Bulletin No. 148

(Second Edition, revised)

A Guide to the Properties, Characteristics, and Uses of Some General Anaesthetics for Fish

Gordon R. Bell

Fisheries Research Board of Canada • Ottawa • 1967

A GUIDE TO THE PROPERTIES, CHARACTERISTICS, AND USES OF SOME GENERAL ANAESTHETICS FOR FISH

Bulletins of the Fisheries Research Board of Canada are designed to assess and interpret current knowledge in scientific fields pertinent to Canadian fisheries. Recent numbers in this series are listed at the back of this Bulletin.

Fisheries Research Board of Canada
Sir Charles Tupper Building
Ottawa 8, Ontario, Canada

The Board also publishes the *Journal of the Fisheries Research Board of Canada* in annual volumes of monthly issues, an *Annual Report*, and a biennial *Review*. Fisheries Research Board of Canada publications are for sale by the Queen's Printer, Ottawa. Remittances must be in advance, payable in Canadian funds to the order of the Receiver General of Canada. Publications may be consulted at Board establishments located at Ottawa; Nanaimo and Vancouver, B.C.; Winnipeg, Man.; Ste. Anne de Bellevue and Grande-Rivière, Que.; St. Andrews, N.B.; Halifax and Dartmouth, N.S.; Ellerslie, P.E.I.; and St. John's, Nfld.

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Price subject to change without notice

ROGER DUHAMEL, F.R.S.C.
Queen's Printer and Controller of Stationery
Ottawa, Canada
1967

FIRST EDITION PUBLISHED 1964

Contents

PREFACE

This second edition has been prepared to meet continuing demand for information on general anaesthetics used in fisheries research. Two additional anaesthetics are included and the information on the others has been updated in the fold-out chart at the back of the bulletin. For the convenience of readers, the numerous references have been annotated.

BACKGROUND INFORMATION

Agents, decribed as general anaesthetics, which reversibly depress the sensory centres of the brain to various degrees and which finally eliminate reflex action, are being used more and more widely in fisheries biology. General anaesthetics first depress the cortex (stage of analgesia), then the basal ganglia and cerebellum (stage of delirium or excitement), and then the spinal cord (stage of surgical anaesthesia). Excessive dosage or prolonged exposure leads to involvement of the medulla; paralysis of the vital respiratory and vasomotor centres is then the usual cause of death. All general anaesthetics act to varying degrees as central nervous system depressants. Information concerning the properties, characteristics, and uses of anaesthetics for fish is so widely scattered that it was desirable to assemble the essential data, as is done herein, to permit ready selection of the most appropriate anaesthetic for laboratory or field work.

The chart presented can serve only as a guide because the effects of anaesthetics are governed by numerous factors. The dosage-response data, given as fairly broad ranges, have a general use because a given dose of anaesthetic is likely to produce the same effect in a number of different species (McFarland, 1959, 1960). However, it is wise to test the dosage-response relationship on a few fish under the pertinent conditions before anaesthetizing larger numbers. The bibliography is not exhaustive and is intended to serve only as a guide to further literature, much of which has been reviewed by McFarland (1959, 1960). Personal observations are added without reference.

Hypothermia as an anaesthetic is not listed because it is a physical method, but mention must be made of its usefulness either alone or in combination with chemical anaesthetics for fish transportation (Ho and Vanstone, 1961; Rodman, 1963. See "General Bibliography"), handling (Sehdev et al., 1963. See "2-phenoxy-ethanol"), and injecting (Ho and Vanstone, 1961). Water temperatures can be lowered by adding either ice, dry ice in an isolating container, or by using mechanical refrigeration. Dry ice cooling might be accomplished by enclosing the solid in an aluminum container with gas venting ports to keep carbon dioxide from the water.

Paper No. 12 concerning the physiology and behaviour of salmonid fishes, from the Fisheries Research Board of Canada, Biological Station, Nanaimo, B.C.
Manuscript received for publication June 15, 1964; revised September 15, 1966.

Another physical method for inducing anaesthesia is electroshock but its use is probably limited to manipulations involving rapid handling.

