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Investigating Fish Mortalities in New York State

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INVESTIGATING FISH MORTALITIES

IN NEW YORK STATE

Basic Procedures and Technical Information

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PREFACE

It has been nearly seven years since this manual was introduced to help facilitate regionalization of fish mortality investigations in New York State. Many individuals have contributed in many ways to the program during that time. An excellent job has been done serving the public and helping to safeguard the state's fish and wildlife resources. The program demands are continuous and serve as a constant reminder of what needs to be done.

We hope the manual has helped to initiate and orient the novice. Even though there has been little feedback, it is time to do some revising. There is a need to re-evaluate, clarify and standardize some aspects of the program. We again ask for your cooperation and continued valuable contributions.

We thank Dr. Jan Spitsbergen for current information on pathology, Lawrence Skinner for reviewing the manual and Frances Bollentin for word processing.

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This manual is the result of the insistence and cooperation of a number of Bureau of Environmental Protection personnel. Major authors are Timothy L. Preddice, Senior Aquatic Biologist; Joseph G. Spodaryk, Associate Analytical Chemist and Gary N. Neuderfer, Associate Aquatic Biologist.

It is with the hope of continued cooperation of all Department personnel in addressing environmental problems that the contributions of the following individuals are gratefully acknowledged. Mr. John Spagnoli, former Bureau Chief and now Director of Region 9, first gave impetus to this project. Ralph Colson, Robert Bauer, and Dr. Edward Kuzia also made major contributions to its development. Dr. Edward Horn, present Chief of Bureau of Environmental Protection, has urged its completion and implementation. Other Departmental staff were involved and are recognized especially for their help in review.

A special note of thanks is given to Dorothy Hanchar, Frances Bollentin and Marian O'Sullivan for the typing of the manuscript.

SAFETY AND TOXIC SUBSTANCE WARNING

Always use caution and discretion while making field investigations and collecting samples. Never jeopardize your personal safety.

Toxic substances causing fish kills may also be harmful to you as the investigator. Toxicity can occur by different routes of exposure including direct contact, inhalation, and absorption from water. If you know or suspect the material might be harmful, do not investigate in the immediate spill area without the proper protective gear.

Three rules in order of priority: assure

1. safety of the investigator(s),
2. safety of the public,
3. safety of the environment.

I. INTRODUCTION

This manual has been prepared to provide specific and updated fish mortality investigation guidelines for regional staff of the New York State (NYS) Department of Environmental Conservation (DEC). The information presented was originally intended to expand and replace much of Chapter 400, Section 447 of the Water Quality Accident Contingency Plan and Handbook (WQAH)[1]. Instead, this manual was prepared as a supplement to the WQAH, providing information about administrative procedures and a technical summary of how an investigation should proceed. It should be used as an aid by DEC personnel and should complement any set of instructions covering field response investigations.

Experience has shown that the public demands quick and efficient response to fish mortalities because they indicate a potential threat to public health and safety as well as to environmental quality. To provide this response, it becomes imperative that policies, procedures and technical information are provided to expediently address these problems. Today's pollution-caused fish mortalities are primarily due to slug discharges and accidental spills for which prompt responses are needed. Obtaining quick response for most situations now requires much greater regional involvement in fish kill investigations than in the past. Today the regions are primarily responsible for investigating fish kills. Involvement of additional people, some of whom may only be vaguely familiar with investigative techniques, increases the need for a fish kill investigation reference.

Should problems arise requiring additional information, training or field investigation, two Environmental Disturbance Investigation Units (EDIU) are available for assistance (Table 1).

Fish Mortality Investigations

Authority:

NYS Environmental Conservation Law[2] (ECL), Article 11, Section 0503, paragraph 1 (paraphrased), states that it is illegal to allow substances in the state's waters in quantities that are injurious to fish, protected wildlife and waterfowl or the propagation thereof. The civil penalty for proven offenses ranges from $500-$1000 per infraction plus $10 per fish killed (ECL 71-0925, paragraph 5). The criminal penalty is a maximum fine of $250 or up to 15 days imprisonment or a combination thereof (ECL 71-0923, paragraph 1). Other laws also apply to these situations and penalties can be greater.

Objectives:

1. Protection

a. To ensure immediate investigation of reported fish mortalities in order to minimize environmental damage to fishery resources.

b. To obtain timely and accurate information and samples necessary to show source, causative agent and effects on the fishery resource for appropriate legal and remedial actions.

2. Surveillance

a. To maintain a statewide surveillance program capable of detecting waters with repetitive fish kills or conditions toxic to fish so that mitigative action can be enacted.

b. To participate in the federal monitoring of pollution-caused fish kills.

Responsibilities:

NYS DEC Regions

Each region is responsible for reporting and investigating all fish mortalities within its boundaries in a timely and efficient manner according to their contingency response plan. The extent of an investigation is dependent on the situation at hand. Regions also have responsibility for public relations, such as warning water users of possible hazard and informing the public of any legal actions.

A regional fish kill coordinator (RC) is assigned by each regional director to ensure that fish kill related activities are carried out thoroughly. The RC's responsibilities may include:

1. Maintaining and updating a regional fish kill log (Appendix 1), fish mortality notification procedure and duty roster consistent with the Region's Water Quality Accident Contingency Plan.

The RC or designate is responsible for keeping a log of all fish kill notifications received and investigations made by regional personnel. Appendix 1 outlines an acceptable format for keeping track of this information as received. The log must be completed and forwarded to the Hale Creek Field Station annually. Appendix 1 is the preferred format for the log but others

can be used providing the same basic information is included. Pertinent information reported should include the municipality and county where the kill originated (under location) and whether an Environmental Protection Agency (EPA) Form 7500-8 (Appendix 5) was completed and submitted. The latter can simply be denoted by an asterisk next to the notification number. Copies of completed EPA forms should be retained and included with other investigation report materials.

