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DEPARTMENT OF FISHERIES AND OCEANS

PACIFIC REGION

**GUIDELINES FOR THE USE OF EXPLOSIVES
IN CANADIAN FISHERIES WATERS**

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INTRODUCTION

SCOPE AND OBJECTIVES

The Minister of Fisheries and Oceans is responsible for the protection of fish, shellfish, crustaceans, marine mammals and their habitats. The detonation of explosives in or adjacent to fish habitat has been demonstrated to cause disturbance, injury and/or death to fish and marine mammals, and/or disturbance, destruction or alteration of their habitats, sometimes at a considerable distance from the point of detonation (Wright 1982, Wright in prep.). Within the context of these guidelines, an explosive is defined as a chemical compound which, when detonated, creates a compressional wave having an almost instantaneous rise time to a very high peak pressure followed by a decay to below ambient pressure by either rapid oxidation or the breaking of high-energy chemical bonds.

A number of sections of the Fisheries Act and its attendant regulations are applicable to the protection of fish and fish habitat from the destructive forces of explosives.

Fisheries Act

- Section 2 defines "Canadian Fisheries Waters" as meaning all waters in the fishing zones of Canada, all waters in the territorial sea of Canada and all internal waters of Canada.
- Section 2 defines "fish" as including shellfish, crustaceans, marine animals and the eggs, spawn, spat and juvenile stages of fish, shellfish, crustaceans and marine animals.
- Section 32 prohibits the destruction of fish by any means other than fishing, except as authorized by the Minister or under regulations made by the Governor in Council under the Act.
- Section 34(1) defines "fish habitat" as meaning spawning grounds and nursery, rearing, food supply, overwintering and migration areas on which fish depend directly or indirectly in order to carry out their life processes.
- Section 35(1) prohibits any person from carrying on any work or undertaking that results in the harmful alteration, disruption or destruction of fish habitat; and
- Section 35(2) allows for the alteration, disruption, or destruction of fish habitat by any means or under any conditions authorized by the Minister or under regulations made by the Governor in Council under this Act.

Fishery (General) Regulations

- Section 58(1) instructs persons who propose to carry on any work or undertaking that results in the harmful alteration, disruption or destruction of fish habitat and who wish to have

the means or conditions of that work or undertaking authorized by the Minister under Subsection 35(2) of the Act to apply to the Minister in a form set out in Schedule IV.

- Section 58(2) instructs the Department of Fisheries and Oceans to issue authorizations under Subsection 35(2) of the Act and to do so in the form set out in Schedule VII.

Marine Mammal Regulations

- Section 7 prohibits disturbance of marine mammals except when fishing for them.

The following guidelines have been prepared by the Department of Fisheries and Oceans (DFO) for use by proponents seeking authorization to destroy fish by means other than fishing or to alter, disturb or destroy fish habitat through the use of explosives. The guidelines are to be applied within Canadian Fisheries Waters pursuant to Sections 32 and 35(2) of the Fisheries Act. The guidelines are intended to provide a minimum standard for the protection of fish and fish habitat. The terms and conditions associated with specific authorizations may be more stringent than the minimum standard of these guidelines in order to satisfy applicable regulations or site-specific fishery resource protection requirements.

Proponents also should ensure that wildlife and other resources are protected and other regulatory agencies are contacted.

RATIONALE

The detonation of explosives in or near water produces post-detonation compressive shock waves characterized by a rapid rise to a high peak pressure followed by a rapid decay to below ambient hydrostatic pressure. The latter pressure deficit causes most impacts on fish.

The primary site of damage in finfish is the swim bladder, the gas-filled organ that permits most pelagic fish to maintain neutral buoyancy. The kidney, liver, spleen, and sinus venosus also may rupture and haemorrhage. Fish eggs and larvae also may be killed or damaged (Wright 1982).

The degree of damage is related to type of explosive, size and pattern of the charge(s), method of detonation, distance from the point of detonation, water depth, and species, size and life stage of fish. Vibrations from the detonation of explosives may cause damage to incubating eggs (Wright 1982, Wright in prep.).