The danger of carcinogenesis in man from the use of the anaesthetics urethan (Wood, 1956; Hueper, 1963, p. 981. See "General Bibliography") and cresol (Hueper, 1963, p. 1003) has been an important factor in excluding them from the chart presented here. In general, from these and other examples it seems wise to avoid prolonged contact with any foreign substances.

It is hoped that the effectiveness of the available anaesthetics for fish will not discourage active testing and development either by "borrowing" from the large and rapidly expanding array of anaesthetics for humans or by modifying the structure of functional groups of the present anaesthetics. Research in anaesthesiology is leading to more precise control and selection of the type and level of anaesthesia, advances which should be exploited in fisheries biology. Current opinion among anaesthesiologists is that more surgical procedures should be performed at only the analgesic level of depression in conjunction with the use of a peripheral muscle relaxant such as meprobamate. The increasing desire and need to perform complex surgery on fish will require the development of more sophisticated techniques for long-term anaesthesia than are available, to ensure the survival of the specialist as well as the "patient."

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Carbon dioxide

FISH, F. F. 1942. The anesthesia of fish by high carbon dioxide concentrations. Trans. Am. Fish. Soc., **72**: 25–29.

Used CO_2 anaesthesia in order to handle fish in 1000-gal tank trucks.

Chloral hydrate

GOODMAN, L. S., and A. GILMAN [ed.] 1965. The pharmacological basis of therapeutics. Collier-Macmillan Canada Ltd., Toronto. 3rd ed. Chapter 10.

Similarities in mode of action and pharmacology of chloral hydrate, trichloroethanol, and tribromoethanol discussed.

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1960. The use of anesthetics for the handling and the transport of fishes. California Fish Game, **46**: 407–431.

Broad yet practical experiments and discussion involving common anaesthetics. Used same fish as in 1959 paper.

Chloretone

McFarland, W. N. 1959. A study of the effects of anesthetics on the behavior and physiology of fishes. Pub. Inst. Marine Sci., **6**: 23–55.

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Meister, A. L., and C. F. Ritzi. 1958. Effects of chloretone and M.S. 222 on eastern brook trout. Prog. Fish-Cult., **20**: 104–110.

M.S. 222 judged superior to chloretone because of easier handling and less respiratory inhibition.

Nelson, P. R. 1953. Use of three anesthetics on juvenile salmon and trout. Prog. Fish-Cult., **15**: 74.

Most desirable concentration of M.S. 222, chlorobutanol, and urethan: 1:12,500, 1:2,000 and 1:190, respectively. Therapeutic ratios low, e.g. 1:10,000 M.S. 222 caused 100% mortality according to this brief report of Nelson's work.

Ether

Cherkin, A., and J. F. Catchpool. 1964. Temperature dependence of anesthesia in goldfish. Science, **144**: 1460–1462.

An investigation into the mechanism of action of anaesthetics using ether, chloroform, halothane and methoxyflurane.

Eschmeyer, P. H. 1953. The effect of ether anesthesia on fin-clipping rate. Prog. Fish-Cult., **15**: 80–82.

Found ether anaesthesia (0.5-1.5% v/v) decidedly advantageous in the marking of fingerling lake trout.

Griffiths, F. P., G. Webb, and P. W. Schneider. 1940. Ether anesthesia of steelhead trout. Trans. Am. Fish. Soc., **70**: 272–274.

Juvenile and adult steelhead anaesthetized and relaxed by immersion for 45–90 sec in 1.5–2% (v/v) solutions.

Methylpentynol

Fry, F. E. J., and K. S. Norris. 1962. The transportation of live fish, p. 595–608. *In* Georg Borgstrom [ed.] Fish as Food, Vol. II. Academic Press, New York.

Emphasis is placed on control of gaseous requirements and ammonia levels during transportation. Sedation of fish by methylpentynol, chloral hydrate, and tertiary amyl alcohol is discussed.

LAPPER, J. 1956. A short survey of methylpentynol. J. Roy. Army Med. Corps, **102**: 77–81.

Use of the drug for human therapy is discussed.

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Basic reference on transportation. Recommend use of methylpentynol, tertiary amyl alcohol, and chloral hydrate for sedation.

M.S. 222

ALLISON, L. N. 1961. The effect of tricaine methanesulfonate (M.S. 222) on the motility of brook trout sperm. Prog. Fish-Cult., **23**: 46–47.

Immobilization of spermatozoa by M.S. 222 shown to cause low fertility of eggs.

ANONYMOUS. Tricaine methanesulfonate (M.S. 222 — Sandoz). The anesthetic of choice in work with cold-blooded animals. Technical Bulletin No. 1. Sandoz Pharmaceuticals, Dorval, P.Q.

Basic reference on use of this anaesthetic.

CAMPBELL, G. D., and D. H. DAVIES. 1963. Effect of ethyl *m*-aminobenzoate (M.S. 222) on the elasmobranch electrocardiograph. Nature, **198**: 302.

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Thienpont, D., and C. J. E. Niemegeers. 1965. Propoxate (R7464): a new potent anaesthetic agent in cold-blooded vertebrates. Nature, **205**: 1018–1019.

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Used sodium amytal (65mg/4 liters), bone charcoal and permutit to control levels of metabolic rate and wastes of fish transported in sealed, oxygen-charged plastic bags. Noted toxicity of anaesthetic to one species.

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Similarities in mode of action and pharmacology of tribromoethanol trichloroethanol, and chloral hydrate discussed.

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Tertiary-amyl alcohol

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amyl alcohol, and the antibiotics terramycin (oxytetracycline) and penicillin. M.S. 222 found best. Antibiotics did not increase survival but may have reduced shedding of tags by 25%.

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An extensive compilation of formulations and chemicals of pharmacological interest with discussion, where appropriate, of their physical and chemical properties, uses and hazards, physiological effects, and methods of assay.

RODMAN, D. T. 1963. Anesthetizing and air-transporting young white sturgeons. Prog. Fish-Cult., **25**: 71-78.
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SPECTOR, W. S. [ed.] 1956. Handbook of biological data. W. B. Saunders Co., Philadelphia.

A concise, comprehensive tabulation of data of importance to general biologists.

WOOD, E. M. 1956. Urethane as a carcinogen. Prog. Fish-Cult., **18**: 135–136.

Author inferred from animal work that urethan might be directly or indirectly carcinogenic to man and therefore should be abandoned as an anaesthetic or used with great care.

Recent Bulletins of the
Fisheries Research Board of Canada

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No. 142. The chinook and coho salmon fisheries of British Columbia. By D. J. Milne. (1964, 46 p., $1.00.)

No. 143. Life history and present status of British Columbia herring stocks. By F. H. C. Taylor. (1964, 81 p., $1.75.)

No. 144. Smelt life history and fishery in the Miramichi River, New Brunswick. By R. A. McKenzie. (1964, 77 p., $2.00.)

No. 145. Scallops and the offshore fishery of the Maritimes. By N. Bourne. (1964, 60 p., $1.75.)

No. 146. Comparative feeding habits of the fur seals, sea lion, and harbour seal on the British Columbia coast. By D. J. Spalding. (1964, 52 p., $1.50.)

No. 147. Lobster storage and shipment. By D. W. McLeese and D. G. Wilder. (1964, 69 p., $1.75.)

No. 149. Economic aspects of the Great Lakes fisheries of Ontario. By Harold C. Frick. (1965, 160 p., $2.50.)

No. 150. Greening in tuna and related species. By N. Tomlinson. (1966, 21 p., $1.25.)

No. 151. Special products from freshwater fish. By A. W. Lantz. (1966, 45 p., $2.00.)

No. 152. Sea stars (Echinodermata: Asteroidea) of arctic North America. By E. H. Grainger. (1966, 70 p., $2.50.)

No. 153, Population dynamics of the petrale sole (*Eopsetta jordani*) in waters off western Canada. By K. S. Ketchen and C. R. Forrester. (1966, 195 p., $3.75.)

No. 154. Marine resources of Newfoundland By Wilfred Templeman. (1966, 170 p., $3.50.)

No. 155. Fishes of the Atlantic Coast of Canada. By A. H. Leim and W. B. Scott. (1966, 485 p., $8.50.)

NOTES

1. *Solubility* — the system and abbreviations commonly used in chemistry handbooks have been adopted. Where no exact values are available, i, indicates insoluble; v. sl. sol., very slightly soluble; sl. s., slightly soluble; s, soluble; v. s., very soluble; and ∞ indicates complete miscibility. Solubilities are given at 20 C unless another temperature is indicated by a superscript.

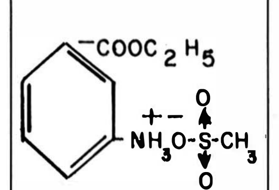
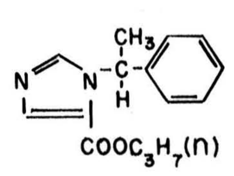
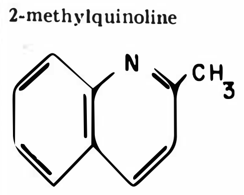
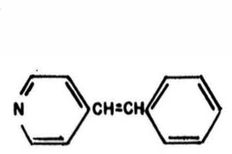
2. *Volume* — all gallons are British Imperial, i.e. 1.2 times US gallons. One litre = 0.26 US gal or 0.22 British gal.

3. *Temperature* — all temperatures are in degrees centigrade or Celsius (C) and can be converted to degrees Fahrenheit (F) thus: $\text{deg F} = \text{deg C} \times \frac{9}{5} + 32.$

4. *Concentration* — 1 part per million (1 ppm) $\equiv$ 1 mg/litre = 1:1,000,000.
   1g/litre $\equiv$ 1:1000 = 1000 ppm.
   e.g. 80 ppm $\equiv$ 80 mg/litre $\equiv$ 1:12,500.

5. Several sections are left blank because no data are available but these can be filled in when data appear.

6. Mention of trade names or manufacturers does not constitute endorsement of the product or firm by the Fisheries Research Board of Canada.

Trade or common names	Chemical names and/or formula	Manufacturer and/or suggested source	Approximate cost Molecular weight	Solubility in g/100 ml			Stability		Hazard	Toxicity to Man		Emergency treatment (for man)	Range of dosage for anaesthesia	Time to		Precautions	Behavioural effects (if peculiar)	Suggested use	Mode of action (data may or may not apply to fish)	Remarks
				Fresh water	Ethanol	Other	Undiluted	Solution		Contact	Ingestion			Immobilization (*min*)	"Righting" (*min*)					
Carbon dioxide (generated from acid-bicarbonate)	CO_2 stored as $NaHCO_3$ (solid)	Generally available as technical grade.	$0.05–0.10/100 ml (conc. solution)	6.9^{0}	sl. s.		Good	Unstable under acid conditions.	None for $NaHCO_3$, sulphuric corrosive.	H_2SO_4 burns	Burn	Raw eggs and milk for ingestion. No emesis. Contact: flush with cold water.	200–400 ppm	1–2		Calculated quantities should be dissolved in buckets before adding to tank, then *well* mixed. Upper levels lethal. Revive immobilized fish before 5 min.	Swim restlessly at surface, lose equilibrium and sink. Respiration decreases.	Where large numbers of fish must be killed with minimum injury, as for preserving bait fish. Where anaesthetized fish are manipulated only briefly.	In humans the responses are complex and varied. May get peripheral vasoconstriction, increased respiratory minute volume and cerebral circulation. Might act by asphyxia from reduction of oxygen binding capacity of haemoglobin (Root effect).	Probably one of the cheapest but also most critical anaesthetics. Ingredients could be pre-measured for the field.
Chloral hydrate Trichlorethylidene glycol Somnos	Trichloroacetaldehyde monohydrate $CCl_3CHO.\ H_2O$ (solid)	Laboratory supply firms; wholesale druggists.	$0.60/100 g 165.42	21^{17}	77^{25}		Slow volatilization	Decomposes very slowly if kept cool and protected from light. Photolabile.		Irritant	May be habit forming. Gastric irritation. Respiratory and cardiac failure.	If conscious, give water, milk, or universal antidote. Then emetic. Call physician.	9.5–14 g/Imp. gal	Approx 2–3		Regulate dosage carefully.		Fish transportation — other anaesthetics preferred. Short-term anaesthesia.	Acts as depressant on human heart; lowers blood pressure. Depresses centres of consciousness, motor side of spinal cord and respiratory centre.	Active metabolite is trichloroethanol. Chloral hydrate long used as a hypnotic for humans.
Chloretone Methaform Sedaform Chlorobutanol	$\beta\beta\beta$-trichloro-*tert.*-butyl alcohol $Cl_3C\text{-}C(CH_3)_2\text{-}OH$ (solid)	Laboratory supply firms; wholesale druggists.	$2.50/100 g 177.47	0.8	v.s.	s. chloroform, et er, glycerol.	Sublimes easily	Stable		Irritant	6 g severe symptoms.	As above for ingestion.	1:2500–1:5000 at 3–10°C (salmon fingerlings)	2–3	3–8	Limited latitude in conc. for immobilizing fingerlings and juveniles.	Respiratory "gasping" (Meister and Ritzi, 1958).	As for chloral hydrate.	In humans a general nerve sedative and anticonvulsant; local anaesthetic causing relaxation of involuntary muscle. Action and toxicity much like chloral hydrate. Active antiseptic.	Also a bacteriostatic agent. Can be used as a preservative of biological specimens. Rate of anaesthetization increased with temperature.
Ether	Diethylether Ethyl oxide $C_2H_5\text{-}O\text{-}C_2H_5$ (liquid: density 0.71 g/ml)	Laboratory supply firms.	$0.20/100 ml 74.12	7.5^{20}	∞		Good; protect from sunlight, explosive peroxide forms. Extremely volatile.	Stable but evaporates.	Extremely flammable, explosive in air. No smoking! Use only with good ventilation.	Irritant	Irritant	As above	1.5–2% v/v 1 oz/gal	1–2 adult salmon	3–20	Mix thoroughly to ensure solution.	Varied response.	Limited; others more useful. Might be useful if anaesthetizing in a tank and want to retain water with minimum contamination. (Aeration will flush off ether.)	Predominantly a narcotic to the central nervous system affecting first the cerebral centres, then the spinal cord and finally the vital centres in the medulla. Further data suggest posterior hypothalamus as a site of action.	Mortalities low. Other ethers might be tested to advantage, e.g. divinyl ether more powerful for humans.
Methyl pentynol Dormison Oblivon (European name) Somnesin	Methylparafynol 3-methyl-1-pentyn-3-ol $HC\equiv C\text{-}C(CH_3)(OH)\text{-}CH_2\text{-}CH_3$ (liquid: density 0.87 g/ml)	Air Reduction Chemical Co. 150 East 42nd St. New York 17, N.Y.	$2.05/lb in 35-lb drum (5 gal) $0.40/100 ml 98.14	ca. 12	∞		Stable	Stable	Flammable: hot gases explosive.	Keep out of eyes.	Rat test LD_{50} (oral) 0.6–0.9 g/kg Therapeutic dose (human) 4 mg/kg	As above	2–4 ml/gal } 1–2 ml/litre } or 3–12 ml/gal	Only slows down 10-inch pinks at this level. 2–4	Rapid 2–4		Occasional violent struggling while going under.	Transportation. Not recommended as anaesthetic for operations. Immobilized fish twitch when prodded or cut.	In mice the carbamate acts upon the cerebral reticular system. Mild sedative and hypnotic in humans and other species: stimulant in large doses. Rapidly inactivated by tissues. Might be hepatotoxic. Mechanism unknown.	Aerated solutions must be treated with an antifoaming agent, e.g. 1% Dow Corning Antifoam AF.
M. S. 222	Tricaine methanesulfonate Methane sulfonic acid salt of meta-amino ethyl benzoate  (solid)	Sandoz Pharmaceuticals Ltd., Dorval, P.Q. Hanover, N.J.	$21/100 g 262.31	v.s.			Good; keep cool and dry.	Slowly decomposes. More labile chemically and metabolically at higher temperatures. Slowly inactivated by fish in contrast to phenoxy-ethanol and amyl alcohol (q.v.)		Negligible	Three times less toxic than Novocaine and ten times less toxic than Cocaine. Cooked, anaesthetized fish not toxic. **Rat test LD_{50} (oral) 5–10 g/kg**	As above	0.5–1.0 g/gal (ca 1:9000–1:4500, brief exposure only) 1:12,500–1:25,000 (generally useful range)	2–4 4–6 (Induction and recovery times decrease with increasing temp. — brook trout yearlings.) cf. phenoxyethanol	3–5 4–6 (Usually directly related to conc. and length of anaesthesia but recoveries faster than most.)	Use fresh solution for best results or freeze stock. Some strains of rainbow trout sensitive. 19 ppm makes trout sperm immotile: keep M.S. 222 from reproductive products. May be toxic when used in water colder than that from which fish taken. Keep exposures short at conc. >1:10,000. Protect all solutions from direct sunlight to prevent toxicity.	At 1:15,000 juvenile pinks often showed no opercular movement but recovered in 5–20 min. Rainbow trout (8–12 inches) usually showed regular opercular movements under similar conditions.	Tagging, fin clipping, spawn taking, examination of living fish. Transportation under tranquillizing dosages, (1:45,000). (See "Remarks".) Photography of fish in aquaria. Operations — 4–5 hr, anaesthesia at 1:15,000. Rapid, deep anaesthesia of large fish (keep exposure as brief as possible at high concentrations). Tagging anchovetas—166 mg. per gal.	A local anaesthetic for humans; acts on nerve terminals. Decreases O_2 consumption in fish tested, probably by decreasing activity. One of a family of amino benzoic acid esters broadly related to cocaines. Allyl-, isopropyl-, and n-butyl esters similar in action to M. S. 222.	Anyone planning to use this anaesthetic should get the free Sandoz bulletin for essential data. If fish immobilized in less than 2–3 min, solution probably too strong. Dilute, or remove fish quickly. Reacts with component of paper roll towel to give yellow colour. May be used for quick spot test. Use for transportation limited by instability of solution. Best anaesthetic for operations. McFarland (1960) does not consider M. S. 222 desirable for transportation.
Phenoxyethanol Phenoxetol	2-phenoxyethanol β-hydroxyethyl phenyl ether Phenyl cellosolve $C_6H_5\text{-}O\text{-}CH_2\text{-}CH_2OH$ (liquid: density 1.1 g/ml)	**Eastman Kodak.** (Practical Grade) Laboratory supply firms.	$0.70/100 ml 138.16	2.67^{25}	s.	s. ether	Stable	Stable: can be re-used.	Low; flash pt. 250°F.	Keep out of eyes.	Irritant. Liver and kidney damage. Est' nated fatal dose 10 g.	As above	0.5–1.0ml/gal. (ca. 1:9000–1:4500) 1.4–1.5 ml/gal (ca 1:3100–1:2900) for pink fry (ca 4 cm) 8°C in salt water (R.R. Parker, pers. comm.)	2–4 2–5	3–6 5–10 or longer at higher dose	Usually best to dissolve or emulsify in an aliquot of warm water before adding to main container. Vehicle such as ethanol might be used.	At dosages around 1:10,000 some salmon, especially adults, go belly up and swim rapidly and erratically ("motor boating"). Hyperactivity during anaesthesia and recovery noted periodically — also with herring — especially at lower dosages, i.e. with longer induction periods.	General handling, tagging and chemotherapeutic agent. Pink fry mortality to time of release 0.6% (R.R. Parker, pers. comm.) Operations — M.S. 222 usually preferred for deep anaesthesia but 1:3000 phen. eth. effectively anaesthetizes 9–11-inch pinks. Dose near lethal: may be hyperactive during recovery. Colour photography of fish held in aquaria.		Used as bactericide in conjunction with quaternary ammonium cpds: also as insect repellant. Adult Sockeye ml/100 Imp gal: 4°C* / 11°C Effective dose (ED) 25 / 43 Lethal dose (LD) 130 / 130 *Induction time with *tert.*-amyl alcohol and M.S. 222 may be doubled for each 10°C rise in temperature but depth of anaesthesia decreases (McFarland, 1959).
Propoxate (R7464)	DL-1-(1-phenyl-ethyl)-5-(propoxy—carbonyl)-imidazole HCl  (solid)	Janssen Pharmaceutica n.v., Research Laboratoria, Beerse, Belgium.	Not yet commercially available. Samples only. 294.79	v.s.		v.s. sea water	Stable	Good; limited re-use possible.		Non-irritating		As above	0.5-10 ppm 2 and 4 ppm Fingerling and adult sockeye salmon, fresh-water 13° ¼ ppm immobilized rainbow trout	3 and 2	5 and 9			General handling, tagging and transport. At ¼ ppm or lower goldfish sedated and O_2 consumption lowered—use for transport.		Highly effective. Margin of safety extremely good on salmon tested. Essential that human toxicity be evaluated. Also effective on frogs and salamanders. Should be marketed in 1967 barring unforseen difficulties. L.S. Smith (pers. comm.) finds recovery of salmon slow.
Quinaldine	2-methylquinoline  (liquid: density 1.1 g/ml)	Matheson, Coleman and Bell Eastman Kodak (Practical Grade)	$3/100 ml 143.18	v.sl.s. but not dose limiting	s.	s. ether, chloroform	Clear liquid becomes reddish-brown on exposure to air.	Effectiveness maintained over several days.	Low combustibility. Avoid prolonged inhalation of vapours.	Keep out of eyes: avoid prolonged contact until long-term tests prove its safety.	Rat test LD_{50} (oral) 1.23 g/kg suggests low toxicity.	As above	5–12 ppm (ca 1:200,000–1:84,000) 1:100,000–1:150,000 (10 inch coho)	1–6 (no loss of equilibrium at this dose) 2–4	1–10 3–5	Keep stock chemical tightly closed and protect from light. Vehicle of acetone or ethanol recommended.	Muscles relaxed and fish can be handled gently but may jump if external stimuli strong. May remain upright.	General handling, blood sampling. Possibly useful for surgical operations at 1:80,000–1:100,000. Coho relaxed and unreactive tc needle punctures and scalpel cuts. Recovery 6–8 min after 20 min anaesthesia. Steinhart Aquarium uses 10% solution in ethanol for some field collecting.	Unknown, but might act like barbiturates as depressant of central nervous system, esp. respiratory centre.	Margin of safety good: therapeutic ratio at least 3 on species tested. Note: Therapeutic ratio $= \frac{LD_{50}}{ED_{50}}$ 3–4-inch herring immobilized in 1–2 min and recovered in 10–15 min. Seems to have sufficient potential to warrant further investigation.
Sodium amytal Amytal ~~Amobarbital sodium~~	Sodium salt of 5-ethyl-5-isoamyl barbituric acid $C_{11}H_{17}N_2NaO_3$ (solid)	Under control in Canada but available for experimental use. First contact Narcotic Division of the Dept. of National Health and Welfare then obtain prices from suppliers such as May and Baker or British Drug Houses.	Contact supplier 248.26	v.s.	s. (1:1)	i. ether	Hygroscopic	Slowly decomposes; should be prepared just before use. Free acid ppt below pH 9.5.		None	Soporific to fatal. Maximum safe oral dose 500 mg	Emetic. Coffee and other stimulants. Keep patient moving and warm. Also as above.	0.5–0.8 g/gal (ca 1:9000–1:6300)	No times available: said to be slow acting.	Recovery might be slow.	Supplies should be closely guarded since continued ingestion may lead to habituation.		Fish transport in soft waters, where sedation reduces oxygen consumption. Not very satisfactory anaesthetic but included because American workers have used it (e.g. Leitritz, 1960).	"Short actor". Not effective analgesic unless used in gross overdosage: hypnotic only: not effective for continuous anaesthesia. May be stimulant at low dosages. General depressant of central nervous system. Increases recovery time and threshold for cerebral neurons esp. of cortex.	Not recommended for use in marine or hard waters because of calcium antagonism. Bone charcoal and permutit might be added to remove toxic waste products during transportation or holding in static water.
4-SP	4-styrylpyridine 4-stilbazole β-4-pyridinostyrene  (solid)	Eastman Kodak	$92/100 g 181.24	ca. 0.005^{13}	s.	v.s. acetone s. $CHCl_3$	Stable	Good; limited re-use possible.		Non-irritating	LD_{50} (oral) rat 2 g/kg LD_{50} (dermal) rat >9.4 g/kg	As for chloral hydrate	20-40 ppm Rainbow trout 10-30 ppm Sockeye fry, fresh water 17°	25-20 15-5	8-7 3-6	Use acetone vehicle. Mix well in final solution or 4-SP will precipitate and be ineffective.	Sockeye fry "snapped" heads in solution. (Not due to acetone.)	General handling and tagging. Note effectiveness against lamprey.		Low water solubility could be a disadvantage except in limiting the dosage. