boating and Fisheries Patrol (QBFP), and the Queensland Fisheries Management Authority (QFMA).

Fish kills are often very visible to members of the community. As the events are also associated with environmental degradation they expect a prompt and professional investigative response from agencies with a role in environmental management. An effective investigation of fish kills needs a prompt response, since water flows and dead fish decay, resulting in early loss of vital information.

This manual is a guide to communication, investigation and reporting protocols for agencies responding to advice of a fish kill. It is designed to assist in:

- achieving a prompt response to all reported incidents;
- establishing prompt communication and co-ordination between agencies to ensure that where possible the agency best able to respond in a particular locality is advised of an incident;
- documenting of initial information and subsequent on-site survey and data collection in accord with a standardised and orderly procedure by whichever agency responds to a reported incident;
- providing timely progress reports and factual information to other agencies which have an interest in investigating fish kills;
- consultation between agencies to reach agreement on whether the likely cause of specific fish kill incidents can be determined on the basis of information available, or whether further investigative work is required, and to agree on the roles and responsibilities of each agency in that further task;
- reaching consensus concerning specific fish kill incidents in regard to follow-up resource management action; and
- collecting and centralising storage of data about fish kill incidents in Queensland to assist future research and better management of the environment.

The manual describes response and investigation processes to ensure:

- collection of statistically robust data and the recording of observations which may help determine the likely cause(s) of a fish kill incident; and
- proper preservation of samples for subsequent chemical analysis, and the dissection of fish to obtain tissue for histopathological examination.

It also notes the most common causes of fish kills and a set of recognised relationships between on-site observations and environmental conditions way might result in a fish kill.

The manual is arranged in three parts:

- Part A is an overview of fish kills, their causes, stages of investigation and channels of communication.
- Part B is a step-by-step protocol for conducting a fish kill investigation.
- Part C comprises appendices of scientific and technical information to assist in fish kill investigations, contact names and addresses for advice and assistance, and names and addresses of appropriate persons/ organisations to be notified.

The manual was compiled with the assistance of staff of the Fisheries Group of the Queensland Department of Primary Industries.

Part A General guidelines

1 Intended users

This manual is presented by the Department of Environment and Heritage under its lead agency responsibility for environmental management.

It was developed for staff of DEH and other agencies such as DPI and local governments who may be called on to respond rapidly to reported fish kill incidents. The manual gives a guide to procedures to be followed in the investigation of a 'fish kill' in Queensland waters.

A rapid response to all reported fish kills is necessary to collect factual information and where appropriate additional data and samples for analysis which are pertinent to the subsequent documenting and investigating of the reported event.

2 Fish kills definition

2.1 Definition of a fish kill

A 'fish kill' is a significant and sudden death of fish or other aquatic animals such as crabs or prawns.

Such events are characterised by large numbers of aquatic animals dying over a short time, usually in a clearly defined area.

2.2 Causes of fish kills

Published scientific research shows that in Australia and overseas fish kills due to natural causes are common and most are likely to have been occurring for a long time (Nowak 1996). However, some fish kills are due to human impacts on the natural environment.

Examples of fish kills in Australia due solely to natural causes are the deaths of large numbers of fish in tropical rivers with the breaking of drought and the onset of the wet season (Bishop 1980; Brown *et al.* 1983; Hart *et al.* 1987; Townsend 1994). With the first storms, large amounts of plant matter accumulated over the dry season are carried into waterways by runoff water. The bacteria and fungi of decomposition immediately begin to break down this organic matter. In the process, their respiration consumes most of the dissolved oxygen from the water, resulting in mass mortality of fish through suffocation. Similarly, many fish kills in Queensland are associated with normal seasonal weather changes — extremes of cold and warm weather can result in mass fish deaths, since fish and most other aquatic organisms lack the means of regulating their body temperatures.

Fish kills attributable to human causes are often associated with discharges or spillages of potentially toxic chemicals. However, a common but more subtle phenomenon is degradation of a natural waterway by interference in the natural flow and the build-up of excessive nutrients which results in the development of stagnant conditions and excessive growth of aquatic plants and/or algae. This stresses fish due to reduced oxygen concentrations during overcast weather when the rate of oxygen production by plants (photosynthesis) is reduced or at night when photosynthesis ceases but algal and plant respiration continues. Where algal and plant growth is excessive, their respiration at night can deplete the available dissolved oxygen sufficiently to result in a fish kill.

Fish under stress as a result of human activities may be more susceptible to harm from natural disturbances such as temperature change and disease.

2.3 False fish kills

Some observations and reports of fish kill incidents, particularly where small numbers are involved — fewer than 50 or 10kg total — are found to comprise discarded catches. These 'false fish kills' are often characterised by the presence of net or hook injuries.

2.4 Reasons for investigating

All fish kills should be investigated so knowledge of the causes of significant and sudden mortalities in fish populations can be improved and, where human impacts are involved, follow-up action can be taken to reduce the possibility of future fish kills.

3 Glossary of technical terms

See appendix 6.

4 Investigation process overview

4.1 Responsibility and actions

Since some fish kills are the consequence of human actions and may indicate activity which has resulted in environmental harm, all fish kills require investigation to determine whether a breach of the *Environmental Protection Act 1994* or the *Fisheries Act 1994* might have occurred.

Response actions and channels of communication are shown in the flowchart (fig.1).

4.2 Investigative steps

The investigation of a fish kill incident is initiated with the reporting or discovery of an event. It proceeds through the data-gathering and evaluative steps of:

- acquiring the initial report and all relevant data from observers;
- surveying the site and collecting data and samples;
- reporting on completion of on-site survey and the storage/forwarding of samples for analysis;
- analysis and interpretation of data and the results of sample analysis; and
- follow-up investigations and initiating other actions.

4.2.1 Need for urgency

Preliminary investigations including any collecting of samples must be carried out without delay. This minimises problems which result from the decay of dead fish and changes to water quality which can occur in a very short time. Such changes can affect the reliability of sample analysis and make determining the conditions contributing to the cause of death of affected organisms more difficult. In addition fish kill sites attract birds and other predators which can result in a loss of vital information.

4.2.2 Need for constant preparedness

To ensure constant preparedness to respond without delay to a reported fish kill incident, all authorities such as DEH and DPI Regional and District Offices and local governments should buy and keep basic fish kill response kits in strategic locations. A kit ensures immediate availability in one place of all essential items required to conduct an on-site survey when a fish kill is reported. Appendix 1 lists a suggested minimum kit. These can be bought at cost from the Scientific Assessment Section, Division of Environment, DEH, Brisbane.

All investigations should be conducted impartially observing sampling protocols and keeping accurate written records at every stage of the investigation. The cause of a fish kill cannot be determined until all relevant data are collected and the results of sample analyses interpreted.

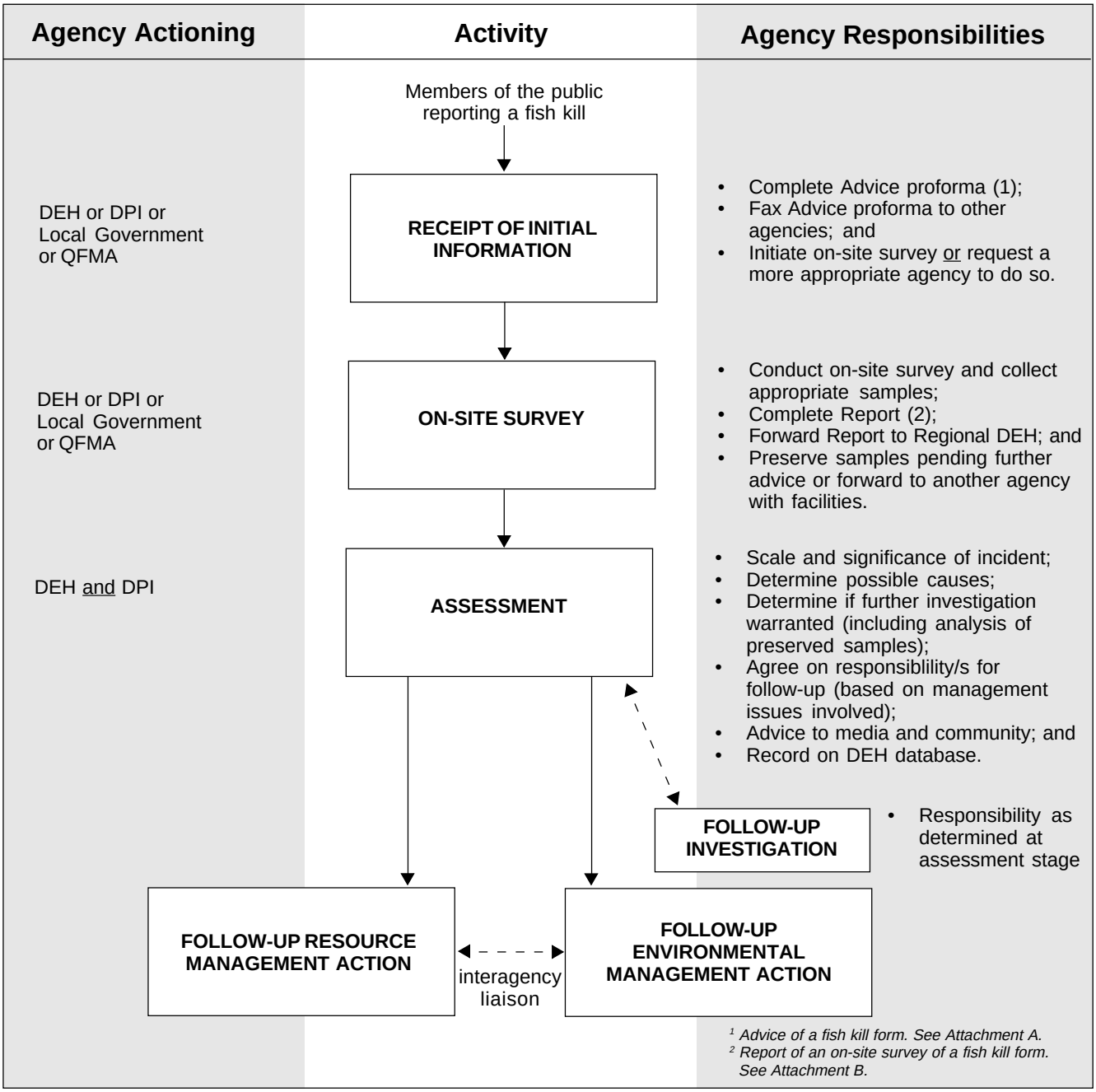

Figure 1. *Responsibilities and actions flowchart.*

Standard procedures should be followed. This ensures unbiased and accurate information on all indicators of interest is recorded for future reference. This also ensures that where follow-up action is indicated, for example a prosecution, lack of credibility does not prejudice the outcome. If departure from standard procedure is unavoidable for any reason, this should be recorded so it can be considered when data are interpreted.

See Part B for further details of sampling and investigative procedures.

4.3 Channels of communication

Fish kills are often very 'visible' events which can attract the attention of media and cause concern among anglers and other members of the public. Observers often regard such occurrences as evidence of pollution and/or lack of environmental safeguards on the part of government.

A number of organisations, media and members of the public have a legitimate interest in fish kill incidents, their investigation and follow-up. Accordingly, providing timely, factual information to all interested parties throughout the investigative process is important. Only statements based on conservative and factual information should be made to media and bodies outside of the official investigation.

There is a risk of giving incomplete and contradictory information to the media if there is more than one channel of official comment concerning the progress of a fish kill investigation. To avoid this problem, DEH will act as the sole reporting agency regardless of which agency's staff are actually on the ground conducting the investigation. Accordingly, any media releases concerning a fish kill incident under investigation should be channelled through DEH. After the cause of an incident has been determined, any media releases concerning follow-up action relating to the incident are a matter for the agency managing the follow-up action. For example, in the case of a fish kill determined to have resulted from inappropriate fishing practices, DPI (Fisheries Group) manages follow-up and is responsible for communication to other interested parties.

An overview of agreed channels of communication and responsibilities about an investigation, reporting and follow-up of all reported fish kill incidents is given in fig.1.

Part B Fish kill investigation

Overview

Figure 2 is a checklist of essential stages in responding to a reported fish kill.
A description of what is involved in each stage follows.

Checklist for responding to a fish kill incident

Check preliminary data available
Advice of a fish kill incident form:
– location
– access
– names and contacts (including possible samples taken)
– conditions at site (now and previous)
– extent of incident

Notify other interested parties
– local government (according to incident location)
– DPI Fisheries (Regional Manager, Fisheries)
– DEH (Regional Manager, Environment)
– fax copy of a completed *Advice of a fish kill incident* form

Visit site
– take fish kill kit, icebox with ice, camera, notebook
– check accuracy of preliminary data, amend as necessary

Collect evidence of possible environmental factors
– collect basic water quality data — temperature, DO, pH, conductivity/salinity (use meters or collect water samples)
– collect water samples for nutrient analysis

Collect evidence of possible contamination factor
– collect water samples (solvent washed and acid washed bottles)
– collect sediment samples (solvent washed and acid washed jars)
– collect fish samples (whole, newly dead or affected if possible)
– collect plankton samples (Lugol's solution)

Collect evidence of possible disease factor
– collect whole fish, store on ice (do not freeze)
– collect and preserve organs (gill bars, livers, kidneys, stomachs and contents)

Complete report from on-site investigation
– Complete *Report of an on-site survey of a fish kill incident* form
– send samples for analysis
– preserve other samples

Notify other interested parties
– local government (according to incident location)
– DPI Fisheries (Regional Manager, Fisheries)
– DEH (Regional Manager, Environment)
– DEH Scientific Assessment Section
– fax copy of a completed *Report of an on-site survey of a fish kill incident* form

Figure 2. *Investigative steps checklist.*

5 Action on receipt of initial notification

As evidence is likely to deteriorate rapidly, an initial response investigation must be commenced without delay. This action should occur as soon as possible after the receipt of notice that a fish kill has occurred by one of the three agencies listed below.

Capability to respond will be enhanced by ensuring well-maintained basic fish kill response kits are available at strategic locations.

When a fish kill is reported, all pertinent information should be obtained from the reporting party. Details should be entered on the *Advice of a fish kill incident* form (Attachment A).

Incidents involving deaths of other aquatic organisms which do not fit the strict definition of 'fish' including animals such as turtles, dugong, crabs, whales, dolphins and seabirds should be responded to similarly.

5.1 Communication to interested parties

The agency receiving the initial notification and completing the advice form is responsible for advising the other nominated agencies. This should be done initially by telephone, followed by a facsimile of the completed form.

In the region where a fish kill has occurred, this advice should be sent to:
– Regional Manager (Environment), DEH;
– Industry Manager (Fisheries), DPI;
– Chief Executive Officer, local government.

They are representatives of key government agencies with responsibilities under the *Environmental Protection Act 1994* for maintaining water quality. The Industry Manager (Fisheries) also has responsibilities under *Fisheries Act 1994* s125.

Contact addresses, telephone and fax numbers for each of the above are given in appendix 7.

5.2 Launching the initial investigative response

5.2.1 Small kills

Fish kills reported as involving fewer than 25 fish will not normally warrant a response other than recording the incident on the advice form and notifying interested parties.

Exceptions to this are:
- any recurring situation, for example if modest numbers of fish were reported as dying on each of a series of successive days. Such reports should be checked to ensure they are not repeat or hearsay reports of a single minor incident;
- all incidents involving rare or protected species, which should be responded to as being of significant size (see 5.2.2 below);
- all reported strandings and/or deaths of other aquatic species such as cetaceans, pinnepeds, dugongs and turtles. These should be responded to as documented in the *Action plan for marine animal strandings, entanglements and oil spill responses* held in each DEH Regional Centre; and
- all incidents involving oil spills. These should also be responded to as documented in the *Action plan for marine animal strandings, entanglements and oil spill responses*. If the spill has occurred in tidal waters within the limits of a port, the Regional Harbour Master should be notified. If otherwise, the DEH Regional Centre should be notified.

5.2.2 Kills of significant size

All such incidents should be investigated. The stages of investigation and responsibilities for investigation are detailed below.

A decision on which agency should launch the initial investigation will depend on the location of the incident, its reported scale, and the availability of agency resources to respond promptly.

If the incident appears to be significant and an offence under Environmental, Conservation or Fisheries legislation is suspected (for example pollution has occurred), the requirements of gathering data (evidence) for subsequent court proceedings should be considered. This is detailed below. If legal action is possible, then officers with appropriate training and credentials should be involved in the investigation from an early stage. However, local unavailability of such persons does not reduce the necessity of an immediate response before vital evidence becomes unobtainable (see sections 4.2.1 and 4.2.2).

Response action by DEH

All things being equal, the initial response will be launched by DEH. This responsibility may be waived by the Regional Manager (Environment), DEH, if another agency has the capability of reaching the site quickly and indicates a willingness to launch the response. In such cases the Regional Manager (Environment), DEH, must be kept informed of the progress of the investigation.

Response action by other agencies

If the agency receiving the initial report can provide expertise closer to the fish kill site than DEH, then that agency can take the initiative to launch the response. However in such cases the Regional Manager (Environment), DEH, must be notified by the responding agency and kept informed of the progress of the investigation.

Combined DEH/agency response action

In some cases, for example in large scale incidents involving more than 1000 fish and several kilometres of waterway, or multiple sites, a co-ordinated interagency response may be appropriate. Such an exercise would normally be co-ordinated by DEH.

5.3 On-site survey

The purpose of the on-site survey is to collect and document factual information about the site and size of the incident, and to collect samples pertinent to determining potential water quality and pathological causes.

A record should be made of all observations and actions taken using the *Report of an on-site survey of a fish kill* form (Attachment B). All activities at the site during the survey should be noted for including in a subsequent report to DEH. This includes particulars of witness statements, details of measurements made, photographs taken, samples collected and their subsequent storage or dispatch for analysis.

5.3.1 Public relations

During this stage of the investigation representatives of the media may arrive on the scene. Curious members of the public may also be attracted to the site.

Media representatives should be advised to seek further information from the DEH Regional Director or the Minister's office.

The most senior investigating official at the site should act as spokesperson and confine comment to the readily observable and indisputable facts. No investigating official should speak beyond their knowledge of the facts.

No opinion should be expressed about the seriousness or possible cause of the incident. This may compromise subsequent legal action if an offence has been committed (see section 5.5).

Observers should be asked to help the investigation by not interfering with or avoidably entering the site which may prejudice the investigation by, for example, moving fish or stirring up sediments. See section 5.3.2 about using official volunteers to help with on-site work.

5.3.2 On-site assistance (volunteers)

To assist the investigation, the on-site senior investigating officer may seek the participation of bystanders in a voluntary capacity. In doing so, the responsible officer must first provide a briefing to ensure that tasks and duties are explained clearly and given in such a way that the volunteers can demonstrate that they understand what they are to do and how they are to do it.

This briefing should ensure that:

- the welfare of volunteers is taken into account at all times;
- all relevant aspects of the Workplace Health and Safety Act are complied with;
- recording and administrative procedures are followed so all legal, health and safety requirements are met; and
- all aspects of the volunteer agreement are met including the signing of a DEH volunteer registration form (Attachment C).

5.3.3 Site identification

Cadastral maps and distances and directions from reference points should be used to record the exact location and extent of the fish kill site. If a site has to be revisited by others for subsequent, more intensive investigations, this information is essential.

5.3.4 Site description

All matters possibly involving the fish kill should be recorded. These include weather conditions, means of access, and observations such as the presence of people, vehicles, discoloured water and sediments, indications of dumping, discharges, scums and odours.

5.3.5 Photographs

Photographs should be taken of the site, evidence of dead or affected fish and other organisms, and any other material suspected of being associated with the fish kill. These include discoloured water and sediments, indications of dumping, discharges and scums. The date, time and location of sequential photographs and the name of the photographer should be recorded.

5.3.6 Witnesses

A statement should be taken from any person at the scene who may have pertinent information. Their identity should be established and statements signed and witnessed.

5.3.7 Quantifying the fish kill

The extent of the affected water and the numbers and variety of fish and other organisms affected should be estimated. Statistically sound estimates should be made using transects and other reliable methods (See appendix 2).

Numbers, species and size ranges of affected fish should be quantified and estimates made of the proportions of each species and size class involved based on sound statistical sampling methods.

If affected fish cannot be identified in the field, specimens can be preserved for identifying by experts later.

5.3.8 Water quality testing and sampling

This task should be completed as far as possible in a way that minimises bottom disturbance and before fish and sediment samples are taken.

On-site testing and sampling should be conducted in the 'kill zone' and unimpacted areas. Establishing 'control' or 'background' conditions in unaffected portions of the waterway is an important factor in attributing the cause of a fish kill incident. For example, in flowing water, upstream and downstream testing and sampling should occur. Similarly, testing and sampling should occur at a range of depths and across the extent of the area to characterise water quality at the scene adequately.

Replicated testing and multiple sampling is necessary to establish statistically robust quantification of conditions at the fish kill site. The minimum replication of a measurement or sample for any statistical analysis is three. The confidence that can be placed on the reliability of measurements made or samples taken to be representative of a situation depends heavily on the number of replicate measurements or samples available. Accordingly, many replicate measurements and samples should be taken, particularly if legal proceedings may follow. Collecting and storing of samples is relatively inexpensive whereas additional sampling later may be invalid. Taking, preserving and storing many samples enables additional samples to be analysed if results from an initial batch of analyses are inconclusive (see appendix 3 and QDEH *Water Quality Sampling Manual,* provided in standard DEH fish kill kits).

At sites where tributary streams or drainlines enter a main channel, each should be tested and sampled.

On-site testing and collection of water samples should cover the following water quality parameters known to be pertinent to maintaining healthy fish:

- water temperature (measured on-site, at surface, mid-depth and bottom)
- dissolved oxygen
- pH
- conductivity
- turbidity

} *preferably measured on-site, at surface, mid-depth and bottom if appropriate instruments available. Alternatively by subsequent laboratory measurements on collected samples.*

- chemical contamination, commonly free chlorine, ammonia, heavy metals, pesticides and herbicides (samples needed for laboratory analysis, except for chlorine which can be measured in the field with a test kit).

On-site measurements should be made and water samples taken, preserved and handled in accord with QDEH *Water Quality Sampling Manual*. An overview is in appendix 3.

Toxic dinoflagellates and toxin-producing blue-green algae (cyanobacteria) are sometimes implicated in fish kills. Any attached or floating algal-mat material should be sampled. In addition, since many potentially toxic blue-green algae do not readily form obvious mats or scums, these can best be sampled by drawing an algae collecting net through the water column. Algal samples can be preserved for up to 24 hours in the dark on ice (not frozen) or indefinitely by adding formalin or Lugol's iodine. These reagents (or chemicals) are supplied as a component of the recommended fish kill kit (see Appendices 1 and 3). Such a sample can be used for microscopic analysis to identify the algae present and to estimate their concentration, a key factor in assessing their contribution to the fish kill incident.

Any environmentally foreign material such as scums or suspected discharge material should also be sampled for analysis. Where appropriate, samples should be taken of any material photographed if suspected to be associated with the fish kill (see section 5.3.4).

5.3.9 Sampling sediments and other potential contaminant indicators

Where the possibility of chemical contamination is a factor, sediment and aquatic vegetation samples and aquatic animals such as molluscs (preferably affected but not dead) should also be collected. Frequently these are able to accumulate contaminants which would be difficult to detect in the water column due to limitations of analytical techniques. Similarly they may act as indicators of irregular contamination events which may not be present in the water column at the time of sampling.

The sampling of sediments is particularly important when reporting or an investigative response is delayed. Dead fish might have been removed or decayed and their evidence lost, and tides and currents might have swept away contaminated water, but sediments retain detectable traces of many contaminants for a considerable time. In addition, many contaminants break down rapidly in water, but persist in the sediments.

If contamination is a possible factor, the investigation of a fish kill is incomplete without sampling of sediments.

Sediment samples should be taken, preserved and handled in accord with QDEH *Water Quality Sampling Manual*. An overview is in appendix 3.

For a relatively recent incident, the top few millimetres of sediment are most likely to contain evidence of relevant contamination.

If sediments are sent for analysis of organic contaminants such as pesticides, then quantification of the total organic carbon fraction of the sediments must also be requested. Without this information, comparison with environmental guidelines or comparison between sites is difficult.

The need for replication of samples also applies to sediment sampling. Individual sediment replicates should comprise at least 500g. Note also that separate containers are needed for sediment samples which are to be analysed for heavy metals and organics such as pesticides.

5.3.10 Observation and sampling of affected fish and invertebrates

Samples of biota from a fish kill site can be of considerable value in determining the cause/s of the incident. These samples can be used to establish the presence of potentially toxic contaminants in the tissues, damage to specific organs associated with specific environmental conditions, the role of disease through the presence of lesions or other histopathological signs in organs, or to eliminate possible causes by the absence of indications.

The appearance and behaviour of affected fish and invertebrates could provide useful clues as to the cause of the fish kill. Examples of possible significant changes in appearance in fish at an incident site are colour changes or darkening, bleeding from body orifices, ulceration and the appearance of parasitic fungal growths. Unusual behaviour of fish at an incident site which are worth recording include loss of equilibrium, convulsive action or spasms such as gaping of the gills, arching of the spine or extreme forward-opening of fins, surface gulping of air, listlessness, and the production of mucus. These signs should be recorded, and quantified if they affect only a portion of those observed. Appendix 5 gives a check list of observable attributes of the environment and fish behaviour at a fish kill incident and explanations of the phenomenon.

Fish and benthic macro-invertebrates such as molluscs and worms should be collected. Wet-sieving of sediments (500µm) could be required for the latter. Specimens which are still alive or freshly dead are most suitable for analysis. Due to the effects of bacterial degradation, fish in an advanced state of decay are of limited value for analysis.

At least 100g of whole fish is required for a heavy metal analysis and at least 250g for organics such as pesticides. Replication of samples is also required to give credibility to any result. Therefore, six fish (three for heavy metals, three for organics) are required but, for preference, more should be taken (see replication and sample size section 5.3.7). If the fish are small, larger numbers need to be collected to achieve the minimum weight requirements for each analysis. These can be bulked for preservation and labelling. For example, a minimum of three 100g bags of fish are needed for a reliable heavy metal analysis.

Fish samples should be preserved as described in QDEH *Water Quality Sampling Manual*. Note that specimens for metal and organic analyses require separate packaging to avoid contamination. This information is reproduced in appendix 3.

If tissues are sent for analysis of organic contaminants such as pesticides, then quantification of the lipid fraction of the tissues must also be requested. Without this information, comparison with environmental guidelines or comparison between sites is difficult.

Several fish, preferably newly dead and free from decay, should be used to provide samples for histopathological examination. If possible these should be dissected on-site to provide gill arches, livers and kidney tissues, fixed in 10 percent formalin. If unavoidable, whole fish can be chilled (not frozen) and dissection carried out off-site. A guide to dissection is in appendix 4.

Accurate labelling of all samples is essential, as is identification on the site map of where within the site specific samples were collected. A samples list should be provided in the report.

5.4 Sample storage and processing

Whether samples are to be forwarded immediately for chemical or histopathological analysis, or held pending further investigation and advice, they should be preserved and packed consistent with guidelines provided in QDEH's *Water Quality Sampling Manual*, and summarised in appendix 3.

Samples may have to be sent on ice to another location for storage if adequate facilities are not available locally. If samples require freezing for preservation but dry ice or a deep freeze is not available at a remote location, a freezing-mixture can be made from crushed ice and ordinary household salt. (One cup of bulk salt to one litre of crushed ice is effective). This maintains temperatures well below freezing until it melts.

Proper storage of samples is essential since due to natural water movements and rapid deterioration of dead fish, later re-sampling may not be useful. Taking samples which may not be needed for subsequent investigation is better than to make further investigation impossible because insufficient samples were taken.

Samples forwarded for storage elsewhere or to a laboratory for analysis should always be securely labelled, each bearing a unique identification number assigned at the point of collection to avoid subsequent confusion between samples.

A written record of samples taken, including place and time of sampling, the taker, and subsequent storage and/or movement of samples, is essential. This should be recorded on the on-site report.

Notification of despatch should be given to the receiving laboratory or storage facility to ensure samples are given prompt and proper attention on arrival. Advice on packaging and labelling, and the use of chain-of-custody procedures (appropriate where the results of sample analysis may be needed as evidence in legal proceedings) are given in QDEH Water *Quality Sampling Manual.*

Details of where samples are stored or forwarded for analysis should be recorded in the report.

5.5 Steps required if court action may eventuate

If pollution or some other offence under environmental, conservation or fisheries legislation is suspected, officers with appropriate training and credentials should be involved from the earliest possible stage of investigations.

Each step of investigation under sections 5.3 and 5.4 above should be conducted in such a way that the accuracy of observations and sources of information cannot be compromised by uncertainty:

- All statements taken should be in writing, signed and witnessed.
- Locations and times of all observations should be recorded in writing in a notebook without erasion. Corrections can be made only by ruling out mistakes and writing in correct information. Blank spaces should not be left in notes.
- The source of any samples collected should be recorded without ambiguity, samples should be clearly and indelibly labelled, and use made of seals and chain-of-custody sheets to reduce the possibility that samples could be substituted or tampered with.

- Measurements of physico-chemical parameters such as temperature and pH, and storage and handling of samples should be consistent with procedures in QDEH *Water Quality Sampling Manual*.

6 Follow-up actions

Follow-up actions to the initial investigation of a fish kill incident are required for:

- determining where possible, on the basis of the evidence available, the cause/s of the fish kill incident. If the scale of the incident on the basis of environmental/ economic harm warrants, a more in-depth investigation to determine the cause/s with more confidence may be needed;
- documenting all data and conclusions reached to ensure that they are available to assist in the investigation of future incidents;
- reporting and communicating to other agencies and the community on the outcome/s of the investigative process; and
- remedial follow-up where appropriate. This could take the form of initiating research into the cause/s of substantial and recurring fish kill incidents which cannot be explained on the basis of evidence available, negotiation with catchment managers to upgrade ambient water quality, or punitive action against polluters.

These actions should occur conjointly by DEH and DPI and any other agency which is an interested party in the specific circumstances of a fish kill incident.

6.1 Determining the cause/s

The investigation of a fish kill is essentially a forensic task. Data collected must answer one or more of three basic questions:

– What is the manner of death — natural or otherwise?
– What is the mechanism of death — asphyxia, toxicosis or septicaemia?
– What is the underlying cause of death — the sequence of events?

In some cases, data collected during the initial investigation will provide valid answers to these questions, for example seasonal evaporation of a confined waterbody might have resulted in gross habitat deterioration. In other cases valid answers will depend on the results of chemical analysis of samples. In some cases no satisfactory answer will be available without additional expert investigation, justified only by the scale of the incident.

Many causative factors are inter-related, and several can occur in a typical fish kill incident together or in sequence. Local weather conditions before the fish kill, the time of day when the incident occurred, whether the deaths occurred catastrophically or over an extended period, whether fish of only a particular size range or species are involved, and a history of similar events in the same location or elsewhere in similar circumstances are important indicators of the potential role of contributing factors.

In many cases several explanations may be plausible if only a single attribute is considered in isolation. Fish deaths that continue at a low rate over an extended period may be due to a marginal environment, the presence of a low-virulence infective agent or chronic exposure to sub-lethal concentrations of a potentially toxic material. Low dissolved oxygen concentrations may be due to a wide variety of causes including the presence of an algal bloom, the collapse of an algal bloom, contamination by a discharge of organic material, a stratification breakdown resulting in the upwelling of de-oxygenated water, or overcrowding of fish in a waterbody which is drying up.

A single event may create a range of factors, each of which has the potential to create conditions resulting in a fish kill. For example, a release of water from a storage dam may involve a surge of bottom water low in oxygen, a stirring of sediments resulting in excessive turbidity and/or a release of organically rich material leading to oxygen depletion as a result of rapid bacterial breakdown.

The investigator/s must keep an open mind and consider all known circumstances and all available evidence in reaching a conclusion based on probability. At the starting point all possible causes can be listed. A rigorous process of checking and elimination can result in a short list of possibilities.

The following subsections outline generally accepted causes of a fish kill incident and related attributes of the environment and affected fish. The check list in appendix 5 is also a guide to interpreting the situation.

6.1.1 Lack of oxygen

Low dissolved oxygen (DO) concentrations can cause suffocation of gill-breathing aquatic organisms. This is one of the most common causes of fish kills. The critical minimum concentration varies with species.

The main response by fish is gasping at the surface in an effort to force oxygen across the gills, and some species can survive this way for many hours.

The potential causes of a lack of dissolved oxygen are numerous, but are usually due to depletion of oxygen by other organisms such as algae and/or submerged aquatic plants (particularly at night or in overcast weather) or bacteria in the presence of organic matter. Possible scenarios leading to low DO in Queensland waterways are:

- discharges of organic matter which can lead to depletion of oxygen day and night;
- discharges of nutrients which stimulate growth of aquatic plants or algae, leading to depletion of oxygen by respiration at night or during overcast weather; and
- removal of oxygen by the chemical reaction when dissolved iron is flocculated in waters affected by acid sulfate drainage (see 6.1.3).

6.1.2 pH stress

Fish have limited tolerance to abnormal pH concentrations. This can result from acid or alkali spills, contaminated runoff or industrial effluents.

Low pH associated with drainage from acid sulfate soils is a common cause of fish kills in disturbed estuarine and coastal situations. Toxic effects can also result from the mobilisation of aluminium and heavy metals from soils into acid sulfate drainage water, and gill and skin damage may be evident in exposed fish. ‘Red spot disease’ which causes body lesions on fish is a common condition in fish exposed to drainage from acid sulfate soils (see 6.1.3).

Recovery from low pH can also cause fish deaths as a result of metals such as iron dissolved in acidic water becoming insoluble and resulting precipitates clogging gills, leading to suffocation (see 6.1.1).

High pH can result from runoff waters contacting lime or fresh concrete, for example the use of lime after an acid spill can result in a fish kill.

6.1.3 Acid sulfate drainage

Draining of coastal wetlands or disturbing of soils formerly coastal wetlands and containing sulfur compounds can lead to a condition known as acid sulfate drainage. Soils or sediments with this potential are called acid sulfate soils and are common in much of coastal Queensland.

The oxidation of naturally occurring iron sulfides in these soils and sediments after mechanical disturbance produces sulfuric acid, which can drain off in large amounts, particularly after rainfall, or following tidal inundation. The immediate effect of this acid runoff is to lower the pH, producing the toxic effects described under 6.1.2 above.

In addition the acidic conditions can dissolve metals such as aluminium and iron and potentially toxic heavy metals such as cadmium from the sediments, resulting in fish deaths from metal toxicity.

When pH returns to normal further downstream, the excess iron dissolved in the acidic water flocculates forming a cloudy, rust-coloured material which can coat vegetation and block fish gills. The flocculation process also uses up dissolved oxygen which can lead to suffocation of fish (see 6.1.1).

Potential acid sulfate drainage situations are found frequently in coastal areas where the surface elevation is less than five metres. The problem of sulfuric acid formation and runoff arises when such areas, which are frequently waterlogged in their natural state, are drained for agriculture or other development. This exposes the iron sulfide layers to the air allowing rapid oxidation. The problem can be made worse if iron sulfide-rich soil is excavated and spread on the surface adjacent to drainage works. Effects can last for 100 years or more, and are often worse after droughts as a result of the watertable being lowered and large amounts of iron sulfide exposed and oxidised. In these circumstances, drought-breaking rains can carry substantial amounts of sulfuric acid and dissolved metals into waterways.

Acid drainage waters are often deceptively ‘clean’ in appearance since one result of acidification is reduced turbidity. However, measured pH during active runoff can show a highly acidic environment. Investigators should be aware that the flushing of such waters can be very irregular, driven by storm events and tidal cycles, so that measurements of pH taken at a later time might reveal nothing abnormal.

6.1.4 Excessive plant growth

Aquatic plants, including algae, share many of the basic attributes of terrestrial plants. One of these is that during daylight hours, oxygen is produced by photosynthesis and consumed in respiration. However, only consumption of oxygen occurs at night since photosynthesis requires an input of light energy. Accordingly although aquatic plants can produce an excess of oxygen over consumption during the day, potentially they can deplete it at night to concentrations lethal to fish.

Excessive plant growth (including algae), symptomatic of excessive nutrient concentrations in waterbodies, can cause fish kills through supersaturation of oxygen during the day (excess oxygen is toxic to fish), or fish kills due to oxygen depletion at night.

These events occur more commonly during warm weather when plant growth is stimulated. Algal ‘blooms’ (green water) may be associated with excess oxygen by day and insufficient oxygen by night.

Excessive plant growth (including algae) can also result in reduced oxygen during periods of die-off which result in large amounts of dead organic matter decaying in the water. Oxygen is consumed by the high numbers of bacteria in the decay process.

6.1.5 Rain and runoff

Rainfall sufficient to produce runoff often results in organic debris reaching waterbodies. This promotes rapid bacterial decay and resulting oxygen depletion problems as noted under 6.1.1.

Runoff can also carry accumulations of potentially toxic material into waterways. This can include such materials as chemical spills, acid from acid sulfate soils, accumulated oils from roadways, and soil contaminated with pesticides from agricultural operations.

6.1.6 Sediment disturbance

Sometimes, bottom sediments accumulate large quantities of nutrient-rich organic matter but cause no problems in the overlying water since contact between the water and the organic matter is limited. However, if the sediments are disturbed by increased flow or other means, the material can become mixed into the water column and result in rapid bacterial decay and resulting oxygen depletion problems as noted under 6.1.1.

6.1.7 Contamination by chemicals

Fish death is often very rapid and there is little or no physical evidence. The chemical may be lost rapidly from the water column and be undetectable in it by the time of investigation. Accordingly, heavy reliance must be placed on residue analysis, particularly of affected fish, other biota and sediments which can accumulate, retain and integrate irregular exposures.

Since the more commonly used and persistent pesticides in urban and heavily farmed areas produce background levels, samples away from the 'kill-zone' must be taken for comparison with those at the fish kill site itself.

Landuse adjacent to the fish kill site is an important consideration if contamination, chemical or otherwise, is suspected. For example, agricultural land such as cotton may be associated with the use of pesticides/herbicides and application can be seasonal. Sewage and other outfalls are a potential source of contaminants. The presence of factories, landfills and feedlots also indicate possible sources.

The presence or absence of phytoplankton may indicate the role of a herbicide.

Contamination by heavy metals may be associated with abnormal pH. Acidic conditions are often associated with the release of heavy metals from soils and sediments. The possibility of drainage from acid sulfate soils should be considered in areas where development works are disturbing soils in areas known to have this problem (see section 6.1.3). Low pH can cause problems for fish through the precipitation of hydroxides (for example ferric hydroxide) on the gill surfaces when pH returns to normal.

6.1.8 Excessive turbidity

Fish adapted to waters of low turbidity can be adversely affected by sudden increases in suspended solids. Gills can become clogged with particulate material, or in some cases injured by abrasive particles.

Some high turbidity problems are the result of algal blooms.

6.1.9 Water temperature

Exposure to water temperatures beyond the range of tolerance of a species is a potential cause of fish kills, particularly in small waterbodies. Extreme weather conditions may be associated with such events.

6.1.10 Salinity changes

Rapid salinity reductions such as after a major storm 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 incursion of saline water into a comparatively freshwater environment.

The evaporation of confined water bodies can raise salinity levels beyond the tolerance of trapped fish.

6.1.11 Parasites and diseases

Fish are subject to a variety of bacterial and viral infections and to a range of parasitic infestations. These are most often a secondary cause of fish kills in fish already stressed by other environmental factors such as physical or chemical degradation or crowded conditions. Sometimes lesions and haemorrhages are indicators of the presence of disease, but these may not be present.

In the course of a disease outbreak in fish the numbers affected can increase over days or weeks to a peak.

Histopathological examination of fresh or appropriately preserved tissue samples is necessary to determine the presence of disease.

6.1.12 Toxic algae

A number of blue-green algae (cyanobacteria) and dinoflagellate species are potential producers of toxins under circumstances which are not well understood. Many of these toxins are acutely toxic to fish.

6.1.13 Sunburn

White lesions on the top of the head accompanied by cloudless weather and very clear water are an indicator of this problem.

6.1.14 Gas bubble disease

Gas bubble disease is characterised by the presence of bubbles of gas in the blood vessels. Death results from blockage of blood supply to vital organs. The bubbles are easily visible in the fins and on the head, and are also present in the gills and behind the eyes. The cause is supersaturation of dissolved gases in the water, usually as a result of high energy, for example flow over a spillway, or heated water discharges from power station operations.

6.1.15 Hydrogen sulfide (H_2S)

Release of H_2S is usually the result of a disturbance of thermal stratification or disturbance of anoxic sediments (from natural causes such as weather conditions or human causes such as release of water from a dam), or collapsing algal blooms. The smell is very characteristic (rotten eggs). Larger fish are usually affected first. A pathological sign is dark brown gill filaments due to the formation of sulf-haemoglobin.

6.1.16 Ammonia

Un-ionised ammonia NH_3 and ionised ammonia NH_4^+ are found in a ratio depending largely on pH and to a lesser extent on other factors. The un-ionised form is potentially toxic to fish, and its proportion relative to the ionised form increases with pH. Sources include fertilisers, organic pollution, collapsing algal blooms, overcrowding of fish and industrial effluents.

6.1.17 Lifecycle related

Some fish species make seasonal migrations for breeding. Sometimes they die after spawning. In other cases their journeys can expose them to stressful environmental conditions. Such fish kills would be confined to single species.

6.1.18 Trawl bycatch

In areas where netting and trawling occurs, some reported 'fish kills' are found to comprise bycatch from these activities. Such fish are likely to have injuries and comprise mainly undersized commercial species or unpalatable species which have been discarded. Apart from evidence of tell-tale injuries, local knowledge should be sought about recent fishing activity in the area.

6.2 Site clean-up

This requires a case-by-case assessment considering factors such as whether all necessary investigations are complete to the point where they will not be compromised by site disturbance and removing evidence, the location and quantity of dead fish and other animals on-site, environmental risks such as the consumption of contaminated carcasses by other animals, and public risk including health and nuisance.

6.2.1 Leaving site as found

This option could be appropriate in a remote location or if attempts to retrieve dead fish such as in densely vegetated areas are impractical. An assessment needs to be made as to whether natural scavengers are present in the area in sufficient numbers. Small quantities of dead fish, particularly trawl bycatch on open beaches, can be left for subsequent tides to remove.

6.2.2 Burial of carcasses near site

This option would be satisfactory in most situations, provided that a hole of sufficient size and depth is made to ensure carcasses will not be uncovered by scavengers.

6.2.3 Assistance by local governments

Local governments normally have procedures for removing dead animals. This can involve use of private contractors. The local government in the area in which the incident has occurred should be advised of assistance required, using the contact numbers listed at appendix 7.

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Part C
Scientific and technical supplement

Appendix 1

Basic fish kill response kit contents

Item	Purpose
list of fish kill kit contents	contents check prior to use
Fish kill reporting and investigation manual	guide to fish kill response and use of the kit
Water Quality Sampling Manual (QDEH 1995)	environmental sampling protocols
large icebox	transport and preservation of samples
roll of weatherproof packaging tape	seal icebox and sample containers
tape measure	to assist site description, etc.
disposable camera	photographic evidence and site ID
notebook, waterproof pen, pencil	recording site observations
waterproof marker and 50 spare plastic labels	labelling of samples as required
thermometer	measure water temperatures
sweep net	collection of fish samples
20 large, 20 small self-sealing plastic bags*	wrapping of fish samples for metals analysis
aluminium foil (10m)	wrapping of fish samples for pesticide analysis
six 1L amber glass solvent-washed sample bottles*	water samples for organics/pesticide analysis
six 1L plastic or glass acid-washed sample bottles*	water samples for inorganics/metals analysis
six 250mL plastic bottles*	water samples for nutrient analyses (N & P)
six 250mL airtight glass bottles*	water samples for DO analysis
six 375mL screw top SW glass jars*	sediment samples for organics/pesticide analysis
six 375mL screw top AW glass jars*	sediment samples for inorganics/metals analysis
10 100mL jars with 10% buffered formalin*	preservation of tissue samples for histopathology
100mL Lugol's iodine	preservation of samples for algae identification
50mL manganous sulfate solution	preservation of water sample for DO analysis
50mL alkaline iodide-azide solution	preservation of water sample for DO analysis
plastic cutting board	dissection for histopathology samples
scalpel (disp. blades)	dissection for histopathology samples
scissors	dissection for histopathology samples
forceps	dissection for histopathology samples
four sets of disposable latex gloves	safe handling of contaminated samples
roll of paper towelling, bottle of Hibitane	disinfect and clean up
indicator strips (pH)	measure water pH

**items with blank labels affixed*

Appendix 2

Quantifying a fish kill using transects

Many fish kills will be too large to count all fish affected. In these situations an estimate of numbers affected can be made by selecting a set of representative smaller portions called transects, counting the affected fish in each of these, and then using this information to calculate an estimate of the total size of the fish kill.

The underlying approach in using transect sampling is that the sample units are areas, selected at random, in which affected fish are counted. The areas (transects) chosen should be of practical size for field counting of affected fish, not overlap, and be representative of the affected area.

The method of allocating transects will vary according to the situation. In general, the more transects used the more accurate the final estimation should be (a minimum of three transects is essential, and if possible enough transects should be used to ensure that at least 5 percent of the estimated affected fish are counted). Other factors affecting the outcome are how representative the transects are of the overall situation and the accuracy in measuring transects and counting affected fish. Avoid over-estimation due to the clumping of floating dead fish from the effects of winds and currents.

Decide on the positioning of the transects independently of any apparent distribution of dead fish, for example, to deliberately choose transects to include only areas where large numbers of dead fish are gathered would result in a serious over-estimation.

The following figures and sample calculations, adapted from Reynolds and Scribner (1986), illustrate approaches which may be adopted for some typical situations. These cover fish kills along narrow streams, shoreline counts along the edges of wide waterbodies, and fish kills across open waters.

Results from these estimations can be made more statistically robust by using more elaborate sampling methods such as stratified random sampling (American Fisheries Society 1992).

Estimation in a narrow stream

The size of transects and the distance between them depends on the length of stream over which the fish kill occurs. The following scale is suggested:

- >5km stream length — use 100m transects at 1km intervals;
- 2–5km stream length — use 50m transects every 0·5km;
- 0·5k–2km stream length — use 10m transects every 100m;
- <0·5km stream length — count at least three transects accounting for at least half the affected area.

Choose a starting point at least a quarter of the way along the fish kill, and count at least three transects at equally spaced intervals. For example in fig.3 which illustrates a fish kill 5km long, fish are counted in each of three transects 100m long (c-d, e-f, and g-h) and spaced 1km apart.

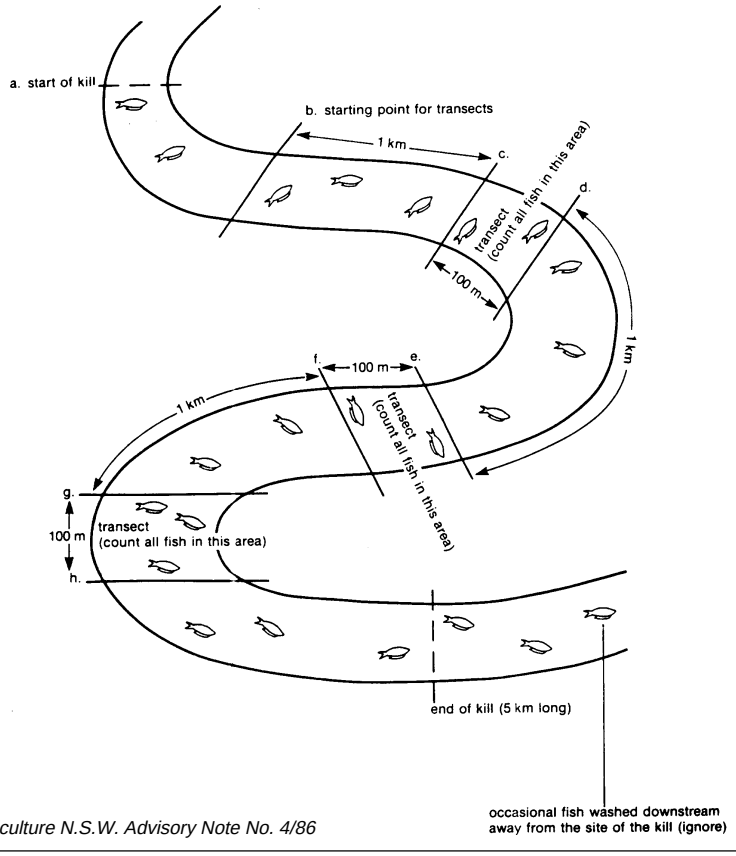
The estimated size of the fish kill can then be calculated as:

$$\text{Total numbers of fish killed} = \text{Sum of counts in transects} \times \frac{\text{Total length of fish kill}}{\text{Sum of lengths of transects}}$$

In this example, if 720 dead fish were counted in transect (c-d), 320 in (e-f) and 103 in (g-h), the total number of fish killed is estimated as:

$$(720+320+103) \times \frac{5000\text{m}}{300} = 1143 \times 16.7 = 19\,100$$

If a portion of the affected area has a high density of dead fish and another only scattered dead fish, this approach may be refined by counting each portion as if it were a separate fish kill with its own set of transects and then totalling the result.



Source: Department of Agriculture N.S.W. Advisory Note No. 4/86

Figure 3. *Suggested counting procedure for a fish kill in a narrow stream.*

Estimation in lakes and wide rivers or estuaries
If dead fish are found only along the shoreline, divide the shoreline into transects using a procedure similar to that for narrow streams described above. See fig.4.

For counting across an area of open water, a set of parallel transects of equal width should be chosen. The width of each transect should not be greater than can be observed from a boat traversing the transect, possibly 10m (see fig.5). If the current is appreciable, the transects should be at right angles to the direction of flow.

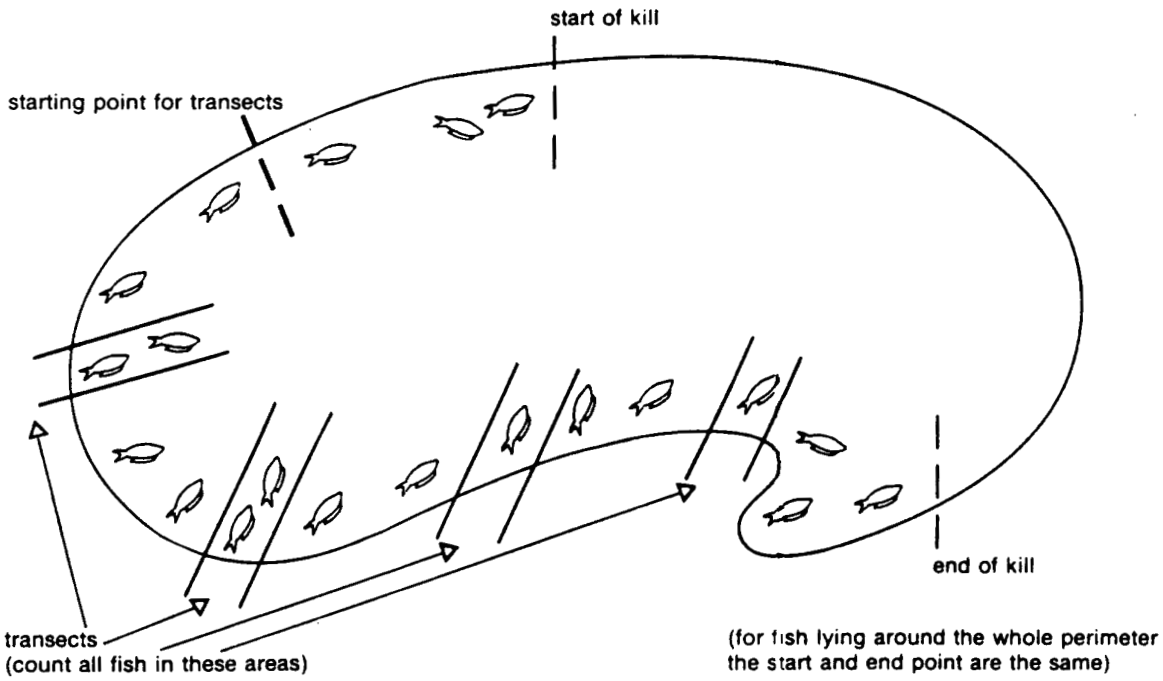
The position of the first transect is chosen at random and the rest of the transects located at equal distances apart to cover the area affected by the fish kill. For example, for three transects, the distance between transects is one-third of the length of the affected area, and for four transects, one-quarter of the affected length.

All dead fish within each transect should be counted, and the length of each transect recorded.

In general, the more transects used the more accurate the final estimation will be (a minimum of three transects is essential, and at least 5 percent of the estimated affected fish should be counted). Other factors affecting the outcome are how representative the transects are of the overall situation and the accuracy in measuring transects and counting affected fish. Avoid over-estimation due to the clumping of floating dead fish from the effects of winds and currents.

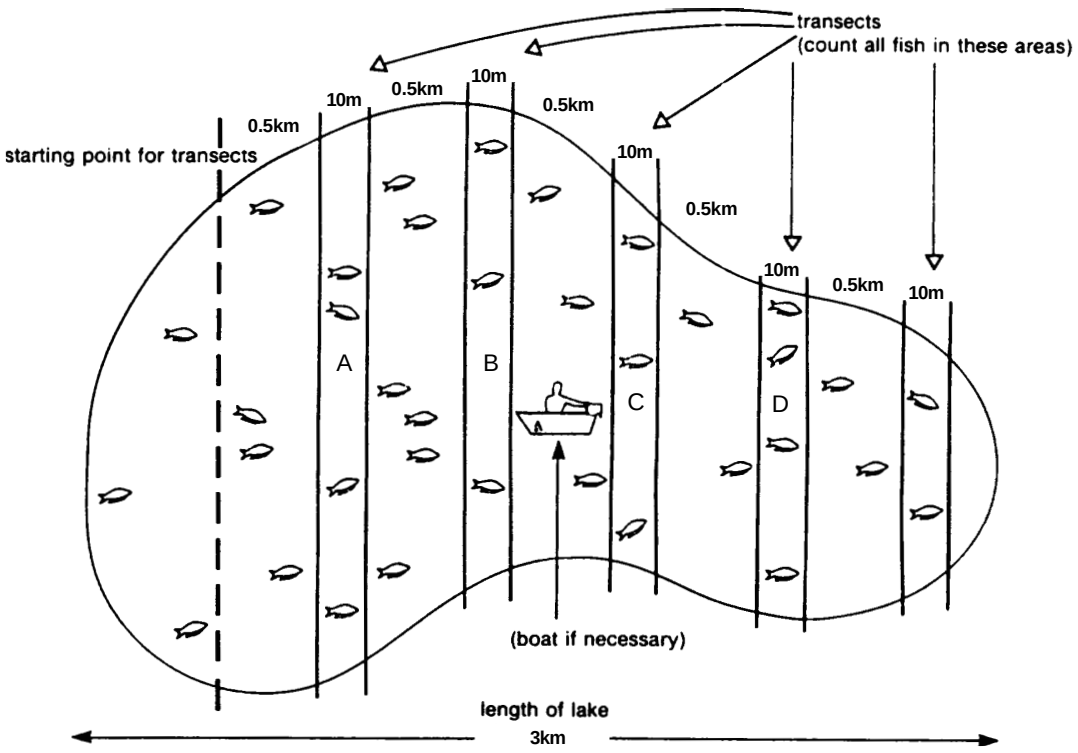
Decide on the positioning of the transects independently of any apparent distribution of dead fish. For example, to deliberately choose transects to include only areas where large numbers of dead fish are gathered would result in a serious overestimation.

Normally each transect would extend across the waterbody from water edge to water edge. However, if dead fish along the shoreline are counted in addition to open water counts, the open water transects should terminate at the outer edge of the shoreline count transects to avoid 'double-counting'.



Source: Department of Agriculture N.S.W. Advisory Note No. 4/86

Figure 4. *Suggested counting procedure for counting dead fish along a shoreline.*



Adapted from: Department of Agriculture N.S.W. Advisory Note No. 4/86

Figure 5. *Suggested counting procedure for fish kill over open water (Diagram not to scale).*

As an example of open water estimation, using fig.5 which illustrates a fish kill in a lake 3km long, fish are counted in each of five transects 10m wide (A, B, C, D, E) spaced 500m apart.

The estimated size of the fish kill can then be calculated as:

$$\text{Total numbers of fish killed} = \text{Sum of counts in transects} \times \frac{\text{Total area of fish kill}}{\text{Width of transects} \times \text{Total transect length}}$$

In this example, if 520, 350, 280, 190, and 330 dead fish were counted in individual transects, the total length of transects was 4500m and the area of the lake 450ha (4 500 000sq.m), the total number of fish killed is estimated as:

$$(520 + 350 + 280 + 190 + 330) \times \frac{4\,500\,000}{10 \times 4500}$$

$$= 1670 \times 100$$

$$= 167\,000$$

If a portion of the affected area has a high density of dead fish and another only scattered dead fish, then this approach may be refined by counting each portion as if it were a separate fish kill with its own set of transects then totalling the result.

Appendix 3

Sample preservation and storage

The QDEH *Water Quality Sampling Manual* describes preservation, transportation, storage and handling procedures for a wide range of environmental samples. Those procedures are appropriate for samples collected as part of a fish kill investigation. However, under field conditions, some instrumentation and equipment might not be available immediately to initial investigators. In these circumstances, an immediate sample should be taken by the initial investigators. This may not be ideal for analysis but it is better than postponing sampling and risking loss of vital evidence.

If legal proceedings are a possible outcome of an incident, particular attention should be taken with records of collection, labelling, use of prescribed containers and methods of preservation, and chain of custody records. See also section 5.5.

The personal safety advice given in the *Water Quality Sampling Manual* is equally applicable to the investigation of fish kills.

The following points summarise the correct handling of samples covered in the *Water Quality Sampling Manual*, and provide additional advice on the preservation of samples from a fish kill site:

- In the absence of a dissolved oxygen meter, a water sample for later analysis can be taken in a clean bottle. This bottle should be filled gently to avoid aeration. No air bubble should be trapped beneath the cap. The sample should be stored in the dark (or wrapped in aluminium foil) and kept cool (but not frozen). If available at the site, Winkler's reagents[1] should be added as preservatives. These are provided in the recommended fish kill kit. These will produce an orange-brown or white precipitate depending on the amount of dissolved oxygen present. The sample bottle should now be sealed without retaining an air bubble.

- Samples which are to be analysed chemically for the presence of organic contaminants (for example pesticides) should be stored in solvent-rinsed glass containers. Where this is not practical, for example plant or animal material, including fish, the sample can be stored in a plastic bag provided that it is first wrapped in aluminium foil to keep it out of contact with the plastic.

- All samples should be kept in the dark and on ice to minimize deterioration.

- Most samples can be preserved for an extended period (weeks to months) by freezing, but in the case of biotic material (for example fish or crabs) they must not be allowed to thaw before reaching the analytical laboratory.

- Samples which are to be used for histopathology can be kept on ice, but they must not be frozen. However, these can be preserved with 10 percent buffered formalin[2] in a suitable glass or plastic container, in which case they need no other protection. This is provided in the recommended fish kill kit (see appendix 1).

- Water samples taken for identifying microscopic algae, including blue-green algae must not be frozen. However, these can be preserved with 2 percent of Lugol's solution[3] in a suitable glass or plastic container, in which case they need no other protection. This is provided in the recommended fish kill kit (see appendix 1).

[1] *The two Winkler's solutions to be added to a water sample to preserve dissolved oxygen for subsequent titration analysis are:*
1·5mL aqueous manganous sulfate solution
(480g $MnSO_4.4H_2O$, or 400g $MnSO_4.2H_2O$, or 364g $MnSO_4.H_2O$/L);
1·5mL aqueous alkaline iodide-azide solution
(500g NaOH and 135g NaI /L, then add 10g NaN_3 in 40mL water).

[2] *Formalin is an aqueous solution of formaldehyde gas. A 10% formalin solution contains 100g formaldehyde/L. To make buffered formalin, add 3g of borax and 50mL of glycerine/L of formalin. To preserve marine organisms, use of seawater (or 35g/L of common salt) in the formalin dilution may give better results in some cases.*

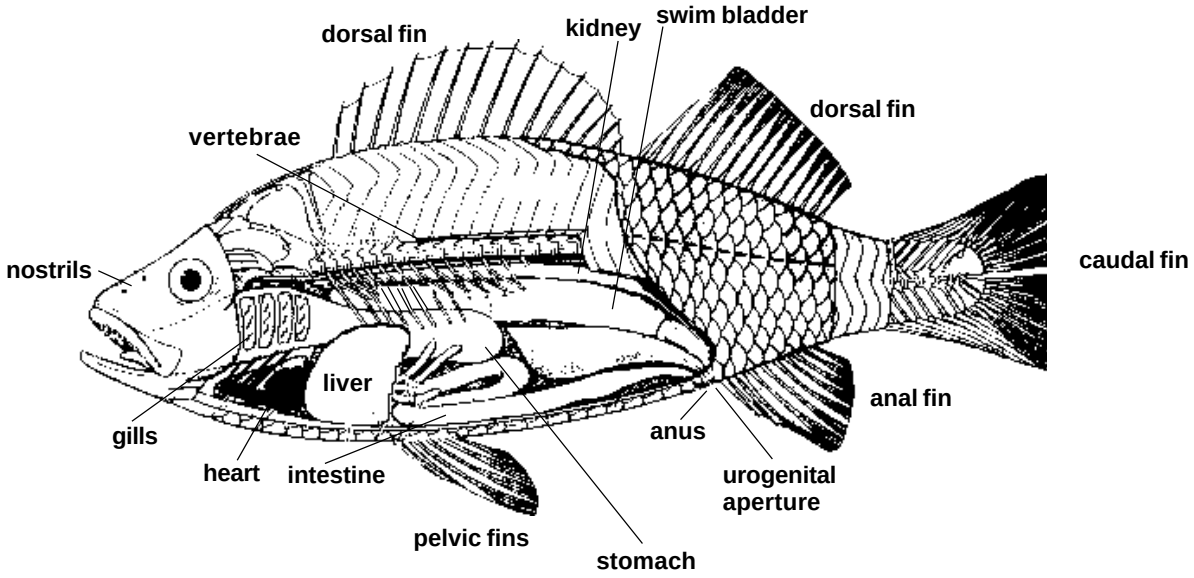
[3] *Lugol's solution is made by mixing the following ingredients in the proportions shown. The mixed solution should be stored in the dark.*
10g pure iodine
20g potassium iodide
200g distilled water
20mL glacial acetic acid

Appendix 4

Dissection of fish to obtain samples for histopathological examination

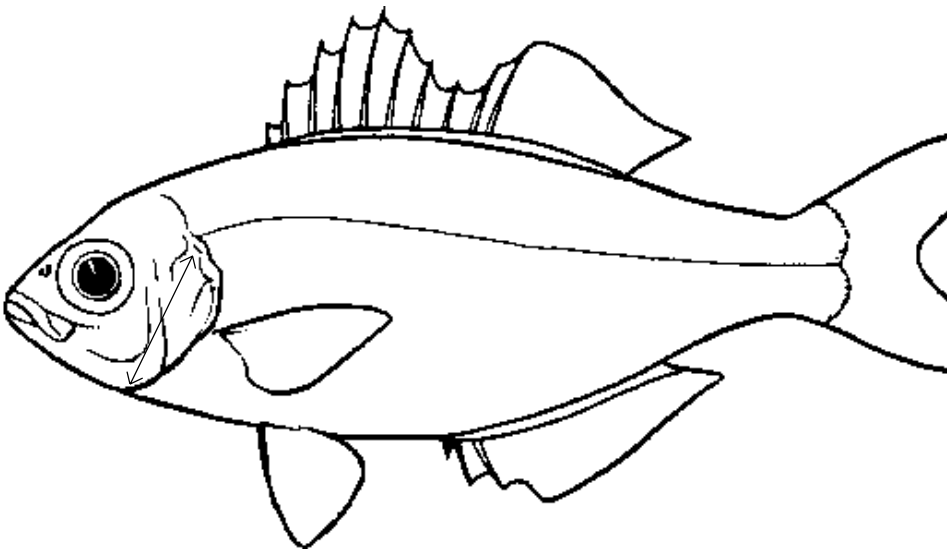
Note: To avoid cross-contamination of samples, sterile equipment should be used for dissections. It should be re-sterilised before changing from one sample to the next.

Basic internal organ structure of a fish

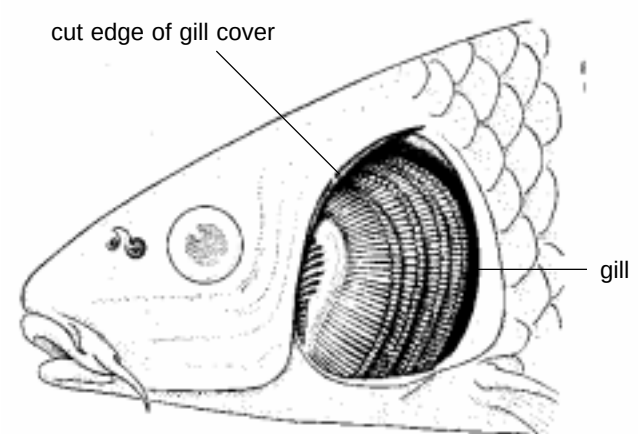


Steps in dissecting a fish to get organ samples

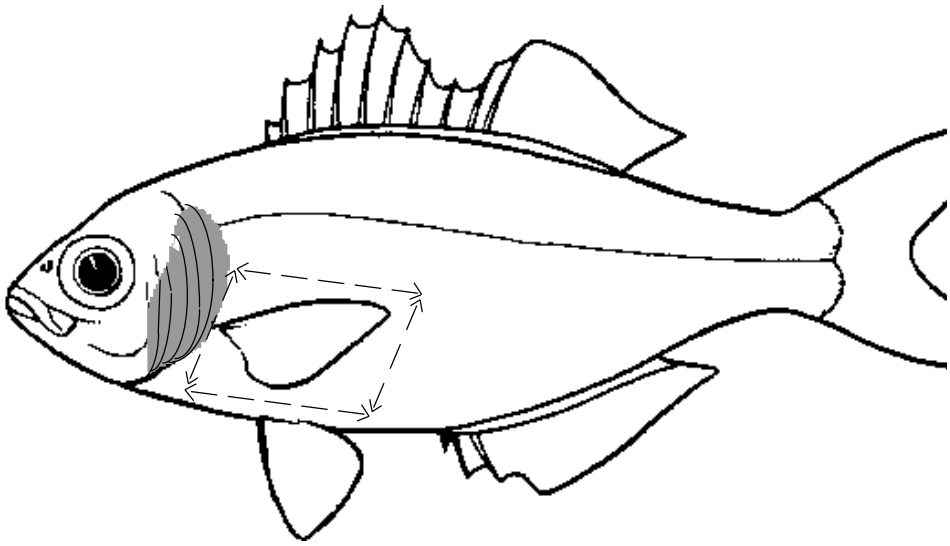
1 Cut off gill cover as shown to expose the gills.



2 Cut out and preserve an entire gill bar for histopathological examination.



3 Cut out a side panel as shown to expose the internal organs. **Start cut forward from anus** to avoid puncturing the intestine.



4 Remove sections of liver and kidney and preserve for histopathological examination. Refer to first diagram to aid identifying organs. The kidney is located between the swim bladder and the vertebrae.

5 Samples of other tissues which have an abnormal appearance, including lesions, and the stomach with contents may also be worth removing and preserving.

Appendix 5

This appendix provides three tables of indications as a guide to interpreting observations made at a fish kill site. They should be used with caution since they may not apply to every situation.

Table 1. *Fish kill causes — interpretation guide: Physical signs*[1]

Physical signs associated with fish mortality	Cause of mortality		
	Oxygen depletion	**Toxic algal bloom**	**Pesticide toxicity**
Behaviour of affected fish	Gasping and swimming at the surface	Convulsive, erratic swimming, lethargy	Convulsive, erratic swimming, lethargy. If organophosphate toxicity, pectoral fins may be thrust forward to extreme position
Species selectivity of kill	None if total depletion, some species tolerant of partial depletion	None	Usually one species dies before others, depending on pesticide concentrations and sensitivity of species present
Size of fish affected	Large fish die first	Small fish die first	Small fish die first
Time of fish kill	Night and early morning	Only during hours of bright sunlight	Any time, day or night
Dissolved oxygen	Less than 2mg/L	Very high, often supersaturated, especially near surface	Normal range
Water pH	6·0–7·5	9·5 and above	7·5–9·0
Water colour	Brown, grey or black	Dark green, brown or golden, often with a musty odour	Normal colour and no abnormal odour
Algae and plankton abundances	Algae dying, few zooplankton present	Abundance of one algal species, few zooplankton present	If insecticide — no zooplankton, but algae present; If herbicide — algae may be absent

[1] *Adapted from Meyer and Herman (1990).*

Table 2. *Fish kill causes — interpretation guide: Environmental conditions*[2]

Condition	Possible cause
Fish (usually larger fish) come to the surface and gulp air, and water has low dissolved oxygen (less than 2ppm)	• Organic matter has depleted the dissolved oxygen. Look for source of organic input: sewage treatment plant, feedlot, algal bloom, run-off rich in organic debris (especially after extended period without rain)
Fish (usually larger fish) come to the surface and gulp air, but water has adequate dissolved oxygen	• Dissolved oxygen may have been temporarily depleted, but is now recovered. Look for sources of organic input (as above). • Ammonia may have reached toxic concentrations, • Toxic algal bloom (especially if water discoloured) • Free chlorine at toxic concentration (especially if gills or scales bloody, and sewage treatment plant nearby)
Fish are dying after heavy rain	• Pesticides or other chemicals might have been washed off adjacent land. • Potentially toxic or organically rich sediments could have been resuspended
Water surface has an oily sheen	• Petroleum leak or spillage from pipeline, truck, refinery, service station
Water conductivity is abnormally high	• Discharge of brine or salt water incursion in near estuarine areas
Water conductivity is abnormally low	• Discharge of storm water or fresh water incursion in near estuarine areas
Water has low pH, with or without orange discolouration of substrate, but good water clarity	• Acidic discharge • Acid mine drainage • Drainage from acid sulfate soil
Only dead fish along shoreline, and air temperature unusually cold	• Fish killed by low temperature
Many small fish dead downstream of a dam	• Fish killed by passage through dam gates or hydroelectric turbines • Gas bubble disease • Release of bottom water with low dissolved oxygen
Many small fish dead downstream of an industrial plant which discharges heated water	• Thermal shock
Kill is restricted to one species or size-class	• Spawning stress • Disease • Schooling in poor quality water

[1] *Adapted from American Fisheries Society (1992).*

Using an intepretation key for fish kill causes

This key to fish kill causes is designed to lead you through a series of questions and answers to a likely cause. Each question gives two possible answers (observations) about the incident you have observed. Only one can be correct. This directs you to another question and so on until you arrive at a likely cause of the fish kill.

The key can work only if you follow the directed questions and answers in sequence.

Always start at question 1 (which gives the options Kill occurred in less than 24 hours … which if true, directs you to question 2 or Not known when kill occurred, or kill continued for longer than 24 hours … you go to question 16).

If you arrive at question 2, you are directed to question 3 or question 8, depending on the time of the kill. If you arrive at question 16, you are directed to question 17 or 23 depending on whether all observed fish are dead or not.

Table 3. *Fish kill causes — interpretation key*[3]

1	Kill occurred in less than 24 hours	2
	Not known when kill occurred, or kill continued for longer than 24 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 2ppm	7
	Dissolved oxygen 2ppm 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 enrichment	
	Algal cells absent ➪ Oxygen depletion due to algicidal substance	
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 spill	
15	pH 6.0 to 7.0 ➪ Oxygen depletion	
	pH below 6.0 ➪ Lethal low pH/heavy metal poisoning/mine or acid sulfate 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 (human 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 haemorrhagic	30
	Lesions haemorrhagic ➪ Possible bacterial or viral disease	
30	Lesions as small discrete bodies or masses in tissues	31
	Lesions appear as gray, 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	

[3] *Adapted from Meyer and Herman (1990)*

Appendix 6

Glossary

acid sulfate soil	Potential acid sulfate soils are waterlogged soils in coastal areas. When they are exposed to the air as a result of excavation or other disturbance, oxidation of iron sulfide occurs, forming sulfuric acid which can be washed into waterways after rainfall.
algae (algal)	Any chlorophyll-containing plant belonging to the phyllum Thallophyta. This includes seaweeds and various non-vascular freshwater plants, and a large number of microscopic species, many of which are single-celled.
algal bloom	A term used to describe a large-scale population increase in an algal species.
biochemical	A chemical process which occurs in the cells of living tissue.
blue-green algae	Despite the name, these are not algae but a type of photosynthetic bacteria. An alternative name for these is 'cyanobacteria'. Individual organisms are too small to be visible to the naked eye, but it is common for blue-green algae to form chains or clumps which discolour the water or form a visible scum.
cetacean	A large aquatic mammal of the grouping which includes whales and dolphins.
dinoflagellate	A common form of microscopic algae which forms very obvious blooms under ideal conditions. These are sometimes called 'red tides' and can be toxic to fish or contain toxins which make fish and shellfish which eat the algae dangerously toxic to human consumers.
flocculate	A form of chemical precipitate which has a cloud-like appearance in the water.
haemorrhagic	Bleeding.
herbicide	A chemical which kills plants or inhibits their growth.
histopathology	Examination of body tissues for evidence of disease.
lesion	Wound.
organism	Any form of plant or animal life.
parasite (parasitic)	An organism which lives in or on another species without benefit to the host.
pectoral fins	The pair of side fins on a fish immediately behind the head which correspond to the forelimbs of higher vertebrates.
photosynthesis	A natural biochemical process in plants and algae in which carbon dioxide is absorbed and converted to carbohydrates (for example sugar or starch) for use as food by the plant. Sunlight provides the energy for this process and oxygen is released as a byproduct. It can only occur during daylight hours.
phytoplankton	Plant species of plankton.
pinneped	A large marine mammal of the grouping which includes seals and sea lions.
precipitate	A substance which comes out of solution, because it is no longer sufficiently soluble, or is the insoluble product of a chemical reaction in the water.
plankton	Very small, often microscopic, aquatic plant and animal life.
respiration	A natural biochemical process in plants and animals which produces energy from carbohydrates. Oxygen is consumed and carbon dioxide is a byproduct. It occurs 24 hours a day in plants and animals
zooplankton	Animal species of plankton.

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McKinlay Shire Council
Burke Street
PO Box 177
JULIA CREEK QLD 4823
(07) 4746 7166 fax (07) 4746 7549

Mareeba Shire Council
65 Rankin Street
PO Box 154
MAREEBA QLD 4880
(07) 4030 3900 fax (07) 4092 3323

Maroochy Shire Council
Currie Street
PO Box 76
NAMBOUR QLD 4560
(07) 5441 8211 fax (07) 5441 8338

Maryborough City Council
431–433 Kent Street
PO Box 110
MARYBOROUGH QLD 4650
(07) 4123 8888 fax (07) 4123 1470

Millmerran Shire Council
2–16 Campbell Street
PO Box 42
MILMERRAN QLD 4357
(07) 4695 1399 fax (07) 4695 1563

Mirani Shire Councd
20 Victoria Street
PO Box 1
MIRANI QLD 4754
(07) 4959 1101 fax (07) 4959 1275

Miriam Vale Shire Council
36 Roe Street
MIRIAM VALE QLD 4677
(07) 4974 5100 fax (07) 4974 5328

Monto Shire Council
51A Newton Street
PO Box 216
MONTO QLD 4630
(07) 4166 1155 fax (07) 4166 1066

Mornington Shire Council
Mission Road
c/o Post Office
GUNUNA QLD 4871
(07) 4745 7200 fax (07) 4745 7275

Mt Isa City Council
23 West Street
PO Box 815
MT ISA QLD 4825
(07) 4744 4200 fax (07) 4744 4227

Mt Morgan Shire Council
32 Hall Street
PO Box 15
MT MORGAN QLD 4714
(07) 4938 1022 fax (07) 4938 1192

Mundubbera Shire Council
28 Lyons Street
PO Box 6
MUNDUBBERA QLD 4626
(07) 4165 4101 fax (07) 4165 4803

Murgon Shire Council
cnr Gore and Stephens Streets
PO Box 115
MURGON QLD 4605
(07) 4168 1499 fax (07) 4168 2627

Murilla Shire Council
cnr Marian and Dawson Streets
PO Box 144
MILES QLD 4415
(07) 4627 1355 fax (07) 4627 1782

Murweh Shire Council
95–101 Alfred Street
PO Box 63
CHARLEVILLE QLD 4470
(07) 4654 1055 fax (07) 4654 1960

Nanango Shire Council
48 Drayton Street
PO Box 10
NANANGO QLD 4615
(07) 4163 1307 fax (07) 4163 1729

Nebo Shire Council
10 Reynoids Street
PO Box 21
NEBO QLD 4742
(07) 4950 5133 fax (07) 4950 5245

Noosa Shire Council
6 Pelican Street
PO Box 141
TEWANTIN QLD 4565
(07) 5449 5200 fax (07) 5447 1062

Paroo Shire Council
cnr Stockyard and Louise Streets
PO Box 75
CUNNAMULLA QLD 4490
(07) 4655 1777 fax (07) 4655 1647

Peak Downs Shire Council
Conran Street
PO Box 117
CAPELLA QLD 4702
(07) 4984 9311 fax (07) 4984 9618

Perry Shire Council
Heusman Street
PO Box 12
MT PERRY QLD 4671
(07) 4156 3155 fax (07) 4156 3214

Pine Rivers Shire Council
220 Gympie Road
PO Box 5070
STRATHPINE QLD 4500
(07) 3205 0555 fax (07) 3205 4658

Pittsworth Shire Council
87 Yandilla Street
PO Box 99
PITTSWORTH QLD 4356
(07) 4693 2455 fax (07) 4693 1182

Quilpie Shire Council
50 Brolga Street
PO Box 57
QUILPIE QLD 4480
(07) 4656 1133 fax (07) 4656 1441

Redcliffe City Council
lrene Street
PO Box 66
REDCLIFFE QLD 4020
(07) 3283 0233 fax (07) 3883 1723

Redland Shire Council
cnr Bloomfield and Middle Streets
PO Box 21
CLEVELAND QLD 4163
(07) 3286 8686 fax (07) 3286 8765

Richmond Shire Council
50 Goldring Street
PO Box 18
RICHMOND QLD 4822
(07) 4741 3277 fax (07) 4741 3308

Rockhampton City Council
Bolosver Street
PO Box 243
ROCKHAMPTON QLD 4700
(07) 4931 1311 fax (07) 4922 1700

Roma Town Council
cnr Bungil and Quintin Streets
PO Box 116
ROMA QLD 4455
(07) 4622 1266 fax (07) 4622 3084

Rosalie Shire Council
89 Mocatta Street
PO Box 50
GOOMBUNGEE QLD 4354
(07) 4696 5311 fax (07) 4696 5324

Sarina Shire Council
65 Broad Street
PO Box 219
SARINA QLD 4737
(07) 4956 1444 fax (07) 4956 1508

Stanthorpe Shire Council
61 Marsh Street
PO Box 402
STANTHORPE QLD 4380
(07) 4681 5500 fax (07) 4681 5540

Tambo Shire Council
Arthur Street
PO Box 136
TAMBO QLD 4478
(07) 4454 6133 fax (07) 4454 6215

Tara Shire Council
19 Fry Street
PO Box 21
TARA QLD 4421
(07) 4665 3133 fax (07) 4665 3460

Taroom Shire Council
Yaldwyn Street
PO Box 21
TAROOM QLD 4420
(07) 4627 3211 fax (07) 4627 3204

Thuringowa City Council
86 Thuringowa Drive
PO Box 86
THURINGOWA CENTRAL QLD 4817
(07) 4773 8411 fax (07) 4773 2936

Tiaro Shire Council
Mayne Street
PO Box 11
TIARO QLD 4650
(07) 4129 2133 fax (07) 4129 2338

Toowoomba City Council
153 Herries Street
PO Box 3021
TOOWOOMBA QLD 4350
(07) 4631 6611 fax (07) 4638 3830

Torres Shire Council
Douglas Street
PO Box 171
THURSDAY ISLAND QLD 4875
(07) 4069 1336 fax (07) 4069 1845

Townsville City Council
103–141 Walker Street
PO Box 1268
TOWNSVILLE QLD 4810
(07) 4722 0200 fax (07) 4722 0400

Waggamba Shire Council
82 Marshall Street
PO Box 212
GOONDIWINDI QLD 4390
(07) 4671 1211 fax (07) 4671 2763

Wambo Shire Council
26 Wood Street
PO Box 549
DALBY QLD 4405
(07) 4662 2922 fax (07) 4662 1738

Warroo Shire Council
73 Burrowes Street
PO Box 63
SURAT QLD 4417
(07) 4626 5299 fax (07) 4626 5370

Warwick Shire Council
64 Fitzroy Street
PO Box 26
WARWICK QLD 4370
(07) 4661 0300 fax (07) 4661 5390

Whitsunday Shire Council
83–85 Main Street
PO Box 104
PROSERPINE QLD 4800
(07) 4945 1255 fax (07) 4945 2505

Winton Shire Council
75 Vindex Street
PO Box 288
WINTON QLD 4735
(07) 4657 1188 fax (07) 4657 1342

Wondai Shire Council
31 Scott Street
PO Box 42
WONDAI QLD 4606
(07) 4168 5155 fax (07) 4168 5808

Woocoo Shire Council
Oakhurst Gardens
Biggenden Road
Oakhurst
PO Box 772
MARYBOROUGH QLD 4650
(07) 4123 1616 fax (07) 4123 2002

Analytical laboratories and technical advice

For advice concerning chemical analyses, storage and handling of samples:
Queensland Government Chemical Laboratory
Queensland Health Scientific Services
39 Kessels Road
Coopers Plains
PO Box 594
ARCHERFIELD QLD 4108
(07) 3274 9111 fax (07) 3274 9119

For advice about diseases of fishes, storage and handling of histopathology samples:
Department of Primary Industries
Yeerongpilly Veterinary Laboratory
665 Fairfield Road
Yeerongpilly
PO Box 594
ARCHERFIELD QLD 4108
(07) 3274 9056 fax (07) 3274 9074

Department of Primary Industries
Oonoonba Veterinary Laboratory
Abbott Street
PO Box 1085
TOWNSVILLE QLD 4810
(07) 4722 2624 fax (07) 4778 4307

For advice concerning conduct of fish kill investigations and interpretation of data:
Department of Environment and Heritage
Scientific Assessment Section
64–70 Mary Street
Brisbane
PO Box 155
BRISBANE ALBERT STREET QLD 4002
(07) 3224 7019 fax (07) 3225 2660

Attachment A

QUEENSLAND GOVERNMENT
Department of Environment and Heritage

Advice of a fish kill incident

- ***This proforma should be used to record all initial reports of fish kill incidents***
- ***Copies of this advice should be faxed to Regional Manager (Environment) DEH, Regional Manager (Fisheries) DPI, and Chief Executive Officer of appropriate Local Government Council***

FM423 OCT98

1 Person completing this proforma

Report received by

Name	Designation

Location

When received

Date	Time

2 Details of person providing information *(required to enable recontact if desired)*

Title: Mr/Mrs/Ms/Dr/Prof/Other ————

Family name	Given name/s

Address

Number Street

Suburb/Town State Postcode

Phone/fax contact

Home Work Fax Mobile

Method of reporting

Phone / in-person / other (please describe)

3 Information provided concerning fish kill incident

(a) Did the person providing the information *observe* the fish-kill *personally?* ☐ Yes ☐ No

(If **no**, record identity of original observer as at (2) above, if available)

.....

(b) Did any other person(s) *observe* the fish kill? ☐ Yes ☐ No

(If **yes**, record identity of other observer(s) as at (2) above, if available)

.....

(c) Location of fish kill

(Must be sufficiently descriptive to avoid *ambiguity.* Include references to fixed features of waterways such as bridges)

.....

(d) Type of waterbody (tick appropriate boxes)

☐ marine ☐ tidal ☐ fresh ☐ running ☐ still

3 Information provided concerning fish kill incident *(continued)*

(e) Access

Boat/car/foot/other (specify)

(f) What is adjacent landuse?

Livestock/crops/houses/sportsgrounds/factories/other (specify)

(g) When was the fish kill observed?

Date	Time

(h) How many dead/affected fish? (indicate over what area or stream length)

Area or length	Numbers dead	Proportions by size and species

(i) Are live/unaffected fish present? ☐ Yes ☐ No

(If **yes**, then describe any unusual behaviour)

(j) Condition of dead fish

Fresh/slightly decomposed/very decomposed	Lesions/injuries	Bleeding	Unusual colour

(k) List common names or species of fish involved (if known)

(l) Any other organisms affected? ☐ Yes ☐ No

(If **yes**, give details)

(m) Weather observations

	Wind	Rain	Temperature
Now			
Previous 24 hours			

(n) Water observations

Smooth/rough	Turbidity	Colour	Current/flow rate and direction

Visible discharges	Floating matter	Scums

(o) Have any samples been taken? ☐ Yes ☐ No

(If **yes**, give details of what was sampled, who took the samples, and present location of the samples)

.....

Initiation of further action

This advice has been referred to: _____

name contact number

Attachment B

QUEENSLAND GOVERNMENT
Department of Environment and Heritage

Report from an on-site survey of a fish kill

- ***This proforma should be used to record observations and data collected during the on-site survey of fish kill incidents. It may be necessary to provide attachments such as photographs, maps and additional data sheets. These should be noted in the body of the proforma.***
- ***Copies of this advice should be faxed to Regional Manager (Environment) DEH, Regional Manager (Fisheries) DPI, and Chief Executive Officer of appropriate Local Government Council***

FM425 OCT98

1 Details of person completing this proforma

Name	Designation	Location

Department/authority

Name	Location/district/region

Address

Number	Street		
Suburb/Town		State	Postcode

Phone/fax contact

Home	Work	Fax	Mobile

2 Details of response to notification of fish kill incident

Advice received from

Name	Designation	Location

(a copy of the proforma *Advice of a fish kill incident* should be attached to this report)

	Date	Time
When advice received		
Commencement of on-site survey		
Completion of on-site survey		
Completion of this proforma		

Note here the reasons for any delay or difficulty in commencing the on-site survey

.....

3 Data from the on-site survey of the fish kill incident

(a) Location of fish-kill

(Must be sufficiently descriptive to avoid *ambiguity.* Include references to fixed features of waterways such as bridges)

.....

(b) Type of waterbody (tick appropriate boxes)

☐ marine ☐ tidal ☐ fresh ☐ running ☐ still

(c) Access

Boat/car/foot/other (specify)

3 Data from the on-site survey of the fish kill incident *(continued)*

(d) Provide a sketch map of the site and its location

(Indicate scale and direction of north, giving latitude and longitude or other references such as GPS or stated map coordinates. Show all sampling points and other features relevant to the conduct of the on-site survey. Also indicate if other maps/photographs form attachments to this report.)

(e) What is adjacent landuse?

Livestock/crops/houses/sportsgrounds/factories/other (specify)

.....

(f) How many dead/affected fish?

Method(s) of estimation	Numbers dead	Proportions by size and species
.....	.....	.....

(g) Were live/unaffected fish present? ☐ Yes ☐ No

(If **yes**, then describe any unusual behaviour)

.....

(h) Condition of dead fish

Fresh/slightly decomposed/very decomposed	Lesions/injuries	Bleeding	Unusual colour
.....	.....	.....	.....

3 Data from the on-site survey of the fish kill incident *(continued)*

(i) List common names or speices of fish involved (if known)

....

(j) Any other organisms affected? ☐ Yes ☐ No

(If **yes**, give details)

....

(k) Weather observations

Now	Wind	Rain	Temperature
Previous 24 hours	Wind	Rain	Temperature

(l) Water observations

Smooth/rough	Turbidity	Colour	Current/flow rate and direction

Visible discharges	Floating matter	Scums

(l) Sediment observations

Mud/sand/gravel	Colour

Other comments

(m) List persons who have given statements or who may have information material to a subsequent investigation

Name	Title	Family name	Given name/s	
Address	Number	Street	Suburb/Town	
Phone/fax contact	Home	Work	Fax	Mobile

Statement taken? ☐ Yes ☐ No

Name	Title	Family name	Given name/s	
Address	Number	Street	Suburb/Town	
Phone/fax contact	Home	Work	Fax	Mobile

Statement taken? ☐ Yes ☐ No

Name	Title	Family name	Given name/s	
Address	Number	Street	Suburb/Town	
Phone/fax contact	Home	Work	Fax	Mobile

Statement taken? ☐ Yes ☐ No

(Attach list of additional persons if necessary)

3 Data from the on-site survey of the fish kill incident *(continued)*

(n) List all samples taken

Detail what was sampled, by whom, the sites (mark map), identification numbers and present location of the samples

.....

.....

.....

.....

.....

.....

(o) Presumptive diagnosis of the cause of the fish kill (if possible)

(Should relate to observations at the site, data collected, and any other matters of fact)

.....

.....

.....

.....

.....

.....

(p) Any other comments, including actions taken to mitigate environmental harm

.....

.....

.....

.....

.....

(q) List of attachments to this report

(Maps, photographs, witness statements, sample dispatch documentation, etc.)

.....

.....

.....

.....

.....

Initiation of further action

This advice has been referred to: _____

name contact number

Attachment C

QUEENSLAND GOVERNMENT
Department of Environment and Heritage

Volunteer registration

For year ending ____ / ____ / ____

FM508 NOV98

1 Personal details

Title (Mr/Mrs/Ms/Dr)	Last name		
Given names		Date of birth	Gender (Male/female)

2 Home address

Number	Street		
Suburb/Town		State	Postcode
Telephone			

3 Address where volunteer activities will be based

Location/Park		
Address		
Postcode	Telephone	Fax

Responsible officer

4 Next of kin/contact person

Name	Telephone
Address	

5 Skills

(a) Do you possess a current first aid certificate? ☐ Yes ☐ No

(If **yes**, record details of level, date obtained, where from)

.....

(b) Detail any machine operators qualifications e.g. Drivers licence, chainsaw ticket etc.

.....

Signature of Department of Environment and Heritage Officer who has sighted documentation

Date

6 This form must be signed by the applicant and the responsible officer as at (3)

Applicant's signature	Date
Responsible officer's signature	Date

7 Insurance and liability information (optional)

(a) Do you have an existing medical or physical condition which may be aggravated by the tasks you will be performing as a volunteer? **Yes** ☐ **No** ☐
(If '**Yes**' please supply details on a separate sheet and mark 'Confidential')

(b) Have you made any claims for personal accident insurance or Workers' compensation? **Yes** ☐ **No** ☐
(If '**Yes**' please supply details on a separate sheet and mark 'Confidential')

(c) Have you previously contracted any illness from a workplace? **Yes** ☐ **No** ☐
(If '**Yes**' please supply details on a separate sheet and mark 'Confidential')

Volunteer information

Job safety
Job safety must always be a high priority and at no time should any person (volunteers, Departmental officers or members of the public) be placed in situations which compromise their own health and safety or that of the people around them.

Please read the Volunteers and Workplace Health and Safety brochure.

Indemnity
All registered volunteers are covered by the Department's indemnity policy. A copy of this indemnity is located with your responsible officer.

Skills requirements
All volunteers must have the necessary skills relevant to the task they are performing within the Department's workplace.

Please return completed form to: Volunteer Co-ordinator
C/- your nearest Queensland
Department of Environment and Heritage office

OFFICE USE ONLY

Region
- Far Northern ❑
- Northern ❑
- Central Coast ❑
- Southeastern ❑
- Southwestern ❑
- **Central office** ❑

Program
Conservation
- - Coastal Management ❑
- - Heritage ❑
- - Marine Park ❑
- - Park ❑
- - Wildlife ❑

Business Support Services ❑

Environment
- - Plannning ❑
- - Pollution Management ❑
- - Waste Management ❑

Date received ____ / ____ / ____

Responsible officer _____

Interview Yes ❑ No ❑

Induction Yes ❑ No ❑ Date ____ / ____ / ____

Volunteer agreement

Individual Yes ❑ No ❑ Date ____ / ____ / ____

Group Yes ❑ No ❑

Name of Group _____

Registration No. _____