Sublethal effects, such as changes in behaviour of fish, have been observed on several occasions as a result of noise produced by explosives. The effects may be intensified in the presence of ice and in areas of hard substrate (Wright 1982, Wright in prep.).

The detonation of explosives may be lethal to marine mammals and may cause auditory damage under certain conditions. The detonation of explosives in the proximity of marine mammals also has been demonstrated to induce changes in behaviour (Wright in prep.).

The number of shellfish and crustaceans killed is believed to be negligible, however, few data are available. Sublethal effects of explosives on shellfish and crustaceans including behavioral modifications are little known or understood (Wright 1982, Wright in prep.).

The use of explosives in and near fish habitat also may result in the physical and/or chemical alteration of that habitat. Sedimentation resulting from the use of explosives may cover spawning areas or may reduce or eliminate bottom-dwelling life forms that fish use for food. By-products from the detonation of explosives may include ammonia or similar compounds and may be toxic to fish and other aquatic biota (Wright in prep.).

In summary, the use of explosives may result in a number of adverse impacts on fish and marine mammals and their habitats. Therefore, DFO has developed the following guidelines to provide information to proponents on the protection of fish, marine mammals and their habitats from impacts arising from the use of explosives in and near water.

EXPLOSIVE USE GUIDELINES AND PROCEDURES

GUIDELINES

1. These guidelines apply to all Canadian Fisheries Waters to which the Fisheries Act and pursuant regulations apply. Where the administration of fisheries is a provincial responsibility, the proponent should consult with the relevant provincial authority.
2. The Department of Fisheries and Oceans (DFO) discourages the use of explosives in and near Canadian Fisheries Waters and encourages proponents to utilize other potentially less destructive methods wherever possible.
3. Proponents considering the use of explosives must consult the appropriate DFO Regional/Area Authorities (Appendix I) as early as possible in the planning process to identify possible alternatives to the use of explosives, the biological resources at risk and/or effective mitigative measures.
4. Authorizations under Sections 32 and/or 35(2) of the Fisheries Act to destroy fish and/or to alter, disturb or destroy fish habitat through the use of explosives in Canadian Fisheries Waters will be granted if the proponent can demonstrate that:
 - a) the use of explosives is the only technically feasible means to attain the desired objective; and
 - b) mitigative measures to reduce the effects on fish and fish habitat to insignificance will be employed; or

- c) no fishery resource or fish habitat is at risk; or
 - d) the use of explosives is required to alleviate an emergency situation threatening human safety and/or property.
5. Ammonium nitrate based explosives, specifically ammonium nitrate - fuel oil mixtures (ANFO), must not be used in or near water due to the production of toxic by-products (ammonia).
6. No explosive may be used that produces, or is likely to produce, an instantaneous pressure change greater than 100 kPa (14.5 psi) at a distance greater than 10 metres from the point of detonation.
Recommended set-back distances for on-land or buried charges required to meet the 100 kPa standard or to determine the zone of lethal impact are shown in Table 1. Equations to derive these relationships have been adapted from Nicholls et al. (1971) and duPont (1977) and are described in Appendix III. A "set-back distance" is the straight line distance through the substrate from the center of the charge to the waterbody.
7. No explosive may be used that produces, or is likely to produce, a peak particle velocity greater than $13 \text{ mm}\cdot\text{s}^{-1}$ in a spawning bed during egg incubation.
Set-back distances from spawning beds required to limit peak particle velocity to $13 \text{ mm}\cdot\text{s}^{-1}$ or less are shown in Table 2. Equations used to derive this relationship are described in Appendix IV.
8. If guidelines 6 and 7 cannot be met, the proponent will be required to assess the potential impacts of the project on fish and fish habitat, and develop a mitigation plan as outlined below.
- a) The proponent will prepare an environmental impact assessment of the project and the potential adverse effects on the fish and marine mammal resources and their habitats in the project area for submission to the DFO Regional/Area authority. This assessment should include:
 - i) an outline of fish, marine mammal species and their habitats found within the project's zone of influence;
 - ii) timing of any seasonal migration;
 - iii) the theoretical lethal range of the explosives to be used (from equations provided in Appendix IV);
 - iv) an assessment of potential impacts arising from the use of explosives and a description of proposed mitigation to reduce the impacts of the project; and

- v) identification of any project operation which may overlap or possibly conflict with other habitat or resource uses such as marine parks, aquaculture, major fishing grounds, archaeological sites, etc.
- b) The proponent will prepare a plan to mitigate adverse effects on fish and fish habitat identified in the environmental impact assessment. This plan should be discussed with DFO Regional/Area Authorities as early as possible in the design stage. The mitigation plan should include the following measures:
 - i) the project should be undertaken at the time of least biological activity or biological sensitivity. Proponents should consult with DFO Regional/Area Authorities to determine the appropriate timing;
 - ii) if multiple charges are required, time-delay detonation initiators (blasting caps) should be used to reduce the overall detonation to a series of discrete explosions; and
 - iii) if possible, large charges should be subdivided into a series of smaller charges (a procedure known as decking) using time-delay detonation initiators (blasting caps) to reduce the overall detonation to a series of smaller discrete detonations or explosions.

The proponent should consider additional mitigation measures for the mitigation plan including but not limited to the following measures:

- i) deployment of bubble curtains/air curtains to disrupt the shock wave;
- ii) detonation of small scaring charges, consisting of detonator caps or short lengths of detonating cord, set off one minute before the main charge to scare fish away from the site;
- iii) physical removal or exclusion of fish from the work area before the blast;
- iv) replacement or enhancement of the habitat upon completion of the blasting.

These or other additional mitigation measures may be required by DFO.

- 9. After loading a charge in a hole, the hole must be back-filled (stemmed) with sand or gravel to the level of the substrate/water interface or the hole collapsed to confine the force of the explosion to the formation being fractured.
- 10. All "shock-tubes" and detonation wires must be recovered and removed after each blast.
- 11. No chemical explosive is to be knowingly detonated within 500 m of any marine mammal (or no visual contact from an observer using 7x35 power binoculars). A greater avoidance

distance may be imposed by the DFO Regional/Area authority depending on the size of the charge or other project or fishery resource specific conditions.

12. All requests to use explosives as an acoustic energy source in geophysical surveys or other applications such as demolition or ice management will be reviewed on a case-by-case basis. A rationale for the use of explosives, an impact assessment and a detailed mitigation plan must be provided.
13. The proponent may be required to undertake a monitoring program in consultation with DFO personnel and at the proponent's expense to determine the effectiveness of mitigation measures.
14. If the adverse effects of the explosives are significantly greater than anticipated, all further use of explosives for the project shall cease immediately pending review of the situation with DFO personnel.
15. The proponent may be required to prepare a report describing the project, the mitigation strategy used to reduce impacts, the effectiveness of the mitigation program, and any residual impacts of the project.
16. Additional site specific terms and conditions may be required restricting timing, location and activities for the protection of fish and fish habitat.

APPLICATION PROCEDURES

Note: a DFO authorization does not relieve the proponent of responsibilities to obtain other required approvals/Permits.

1. Proponents should consult DFO as early as possible in the planning process to help identify potential issues before irrevocable commitments (such as contracts for equipment/services) are made and to avoid any unnecessary delays in the approval process.
2. Proponents unable to guidelines 6 and/or 7 must complete and submit an application for authorization under section 32 of the Fisheries Act to kill fish by means other than fishing (see appendix ii) Application forms are available from the appropriate DFO Regional/Area Office (see Appendix I), and must be submitted at least 28 days before the date of the intended use. If an unforeseen need to use explosives arises, the 28-day application review period may be waived and an authorization issued as expeditiously as possible so as not to unduly delay a project.
3. Proponents whose undertakings may result in the harmful alteration, disruption or destruction of fish habitat and who wish to have the conditions of that undertaking authorized by the Minister under Section 35(2) of the Fisheries Act should apply to the

Minister , through the appropriate DFO Regional/Area Office, in the form set out in Appendix III.

4. The 28-day prior notification requirement is waived in the event of an emergency where lives and/or property are threatened. In such cases, the amount of information required may be reduced due to the urgency of the situation. Any verbal request for an authorization must be followed by a written confirmation of the project details.
5. If applicable, when an Authorization is issued, proponents must notify the Canadian Coast Guard for issuance of a "Notice To Mariners" and a "Notice To Fishermen" and are encouraged to give public notice of intended activities through local newspapers and fishermen's broadcasts or other appropriate media.
6. An environmental impact assessment and mitigation plan should be submitted with the application if the proponents are unable to meet guidelines 6 and 7.

If a proponent encounters difficulty in completing this assessment, consultation with DFO personnel is encouraged.

7. A DFO authorization is related to DFO concerns only and does not relieve the proponent of responsibilities to obtain other approvals/permits if required by other government departments and aboriginal management boards which may be affected by the proposal. The proponent will be responsible for obtaining any additional permits/approvals that may be required by these departments/boards. Management boards established under land claim settlements and other government agencies may require a review period longer than 28 days.

REVIEW PROCESS

DFO will review the application under the Fisheries Act, the policy for the management of fish habitat and federal environmental assessment legislation, as required. The evaluation will involve four steps:

- a) determination of the adequacy of the information provided by the proponent;
- b) analysis of the information provided and assessment of the extent of risk or potential damage to fish and fish habitat resources and the acceptability of this level of damage;
- c) determination of the probable success of proposed mitigation measures and consequently the acceptability of any residual impacts; and
- d) contacting other relevant agencies with respect to fisheries resource concerns

An authorization/authorizations under the Fisheries Act will be issued if the impacts to fish and fish habitat arising from the project can be reduced to insignificant levels.

UPDATING

These guidelines will be reviewed and updated as necessary.

REFERENCES

- duPont. 1980. Blasters handbook. 16th edition Explosives Products Division, E.I. duPont de Nemours & Co. Wilmington, Delaware. 414 p.
- Nicholls, H.R., C.F. Johnson, and W.I. Duvall. 1971. Blasting vibrations and their effects on structures. U.S. Dept. of Interior, Bureau of Mines, Washington, D.C. Bull. 656. 105 p.
- Wright, D.G., 1982. A discussion paper on the effects of explosives on fish and marine mammals in the waters of the Northwest Territories. Can. Tech. Rep. Fish. Aquat. Sci. 1052: v + 16 p.
- Wright, D.G., in prep. The effects of the use of explosives on fish and marine mammals, including models to predict their impact and mitigation strategies to reduce the effect on fish and marine mammals. Can. Tech. Rep. Fish. Aquat. Sci. xxxx: xx + xx p.

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Table 1. Set-back distance (m) from point of detonation to general fish habitat for various substrates

Substrate	Weight of Explosive Charge (kg)						
	0.5	1	5	10	25	50	100
Rock	7	10	15	20	35	50	70
Frozen Soil	5	8	14	20	31	45	62
Ice	5	8	13	18	30	40	55
Saturated Soil	4	6	12	18	28	40	55
Unsaturated Soil	3	5	10	12	20	28	40

Table 2. Set-back distance (m) from point of detonation to spawning habitat for all types of substrate.

Weight of Explosive Charge (kg)	0.5	1	5	10	25	50	100
Set-back distance (m)	15	20	45	65	100	143	200

Appendix 1 DFO Regional/Area Contacts - Pacific Region

Habitat And Enhancement Branch

North Coast Division

Area Chief
Habitat And Enhancement Branch
South 417-2nd Ave. W.
Prince Rupert, BC V8J 1G8
Voice: (604) 624-0453
Fax: (604) 627-3056

South Coast Division

Area Chief
Habitat And Enhancement Branch
3225 Stephenson Pt. Road
Nanaimo, BC V9T 1K3
Voice: (604) 756-7284
Fax: (604) 756-7162

Fraser River Division

Area Chief
Habitat And Enhancement Branch
610 Derwent Way
Annacis Island
New Westminster, BC V3M 5P8
Voice: (604) 666-0315
Fax: (604) 666-6627

Yukon and Northern B.C. Division

Area Chief
Habitat And Enhancement Branch
122 Industrial Road
Whitehorse, Yukon. Y1A 2T9
Voice: (403) 668-4611
Fax: (403) 668-6829

Northeastern and Southeastern B.C.

Area Chief, Eastern B.C.
Habitat Management Unit
327 - 555 Hastings Street
Vancouver, B.C. V6B 5G3
Voice: (604) 666-2057
Fax: (604) 666-7907

Appendix II. Application for Authorization to Kill Fish by Means Other Than Fishing

Page 1

I, the undersigned, hereby request authorization to carry out the works or undertakings described on this application form. I understand that the approval of this application, if granted, is from the Department of Fisheries and Oceans standpoint only and does not release me from my obligation to obtain permission from other concerned regulatory agencies

If an authorization is granted as a result of this application, I hereby agree to carry out all activities relating to the project within the designated time frames and conditions specified in the authorization.

Applicant's Name (Please Print)

Applicant's Business Address

Applicant's Telephone Number

Applicant's Facsimile Number

Date of Application

I solemnly declare that the information provided and facts set out in this application are true, complete and correct, and I make this solemn declaration conscientiously believing it to be true and knowing that it is of the same force and effect as if made under oath. This declaration applies to all material submitted as part of this application.

Applicant's Signature

Application for Authorization to Kill Fish by Means Other Than Fishing

Name of watercourse or waterbody

(including coordinates)

Nearest Community

County

Province

Provide details of proposed activity including reasons as to why explosives must be used

□

Application for Authorization to Kill Fish by Means Other Than Fishing**Schedule of Operations****Proposed starting date (D - M - Y)****Proposed completion date (D - M - Y)**

The following documents will assist in assessing your application and help expedite its approval. Please check which documents you have attached.

- | | |
|---|-----|
| Map indicating location of project | [] |
| Engineering specifications | [] |
| Dimensional drawings | [] |
| Assessment of fish and marine mammal community | [] |
| Assessment of potential effects of project on fish and marine mammals | [] |
| Measures proposed to mitigate potential damage to fish and marine mammals | [] |
| Measures to compensate for the loss of fish and marine mammals | [] |
| Other | [] |

Application for Authorization to Kill Fish by Means Other Than Fishing

Explosives Contractor (If different from applicant)

Name

Address

Telephone number

Facsimile number

Details of Explosives

Type (including trade name)

Total weight of explosive to
be used (kg)

Weight of individual shots /

Weight per delay

Shot pattern

Detonation depth

Delay period (msec)

Method of detonation

Appendix III. Application for Authorization for Works or Undertaking Affecting Fish Habitat

Appendix IV. General Equations To Determine Set-Back Distance And Lethal Impact Zone For Buried Explosives

Equation (A)

$$P_W = \frac{2 (Z_W/Z_R) P_R}{1 + (Z_W/Z_R)}$$

P_W = pressure (kPa) in water
 P_R = pressure (kPa) in substrate
 Z_W = acoustic impedance of water
 Z_R = acoustic impedance of substrate

describes the transfer of shock pressure from the substrate to the water.

Equation (B)

$$\frac{Z_W}{Z_R} = \frac{D_W C_W}{D_R C_R}$$

D_W = density of water = $1 \text{ g}\cdot\text{cm}^{-3}$
 D_R = density of the substrate in $\text{g}\cdot\text{cm}^{-3}$
 C_W = compressional wave velocity in water
 = $146,300 \text{ cm}\cdot\text{s}^{-1}$
 C_R = compressional wave velocity in substrate in $\text{cm}\cdot\text{s}^{-1}$

describes the relationship between acoustic impedance and the density and velocity of the medium through which the compressional wave travels.

the following values are used for D_R and C_R for various substrates:

Substrate	D_R ($\text{g}\cdot\text{cm}^{-3}$)	C_R ($\text{cm}\cdot\text{s}^{-1}$)
Rock	2.64	457,200
Frozen Soil	1.92	304,800
Ice	0.98	304,800
Saturated soil	2.08	146,300
Un-saturated soil	1.92	45,700

Equation (C) $V_R = \frac{2 P_R}{D_R C_R}$

describes the relationship between the peak particle velocity (V_R) and the pressure, density and compressional wave velocity in the substrate.

Equation (D) $V_R = 160 (R/W.5)^{-1.6}$

$V_R =$ peak particle velocity in $\text{cm}\cdot\text{s}^{-1}$

$R =$ the distance to the blast in m

$W =$ the charge weight in kg

is known as the scaled distance relationship and is used to equate the peak particle velocity to charge weight and distance:

□

Appendix V. Sample Calculation

Example: calculations to determine the set-back distance or probable zone of lethal impact for a 25 kg charge set in rock to meet 100 kPa limit

1. From Equation (B):

$$\begin{aligned} Z_W/Z_R &= \frac{D_W C_W}{D_R C_R} \\ &= \frac{(1 \text{ g}\cdot\text{cm}^{-3}) (146,300 \text{ cm}\cdot\text{s}^{-1})}{(2.64 \text{ g}\cdot\text{cm}^{-3}) (457,200 \text{ cm}\cdot\text{s}^{-1})} \\ &= 0.1212 \end{aligned}$$

2. From Equation (A):

$$\begin{aligned} P_W &= \frac{2 (Z_W/Z_R) P_R}{1 + (Z_W/Z_R)} \\ P_W &= \frac{(2) (0.1212) P_R}{(1) + (0.1212)} \\ P_W &= 0.22 P_R \end{aligned}$$

3. To limit P_W to 100 kPa($\text{kg}\cdot\text{m}\cdot\text{s}^{-2}\cdot\text{m}^{-2}$)

$$\begin{aligned} P_R &= \frac{P_W}{0.22} \\ P_R &= \frac{100 \text{ kPa}}{0.22} \\ P_R &= 455 \text{ kPa} \\ &= 4.55 \times 10^2 \text{ kPa} \\ &\square \end{aligned}$$

4. Convert kPa to dynes ($\text{g}\cdot\text{cm}\cdot\text{s}^{-2}$)

$$\text{dynes} = \text{kPa} \times 10^4$$

$$P_R = 4.55 \times 10^2 \times 10^4$$

$$P_R = 4.55 \times 10^6 \text{ dynes } (\text{g}\cdot\text{cm}\cdot\text{s}^{-2})$$

5. From Equation (C):

$$V_R = \frac{2 P_R}{D_R C_R}$$

$$V_R = \frac{(2) (4.55 \times 10^6 \text{ g}\cdot\text{cm}\cdot\text{s}^{-2})}{(2.64 \text{ g}\cdot\text{cm}^{-3}) (457,200 \text{ cm}\cdot\text{s}^{-1})}$$

$$V_R = 7.54 \text{ cm}\cdot\text{s}^{-1}$$

6. From Equation (D):

$$V_R = 160 (R/W)^{.5} - 1.6$$

$$R = (W)^{.5} (V_R/160)^{-0.625}$$

$$R = (25 \text{ kg})^{.5} (7.54 \text{ cm}\cdot\text{s}^{-1}/160 \text{ kg}\cdot\text{cm}\cdot\text{s}^{-1}\cdot\text{m})^{-0.625}$$

$$R = 33.74 \text{ m}$$

Therefore a 25 kg charge of explosives detonated in rock requires a set-back of 33.74 m from general fish habitat in order to reduce the overpressure produced by the detonation to less than 100 kPa.

Similarly, a charge of 25 kg detonated in the rock substrate of a stream would produce a lethal zone with an approximate radius of 33.74 m.

Since the area of overpressure (>100 kPa) would exceed 10 m (guideline 6), a full mitigation plan would need to be developed by the proponent and approved by DFO Regional/Area authorities (guideline 8).