2. Assigning investigative responsibilities in line with their supervisory role and the region's response plan.

3. Acquiring and maintaining necessary investigative supplies and equipment (see suggested list--Appendix 2).

4. Maintaining a supply of necessary forms, ensuring their completion and availability for case files including:

a. Fish Kill Notification Form (Appendix 3 or similar).

b. If the kill is investigated, Fish Kill Field Investigation Form (Appendix 4 or similar).

c. Continuity of Evidence Form (Appendix 7 or similar.

d. If the kill is pollution-caused, EPA Form 7500-8 (Rev. 4-86) (Appendix 5).

5. Arranging for necessary laboratory services and transfer of samples.

6. Informing involved regional personnel, EDIU staff and the public of the status of investigations.

7. Recommending appropriate legal and remedial action and tracking actions that are still pending.

Bureau of Environmental Protection

The Division of Fish and Wildlife, Bureau of Environmental Protection (BEP) maintains one EDIU at the Region 8 Headquarters in Avon for Regions 7, 8 and 9 and a second EDIU at the Hale Creek Field Station in Gloversville primarily for problems occurring in Regions 3, 4, 5 and 6 (Table 1). Fish kill investigations occurring in Regions 1 and 2 have normally been handled by regional personnel because of distance and time factors. The Avon and Hale Creek EDIUs each have a biologist-chemist team with extensive experience in conducting fish kill investigations. Their knowledge and experience may prove helpful in solving

atypical fish mortality problems. For situations that appear too complex for regional resolution, the appropriate EDIU should be contacted immediately following verification of the mortality. The EDIU can provide direction and, if necessary, will conduct an investigation. Certain chemical analysis and biological services (toxicity testing, macroinvertebrate surveys) are also available to the regions via the EDIUs. Making prior arrangements for these services and transferring samples to the appropriate EDIU is a regional responsibility.

In addition to investigative and laboratory services, the EDIUs can provide fish kill investigation training to Environmental Conservation Officers and other regional staff, particularly new personnel unfamiliar with these procedures. Arrangements for regional training by an EDIU can be requested by the regional coordinator.

The Hale Creek Field Station EDIU is also responsibile for compiling an annual statewide report summarizing the investigations for the calendar year. This information is provided to each RC, other DEC Units and is available to the public on request.

Division of Fish and Wildlife

In the event that fishery resources are suspected of being contaminated by a pollution incident, the Bureau of Environmental Protection should be consulted for appropriate action(s). This Bureau will consult with the New York State Department of Health, as needed, and ensure that actions are consistent with other policies developed to protect the health of potential fish consumers.

II. INVESTIGATION PROCEDURES

Introduction

Fish mortalities occur in many forms dependent on whether caused by natural factors or by one or more of man's many influences on aquatic environments. Because of the variety of causes of fish kills, several investigative techniques are needed to assess these differing situations. It is stressed that immediate regional action (occasionally with the assistance of an EDIU for complex situations) is absolutely necessary for a successful conclusion to a fish mortality investigation with today's short-term and often complex problems.

The following information is provided to give uniform detailed instructions and guidance to regional DEC personnel involved with fish kill investigations. A concise summary of the investigative procedure (flow chart in Appendix 6) is included on pages 6 and 7 followed by procedures and technical information. Regional personnel may find it helpful to have at least a copy of the summary close at hand during an investigation. The remainder of the information is mainly for reference should questions arise.

SUMMARY OF FISH MORTALITY INVESTIGATION PROCEDURE

I. NOTIFICATION & REGIONAL ALERT

A. Record pertinent information for decision-making process and reporting

B. Alert regional response plan personnel

II. INITIAL REGIONAL INVESTIGATIVE DECISION

A. No further action necessary

B. Initial investigation

1. Locate and verify mortality

2. Note condition of fish

3. Determine if caused by natural causes or by pollution

4. Collect initial upstream, source and downstream water samples

5. Determine relative importance and size of mortality

6. Alert regional office for any needed assistance

7. Interview complainant/local residents

8. Contact polluter

III. SECOND REGIONAL INVESTIGATIVE DECISION

A. No further action necessary

B. Additional regional and/or EDIU investigation (analyses) needed

1. Additional regional investigation, e.g., additional personnel involvement, sampling, etc.

2. Additional capabilities--regional personnel request EDIU assistance

IV. FISH KILL FORMS, INVESTIGATION REPORT & LABORATORY RESULTS

A. Final fish kill report and information summarizes

1. Field investigation findings

2. Laboratory analyses and toxicity test results

B. Regional coordinator or investigator completes EPA 7500-8 for actual/suspected pollution-caused fish kills and forwards form directly to EPA.

C. Regional coordinator forwards information, as necessary, only to regional personnel involved with legal and mitigative actions and to EDIU. Until settlement is reached information is generally kept confidential.

V. REGIONAL ACTIONS

A. No further action necessary

B. Cleanup, abatement and litigation

VI. FEEDBACK OF FINAL OUTCOME

A. Involved regional units communicate results to each other and the regional coordinator, central office units, and the public

B. The regional coordinator maintains an annual log (Appendix 1) of all fish mortality notifications and investigations and a file of all EPA Reports of Pollution-Caused Fish Kill or Abnormality (EPA Form 7500-8, Appendix 5)

VII. ANNUAL STATEWIDE REPORT (by BEP)

A. For purposes of programmatic quality assurance and surveillance, BEP annually prepares a statewide summary report on regional investigations and program trends

VIII. FINAL FISHERY DECISIONS

A. Change in fishery resource management as a result of contamination (?)

B. Plan to study serious or suspected pollution problems (?)

Overview of Fish Mortality Investigation Steps

Notification and Regional Alert

As stipulated by Department policy, fish kills are defined as a type of water quality accident and, therefore, are the initial responsibility of the Regional Director or the Regional Environmental Quality Engineer. Because fish mortality notifications occur through many channels, a response procedure and duty roster must be developed that is consistent with the Region's Water Quality Accident Contingency Plan. These should be well defined and updated as necessary. The person designated as the Regional Fish Kill Coordinator must be involved in a sound notification/action plan involving Fish and Wildlife, Water (Spill Response), Law Enforcement, and Pesticide Units. Regional Pesticide Control Specialists should always be notified of any suspected pesticide kill since they are the most qualified regional personnel to sample these materials. Secretaries in all of these units should also be made aware of the contingency plan and need for response because many times they receive the fish kill notification and are the sole person in the unit office. Since notifications are sometimes received outside of normal working hours, a well defined response procedure should take this into account in order to avoid confusion and unnecessary delay.

The response procedure and duty roster should serve to:

1. Indicate clearly who on the regional staff should receive notification of a fish mortality during what period.

2. Identify authority for taking necessary measures to address the incident.

3. Assure ability to react quickly with necessary equipment and supplies (Appendix 2).

During normal working hours, regional personnel receiving a notification should be able to contact a qualified responder within the region.

If any type of hazardous spill emergency occurs, the state DEC hotline answering service should be called 1-800 (or 518) 457-7362. The Coast Guard maintains a National Response Center in Washington, DC for reporting spills of hazardous materials in navigable waters. The toll-free number is 1-800-424-8802. EPA Region 2 (Edison, NJ) also maintains a 24-hour notification number: 1-201-548-8730. CHEMTREC (Chemical Transportation Emergency Center), a national chemical emergency information center, is also

available for providing hazard information and guidance when given certain information regarding accidents, spills and other emergencies. This toll-free number is 1-800-424-9300 and should be used only when emergencies are in progress.

Appendix 3 is an example of a fish kill notification form showing what information is needed from a caller in order to make necessary investigative decisions. Copies of a form acceptable to the region should be available to personnel who are likely to receive notification of a fish kill. Whoever receives this information should get it to appropriate personnel immediately. This information cannot be left on a desk until a response person returns from the field, meeting, etc., to begin the initial decisions. Pertinent information regarding notifications and investigations must be logged in (Appendix 1) and forwarded annually to BEP by the regional coordinator.

Initial Regional Investigative Decision

After notification, it must be decided if immediate regional investigation is warranted. Things to consider in making this decision are: (1) is the reported fish mortality in progress or is it over (i.e., are fish still in distress or have they been dead for some time)?, (2) what is the magnitude?, (3) what species are involved?, (4) where is it located, etc.? In most instances, and especially when the mortality is recent or in progress, immediate regional investigation may be warranted.

Once the decision has been made to investigate a mortality, it is usually imperative that a quick response be implemented. Many mortalities are the result of a slug discharge or accidental spill and for these cases it is necessary to be on the scene as soon as possible to collect information and water samples before lethal conditions dissipate. Unless water samples are collected during the period of lethality, there may be insufficient evidence to prove a violation of Environmental Conservation Law.

Qualified regional personnel closest to the kill site must initially accomplish the following:

1. Locate and verify the kill.

2. Record information as suggested on Field Investigation Form (Appendix 4).

3. Sample water and biological specimens (see Sampling Procedures, page 17).

4. Gather any additional information or samples which may be pertinent.

5. Contact suspected polluter.

6. Alert supervisor or RC of findings and, if needed, have them request additional investigative assistance from the region or EDIU, and alert waterway users to possible hazard. Names and phone numbers of appropriate EDIU staff are given in Table 1.

Investigators should be aware of and respect the property rights of people and companies. It is advisable, especially from the viewpoint of good public relations, to obtain permission before entering private property.

It has been Department policy to personally contact the party suspected of being responsible for the fish mortality. If circumstances do not permit such contact during the initial investigation, an attempt should be made to contact someone as soon as possible thereafter. The reasons for this are to: (1) inform the individual(s) that a fish kill has occurred and that an investigation is being made to determine the cause and locate the source, (2) obtain information as to the cause of the discharge, the toxicant(s) involved, and the countermeasures being taken, and to (3) secure samples necessary to define the problem. Whenever contacting an individual who could be a likely suspect in a law violation, their right to remain silent and to have an attorney present during questioning must be explained before questioning.

Second Regional Investigative Decision

With the information from the notification and the initial investigation, a decision can then be made regarding whether additional assistance is necessary to handle the incident.

If the situation lends itself to regional evaluation (considering available expertise, equipment, and the situation at hand), the investigation should be pursued to completion. Basically, this entails gathering any other additional information or samples which may be needed. It also involves assessment of damages (i.e., miles of stream, number and species of fish affected, etc., -- see Estimating Fish Affected, page 22). Some laboratory support is available from the EDIUs as needed. Arrangements for analyses and transfer of samples are to be made through the RC as soon as possible. All samples must be accompanied by a Continuity of Evidence Form (Appendix 7) or a facsimile.

If the region decides that the incident is beyond its immediate capability for assessment, advice or assistance from the appropriate EDIU should be requested. If the complexity of the situation requires that EDIU personnel be on the scene, then they will assume responsibility for

investigating the incident. Regional staff may be needed to assist the EDIU members and they should be prepared to implement EDIU instructions as necessary.

Fish Kill Forms, Investigation Report and Laboratory Results

A copy of the completed Fish Kill Notification Form (Appendix 3) and other pertinent information should be supplied to the RC as soon as possible following the investigation. Investigators should always retain original field notes because these records may be the basis for testimony in an enforcement hearing. Where legal action is possible, a final fish kill report summarizing the investigation, laboratory analyses, legal evidence, and any other pertinent facts should be written. This should be accomplished in a timely fashion, making sure that all information is correct and kept confidential (as necessary) prior to any possible legal actions. The final regional report is supplied only to regional personnel involved with litigation and abatement.

The RC is responsible for maintaining a supply of fish kill report forms and a file of copies of submitted Reports of Pollution-Caused Fish Kill or Abnormality (EPA Form 7500-8, see Responsibilities NYS DEC Regions-- page 2).

Regional Actions

Regional actions are usually dependent on the extent of damages and the investigative results as summarized in the final fish kill report. Mitigative actions and fines levied are based on: (1) importance/use classification of affected water body (i.e., drinking water, trout spawning, high class fishing and swimming water), (2) repeated occurrences, (3) number and species of fish affected, (4) miles of stream or surface acreage affected, (5) whether the pollutant discharge was purposeful, accidental or due to negligence or vandalism, (6) clean-up efforts and amendments offered, (7) Departmental investigative expenses, (8) restocking expenses.

It is emphasized that the Department is more interested in limiting damages to the environment, effecting efficient cleanup and preventing recurrences than in collecting fines. Regional personnel involved with litigation are strongly urged to compare final decisions from similar cases, both within the region and from other regions, before final settlements are determined. Uniformity in these actions should exist across the entire state. It has been suggested that minimal compensations in all cases should at least cover Departmental investigation costs.

Feedback of Final Outcome

This phase of the fish kill investigation process is as important as the others previously described and is a regional responsibility often overlooked. It involves informing the public through radio, television, newspapers, etc., of final outcomes and Departmental actions, especially for those situations where public awareness is great. Fish kills near urban areas or those caused by significant quantities of hazardous material are situations where the news media should be utilized. The feedback of information should also include informing all personnel involved with a particular situation of the final settlement and decisions. This will satisfy the curiosity of investigators and will ensure that their efforts are not neglected. Keeping personnel informed can create better employee morale. Informing the public and involved personnel is a regional responsibility that can be coordinated through the RC.

Information should also be sent to BEP's Hale Creek EDIU on at least an annual basis. A completed regional notification/ investigation log should be supplied for inclusion in the annual statewide report. Narrative information regarding significant kills, settlements, problems, standardized procedures, etc., would also be desirable as it might serve to benefit the program statewide.

Annual Statewide Report (by BEP)

Reporting of all fish mortalities to the EDIU has a twofold purpose. The first is to audit regional fish kill investigative performance to ensure completeness and uniformity among regions in the quality of the investigations and actions taken. Problems encountered during this process will be addressed by EDIU personnel through additional training, improved communications, etc.

The second purpose for feedback of information is for monitoring at both the state and federal level. To meet the state's needs, an annual report summarizing fish mortalities by region will be produced by BEP. Repetitive fish kills will be identified, if not already done so by the regions, and will be given more attention. This report will also show trends in fish kill incidents which should prove helpful for BEP, Division of Fish and Wildlife, and Division of Water in long-range planning. A similar surveillance network has been established at the federal level and is the reason for completing EPA Form 7500-8 (Rev. 4-86) which reports pollution-caused fish kills and abnormalities (Appendix 5).

Final Fishery Decisions

The Division of Fish and Wildlife has responsibility for final fishery decisions such as restocking, consumption advisories and closures (with NYS DOH input). Some decisions may be based on immediately available information and others may eventually be based on annual report or chemical monitoring information. The annual report may identify some major potential pollution threats which the Division of Fish and Wildlife and/or the Division of Water may want to check more closely in order to identify the magnitude and seriousness of the situation so that appropriate actions can be taken.

III. TECHNICAL INFORMATION

Fish Mortality Causes -- Natural vs. Pollution

The initial objective of any fish mortality investigation is to determine whether it is caused by natural factors or pollution. Fish mortalities attributed to natural causes such as dissolved oxygen depletion, spawning mortality or disease are most common in lakes and ponds rather than streams. Pollution-caused kills can be found in all types of waters but records show they occur most frequently in streams where dilution factors are small. A basic rule of thumb to follow when questioning whether a mortality is natural or pollution-caused is to observe the affected fish and invertebrate life. If serious, pollution usually affects all life forms in the water. This means many species of fish, both young and adult, and most aquatic invertebrates will be affected. Fish mortalities from natural causes usually involve only one or two species of fish and primarily one size group. There are a few exceptions to this rule, the most common of which is caused by dissolved oxygen depletion.

Dissolved oxygen (DO) depletion is still a common cause of fish mortalities and can be due to natural conditions or to man's activities. Natural DO depletion can occur during the winter under an opaque ice and snow cover. This usually happens in enriched ponds. The snow and ice restrict the vegetation's ability to produce oxygen and eventually natural respiration depletes the dissolved oxygen supply and fish suffocate. "Winterkills" of this nature affect all sizes and species of fish and can also affect aquatic insects, crayfish, frogs and turtles. These kills are usually not discovered until spring when the ice melts and recedes from shore. Lethal DO levels can also occur from spring to late fall, especially in nutrient enriched ponds or lakes with large quantities of planktonic algae. This commonly occurs during a period of successive cloudy days following warm, sunny weather. As with winterkills, the reason for this type of mortality is that the total DO required by aquatic life exceeds that available. One obvious difference between summer and winter DO kills is that frogs and turtles are usually unaffected during the summer.

Pollution-caused DO depletion can be caused by waste discharges of high organic content such as from dairy washings, cannery wastes, ensilage leachate, etc. Fortunately, these cases now occur less frequently because of discharge regulations and improved treatment facilities.

Other causes of natural fish mortalities include: (1) annual die-offs of weakened fish following spawning such as occurs with the salmon in Lake Ontario tributaries, (2) over-population related mortalities such as with the annual spring herring die-offs in Lake Ontario and the Hudson River, and (3) mortalities from disease. During these natural occurrences, numerous live fish can usually be found in the same area where the dead or dying fish are observed. A few unusual fish mortalities have also been caused by lightning strikes, electrified metal water pipes and by naturally-produced toxins from certain blue-green algae.

Man-induced fish kills are the primary targets of today's fish mortality investigations. The majority of pollution-caused fish kills are now caused by toxic substances rather than by DO depletion. There are many chemical substances produced and used by man which are extremely toxic to fish and other aquatic life. Such chemicals are sometimes spilled accidentally, discharged as wastes, or reach waters following the normal use of the product. Categories of pollution-caused fish kills are given on EPA Form 7500-8 (Appendix 5).

It should be pointed out that an apparent natural mortality may at times be the result of pollution problems. Stress caused by exposure to sublethal concentrations of toxicants may reduce disease resistance. Thus, the underlying cause of the mortality may be the subtle effect of a toxicant and not the obvious disease agent. For example, the discharge of nutrient-rich sewage may enhance the growth of fish pathogens in the aquatic environment, or produce conditions leading to oxygen depletion. These types of factors should be considered when determining if a mortality is due to natural causes or as an indirect result of man's activities. Problems that are difficult to identify may be worth discussing with EDIU members to determine how the situation could best be resolved.

When significant disease or abnormality (tumors, deformities, etc.) problems are found in wild fish populations, the Fish Pathology Laboratory at Cornell University should be notified and consulted for possible assistance in diagnosing and documenting the problem. See the Fish Pathology section (page 25) for additional information.

Field Notes and Observations

Field Notes

All field notes and labels must be done as clearly as possible. Preferably, they should be written in waterproof ink and permanent marker on waterproof paper (field

notebooks) and labeling tape, respectively. Labeling is discussed further on page 19 in the Sampling section of this manual. If possible, information from each sampling location should be recorded on a fish kill field investigation form such as the one provided with this report (Appendix 4). Some additional information is usually necessary for differing situations. Therefore, some judgment is necessary in deciding what is needed and what to look for.

Observations

An indication of the pollutant affecting fish can sometimes be discerned by observing the fish's distress pattern. Observation of unusual swimming movements or reactions to an external stimulus, coupled with an investigator's knowledge of possible pollution sources in the area of the kill, often allows an investigator to make a preliminary judgment as to possible cause. However, observation of distress reactions as an aid in determining cause is severely limited, since widely differing classes of toxic materials may induce the same reaction pattern. The same is true of body surface reactions, such as excess mucus production and surface hemorrhages. Exposure to a particular chemical may cause a fish to go through several phases of distress characterized by different movement patterns. Nonetheless, such observations should be made and may be useful.

Three distress patterns are noteworthy:

1. Swimming at surface, gulping air -- This is the most easily identifiable reaction typical of fish in distress from low dissolved oxygen. When disturbed, such fish will usually seek cover or swim downward in deep water then return to the surface. Fish may also seek out and congregate in fresh water flows or along shore where there might be groundwater seepage. Both activities may also occur in response to the presence of some toxic chemicals.

2. Extreme lethargy -- When fish do not respond readily to stimuli, even though appearing rather normal, and can be caught easily by hand, a number of possibilities are indicated including surfactants, pesticides, and ammonia.

3. Extreme agitation -- Many toxicants at acute levels cause an extremely agitated response. Included here are exposure to high or low pH, chlorine, cyanide, and some phenols, to name a few. The response to cyanide is quite characteristic, with the fish skittering on the surface often in a circular pattern. Fish about to expire from ammonia and chlorine poisoning may show a violent swimming burst immediately before death, especially if disturbed.

The following is a list of some distress symptoms to be looked for and recorded:

1. Breathing rate (opercular beats/minute)
2. Convulsive reactions
3. Gulping air
4. Light avoidance or attraction
5. Jumping
6. Hyperactive
7. Lethargy
8. Whirling
9. Loss of equilibrium

In addition to activity patterns which may be obvious, there are certain reactions on the surface of the body to note. These include:

1. Discoloration of skin, fins, gills, eyes.

2. Lesions (including physical injury) and ulcers.

3. Surface hemorrhaging (blood spots may occur due to a variety of toxicants including acids, fluoride, some pesticides and surfactants).

4. Ectoparasitism of skin, fins, gills.

5. Excessive mucus accumulation (may indicate exposure to heavy metals or some phenols).

6. Bulgy eyes.

Sampling

Sampling Locations

As previously indicated, samples must be taken at several locations. These include:

1. Kill area.

2. Below/downstream from the kill area.

3. Effluent site or pollution source.

4. Upstream from the suspected source.

5. In-plant site (when necessary).

When an investigator arrives at the site of a fish mortality and verifies it as probably pollution-caused, a water sample should be collected immediately. Instructions and container descriptions for water samples are on page 18. The investigator should then move to successive downstream locations (usually bridges) following dead or distressed fish or discolored water to see if the toxic zone or slug can be found. If distressed fish are observed at one or

more locations, water samples(s) should be collected immediately at those sites or slightly downstream from them. Where fish are scarce or absent, it may be necessary to check for dead or distressed invertebrates on the stream bottom before sampling. Downstream water sampling may seem futile at times, but data from apparently nontoxic samples collected far downstream from the source have proven a violation. Some judgment must be exercised regarding where to collect samples and the number needed.

Once the lethal slug or toxic zone has been sampled, or the possibility thereof is ruled out, the investigator should next attempt to locate the source. To do this, successive upstream locations from the originally reported kill site are observed and sampled until a location is found where fish appear normal. The source is now bracketed between this upstream site and the kill area and must then be sought out on foot either by walking the stream banks or by making successive downstream inspections from the nearest roads. Topographic maps of the area are invaluable aids for locating likely spots such as buildings near streams. Often dead fish and invertebrates can be traced upstream to the actual discharge point.

Water Samples

Water samples serve a dual purpose. Part of a sample is used for chemical analysis and some is used for toxicity tests (e.g. static bioassays to determine if the sample is toxic to aquatic life). At least a 1/2-gallon (preferably one gallon) water sample is needed from each station. Plastic containers are preferred for most water sampling because they are less subject to breakage and are easier to carry in the field. However, glass containers must always be used when the sample is suspected to contain oils, petroleum derivatives or other organic chemicals (solvents, phenols, pesticides). Some precautions are also necessary in choosing bottle caps and cap liners. Plastic caps (no liner) or caps with a plastic or Teflon® liner are best. Aluminum foil, commonly used and recommended as a cap liner for samples containing petroleum products, should not be used with very acidic, basic (caustic) or highly chlorinated water samples.

If possible, always use new sample bottles and thoroughly rinse each two or three times with the sample water before collecting the sample. Plastic containers should not be reused. If it is necessary to reuse glass containers, first clean them thoroughly according to the following steps:

1. Rinse well with tap water.

2. Wash completely with detergent and hot water, then rinse thoroughly with hot water.

3. Rinse with pesticide grade acetone, hexane or another acceptable organic solvent and rinse again with tap water.

4. Rinse with dilute acid.

5. Rinse very thoroughly with distilled/deionized water.

Normally stream samples are taken mid-depth without skimming the surface by lowering the bottle to collection depth and then removing the cover. Use gloves to protect skin from contaminants that may irritate or be absorbed through it. Covers should be replaced before withdrawal to exclude air. When there are visible floating materials (e.g., oils), an additional sample of the surface material should be taken.

Fish Samples

Fish samples collected during a pollution-caused kill are usually not as important to the investigation as the water samples. In fact, fish killed by many of the common lethal agents such as low DO, pH and chlorine are of no value for chemical analyses. However, fish should always be collected for chemical analysis if the suspected cause of death involves pesticides, phenols or cyanide. Fish from natural mortalities, should not be routinely collected.

Pathological services for addressing disease and abnormality problems are available through the Department of Avian and Aquatic Medicine at Cornell University. See the section on Fish Pathology on page 25.

Fish samples for chemical analysis should include about six or more of the larger individuals (preferably $\geq$8 inches) of several species. These should be individually wrapped in aluminum foil or placed in plastic bags and grouped according to location and species. Only distressed (moribund) or recently dead fish (i.e., no apparent decomposition) should be collected. Fish samples from a pollution-caused mortality should not only include toxicant-affected fish, but also healthy fish from at least one unaffected upstream area which will be used as controls for chemical comparisons.

Labeling, Sample Care and Transfer

It is extremely important that all water and fish samples be labeled completely and clearly with a waterproof or permanent marker. The label for each sample should

include exact location, date, time, collector's name, plus any other pertinent information, such as name of suspected toxicant or type of industry involved, which may prove helpful to the scientists during analysis.

Fish and water samples should immediately be placed on ice in a cooler and, if possible, delivered to the EDIU within 24 hours. If quick delivery is impractical, water samples should be stored in a refrigerator at 3-4°C (37-39°F) and fish samples should be frozen. Access to storage refrigerators and freezers must be controlled because of legal implications. Chemical techniques for preserving water samples to be analyzed for particular contaminants are indicated in various reference manuals. Information can be obtained by contacting an EDIU chemist. Preservatives should not be added to any water samples to be used for toxicity tests. Fish specimens must never be placed in water samples because they will affect the results of subsequent chemical or biological tests.

It is best that samples are delivered to the laboratory as soon as practical, preferably within 24 hours. Delivery of the samples is a regional responsibility and arrangements should be made through the RC prior to transfer. A chain of custody or Continuity of Evidence form similar to that shown as Appendix 7 must accompany all samples transferred for analysis. A copy should be kept with original case records.

Measurements

During most fish kill investigations it is necessary to measure a few basic water quality parameters while in the field because they can change during sample storage. Suggestions for a few of the common parameters are given in the following paragraphs.

Temperature

A good grade thermometer should be used and, if possible, it should be checked with a thermometer certified by the National Bureau of Standards (NBS) or one traceable to such a standard. The EDIUs can check thermometers that are to be used for fish mortality investigations. Remember that rapid temperature change alone can be lethal to aquatic life.

pH

The pH should be measured in the field using a properly maintained and calibrated pH meter and electrode. Colorimetric kits can be used for spot checks, but a pH meter and probe must be used for obtaining accurate data particularly when possible violations are involved. It is

generally recognized that pH levels below 4 and above 10 are rapidly lethal to most species of freshwater fish. Depending on conditions and species, acute mortality may occur at slightly higher or lower levels around both extremes.

Chlorine (total residual)

When chlorine is the suspected cause, it is best measured in the field. Field kits employing the DPD (N,N-diethyl-p-phenylenediamine) colorimetric method are available. Keep in mind that some reagents in field kits deteriorate, become outdated and need to be replaced. Use the best available procedure employing proper techniques. Work on the assumption that some data is better than no data.

If chlorine measurements cannot be made in the field, then samples for chlorine determination should be obtained in properly cleaned bottles, filled to the top, and tightly capped. All caps should be made of an inert material or have an inert liner (plastic or Teflon®). Keep samples cold, avoid exposure to light and agitation, and transport to a lab for analysis as soon as possible utilizing Continuity of Evidence Forms (Appendix 7). It is often possible to make arrangements for analysis at a local sewage treatment plant (STP), water filtration plant, or other facility having the necessary equipment.

It is generally recognized that total residual chlorine levels down to a few tenths of a mg/L are rapidly lethal to freshwater organisms. However, static laboratory toxicity tests at these low concentrations are usually inconclusive due to the reactivity and dissipation of chlorine. As with most toxic chemicals, chlorine toxicity is dependent upon temperature, exposure time and the species affected. Salmonid species appear to be more sensitive than most other fishes.

Dissolved oxygen

Equipment should be available to measure DO in the field using a properly maintained and calibrated dissolved oxygen meter and electrode or the Winkler (Azide modification) titration method. These EPA-acceptable methods must be used where violations are involved. If a water sampler is necessary, only those (e.g., Kemmerer, alpha, etc.) which avoid aeration of the sample being taken should be used.

Appendix 8 presents mean lethal oxygen level data for six species of fish. It may prove helpful in deciding and proving whether a violation exists.

Five-day biochemical oxygen demand (BOD) tests are sometimes run in connection with DO cases to provide a measure of the oxygen consuming capacity of the water or wastewater samples. They are not strictly necessary to prove what killed the fish in a DO case, but they may be necessary to pinpoint the source of the oxygen demanding waste. If such test capability is not available at or through the regional office, perhaps an arrangement can be worked out with a local STP or other facility. If these options are not available or are impractical, samples for BOD testing can be kept on ice and transported within 24 hours to one of the EDIU field stations.

Other

In order to aid in establishing cause, field kits for other frequently encountered pollutants such as ammonia, copper, cyanide, etc., are available. However, data obtained with field kits should be confirmed by an accepted laboratory procedure. Suggestions for meters, kits, etc., can be obtained by contacting the EDIU chemists.

Estimating Fish Affected

An estimate of the number of fish killed is an important part of the investigative process, particularly if legal action might follow. A methodical and indisputable estimate of fishery damage is necessary to establish the extent of damage and to form a basis for punitive compensation, especially for contested cases.

It is common knowledge that mortality estimate procedures are inherently inaccurate. At best, even the most elaborate and time-consuming method provides only an estimate because dead or injured fish are obscured by debris, turbid water or float away before being counted. Also, it is very easy to overlook the very small young-of-the-year fish and only count larger or catchable-size sport fish.

Several acceptable methods for estimating numbers of fish killed are presented in the American Fishery Society's "Fish Kill Counting Guidelines"[3]. Any of these methods are professionally accepted and may be used by regional personnel, but most are very time consuming and likely too expensive to conduct. An adaptation of one of these methods has been successfully used to assess damages in New York State for over 35 years. It basically involves the following:

1. Determine the upstream and downstream limits of the kill.

2. Count and identify all visible dead fish by species over several known lengths of stream.

3. Extrapolate the results to the total area or length of stream affected.

Fish kill estimates for very small mortalities of less than 1,000 fish are usually the most accurate, especially if they occur in a small, relatively shallow, clear pond or short section of stream. In these situations, practically all the fish affected can be individually counted. The total number killed, therefore, is not an estimate but rather an actual count. For larger ponds, lakes and long stretches of streams or rivers, actual counts of all fish affected are impossible, thus estimates must be made.

On lakes and large ponds where a fish mortality has occurred, it has been common practice to make shoreline counts of dead fish, especially on the windward side where wind and wave action accumulate the fish. At times, because dead fish are numerous, actual counts of those swept along shore is impractical. Therefore, estimates have to be made based on known lengths of shoreline. This method is generally used during large natural mortalities such as the annual herring die-offs in Lake Ontario and in the Hudson River. Estimates for these situations do not necessarily have to be too accurate because no corrective action is necessary. Fisheries managers mainly need to know the magnitude of the mortality, species affected and size groups of each species affected. For large bodies of water where a contaminant is suspected to have caused the kill, counts of visible fish floating in open water should also be made and included in the total estimate in addition to shoreline counts. Methods for open water estimates are presented in the AFS guidelines.

For estimates on long stretches of stream or river it is best to first survey the entire affected area noting where dead fish are most concentrated to get an overall mental picture of the physical nature (amount of riffles, pools and laminar flow areas) of the affected area. Topographic maps should be used at this time. Several counts of dead fish for a known length of shoreline in each of these different habitats are necessary for a reasonably accurate total estimate of damage. Estimates are made for each of the habitats then extrapolated to the total length of river affected based on the percentage of total length comprised of riffles, pools, etc. This total estimate should include all dead fish, young and old, small and large, and sport as well as nonsport species.

Toxic Conditions -- No Fish Present

In places where localized pollution is quite serious, fish and most other aquatic life forms may be absent. For these cases, no obvious fish kill may ever be brought to anyone's attention simply because no fish are present. These situations may not be very obvious because the water often is clear and looks clean. Regions should have an aquatic biologist, either a regional biologist or one of the EDIU biologists, inspect any of those areas where toxic conditions are suspected.

For areas where toxic problems occur or are thought to occur, on-site or in situ toxicity tests with fish can be conducted to isolate the source of the contaminant. These biological tests are especially helpful for investigating suspected chronic pollution situations where discharges are intermittent and/or continuous sublethal effects are suspected.

Little equipment is needed to conduct in situ toxicity tests and the technique is simple to learn. Basically, fish are placed in plastic minnow traps (entrance holes plugged) located at strategic locations in the water. Mortalities are monitored daily until the source is bracketed between affected and unaffected cages. The source can then be located and sampled for subsequent chemical and biological laboratory analyses. With these data, provided standard procedures are followed, a violation of Environmental Conservation Law can be proven.

EDIU members can give detailed instructions and assistance with in situ testing and, in fact, it is suggested that they be contacted before testing to ensure that all phases are accomplished correctly. The regions may choose to request that the EDIU coordinate any in situ testing with assistance from regional staff.

IV. FISH PATHOLOGY

The Fish Pathology Laboratory at Cornell University has operated since 1984 as a collaborative effort between Cornell and DEC to assess lesions and diseases in feral and stocked fish populations throughout New York State. The main objective of this cooperative fish pathology project is to investigate possible associations between environmental contaminants and fish health.

If possible, notify the Fish Pathology Lab beforehand in order to coordinate and confirm fish collection, handling and delivery. It may also be necessary to obtain related collection site information on basic water quality parameters (temperature, DO, pH, conductivity, etc.) and possible pollutant sources (upstream industrial or municipal discharges) for proper diagnostic and toxicological work to be carried out.

Submission of Fish Samples

1. Ideal samples: An ideal sample from a fish mortality for microbiological and histological workup would be 10 or more moribund live or freshly dead fish. An ideal sample for pathological workup for abnormalities or tumors would be 20 fish of representative size which are alive (kept in water in a cooler) or are freshly dead (kept on ice). If possible, samples should be delivered within 24 hours of collection.

2. Live fish: The most desirable sample for pathological study is a number of live fish exhibiting the lesion of concern. Submission of live fish ensures the maximal likelihood of a complete diagnosis. If a mass mortality occurs, 10 or more moribund live fish would be a good submission. With live fish, blood cells can be studied, various tissues can be cultured for bacterial pathogens, virus isolation procedures can be carried out, excellent histological sections of any lesions such as neoplasms (tumors) can be obtained, electron microscopic studies can be done, and a complete necropsy can be conducted to ensure that no lesions of any tissue are overlooked.

3. Iced fish: The second most desirable type of submission would be whole freshly dead fish on ice (<u>not frozen</u>). Because fish undergo autolysis (decomposition) much more rapidly after death than warm-blooded animals, even when held on ice, the more rapidly dead iced fish samples are received, the better. Dead iced fish received

within 1-3 days after death can be used for complete necropsies, tissue culture for bacterial pathogens, isolation of certain hardy viruses, and the examination of various tissues for histologic lesions.

4. Formalin-fixed fish: The third and least desirable choice for submission would be formalin-fixed, whole small to medium-sized fish, or formalin-fixed pieces of lesions from large fish. Histopathologic studies can be conducted on such samples and parasites in tissues can often be identified. Fish or samples of fish tissues should be fixed in at least ten times their volume of 10% formalin, preferably neutral buffered formalin (100 mL 40% formaldehyde, 900 mL tap or distilled water, 4 grams $NaH_2PO_4 \cdot H_2O$, 6 grams Na_2HPO_4). The belly of a whole fish should be slit open prior to fixation to ensure complete fixation. Pieces of lesions fix best if they are 5 mm or less in thickness.

5. Frozen fish: Only very limited pathology information can be obtained from a frozen fish. A necropsy can be done to look for grossly observable lesions. Certain parasites may be identifiable. It may be possible to determine whether a mass is a neoplasm or inflammation; however, freeze artifacts make such a determination difficult or impossible. Given a neoplasm, it would be unlikely to tell what kind of neoplasm it is from frozen tissue.

Sample Delivery

The best way to ensure proper, speedy delivery of fish samples to the Fish Pathology Laboratory is to personally deliver the fish. If this is inconvenient, particularly for those in areas of the state far from Cornell, freshly dead fish can be wrapped in plastic bags and placed on 3-5 pounds of ice (frozen cold packs or plastic bottles are less likely to leak) in a sturdy plastic cooler (or sturdy 1"-thick styrofoam cooler placed in a cardboard box). Such a cooler should be sent overnight UPS or Federal Express. Overnight packages are best sent sometime during Monday-Wednesday so that if a delay occurs, the package is unlikely to sit on a loading dock over the weekend. Once formalin-fixed samples have been fixed in 10 times their volume of formalin for 24 hours, the fixed samples can be placed in a small amount (10-20 mL) of 10% formalin in a Ziploc® plastic bag. To prevent leakage, this bag should be placed inside a second Ziploc® bag. Tape the seals on both of the bags. The bag of specimens should be

surrounded by packing material such as newspaper or styrofoam beads in a sturdy cardboard box and shipped via U.S. mail or UPS. Packages should be addressed to Dr. Jan Spitsbergen, Department of Avian and Aquatic Animal Medicine, Schurman Hall, New York State College of Veterinary Medicine, Cornell University, Ithaca, NY 14853. Please call the lab to notify personnel of the shipment (phone 607-253-3365).

V. CONCLUDING STATEMENT

It is hoped that this information will help to solve some of the problems inherent in the fish kill investigation program. The functioning of regional coordinators and of well-defined and maintained response plans should help to eliminate confusion and enhance communication. Some information and guidelines included in this report will, no doubt, have to be revised as the program evolves. If any questions arise which are pertinent to fish kills, contact the appropriate Environmental Disturbance Investigations Unit for guidance and assistance.

TABLE 1. ENVIRONMENTAL DISTURBANCE INVESTIGATION UNITS
- personnel and phone numbers -

REGIONS	APPROPRIATE EDIU	OFFICE PHONE
1*, 2*, 3, 4, 5, 6	Hale Creek Field Station	518-773-7318
		HOME PHONE
	Joseph Spodaryk Associate Analytical Chemist	518-883-5620
	Timothy Preddice Senior Aquatic Biologist	518-725-7206
		OFFICE PHONE
7, 8, 9	Avon Field Station	716-226-2466
		HOME PHONE
	Gary Neuderfer Associate Aquatic Biologist	716-424-4926
	Robert Bauer Senior Analytical Chemist	716-582-1527

During normal working hours on week days, the office telephone should be called. During all other hours, attempt to contact staff at home. If no contact is made, the following Bureau of Environmental Protection (BEP) staff should be called:

Lawrence Skinner 518-283-7661 (home phone)
Principal Fish & Wildlife Ecologist

James Colquhoun 518-439-1231 (home phone)
Chief Fish & Wildlife Ecologist

*Analytical chemical services are provided to Regions 1 and 2 at the Hale Creek Field Station.

Questions regarding pathology, tumors, etc., in wild fish can be referred to the Department of Avian and Aquatic Animal Medicine at Cornell University:

Dr. Jan Spitsbergen - 607-253-3365.

Very large fish kills and those possibly involving unusual, rare or endangered species should also be reported to the Curator of Ichthyology at the NYS Museum (Education Dept.)--Biological Survey:

Dr. Robert Daniels - 518-283-9005

NOTE: Table 1 phone numbers are current as of February 1, 1990.

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2. New York State Department of Environmental Conservation. 1986. Environmental Conservation Law of New York Vol. 1. Gould Publications, Binghamton, NY.

3. American Fisheries Society. 1982. Monetary values of freshwater fish and fish-kill counting guidelines. Am. Fish. Soc., Spec. Publ. no. 13. 40pp.

4. Data contained in Appendix 8 are taken from the following sources:

   a) Burdick, G. E., M. Lipschuetz, H. J. Dean, and E. J. Harris. 1954. Lethal oxygen concentrations for trout and smallmouth bass. NY Fish & Game Jour. 1(1):84-97.

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   c) Cooper, A. L. 1960. Lethal oxygen concentrations for the northern common shiner. NY Fish & Game Jour. 7(1):72-76.

VII. SUGGESTED REFERENCES

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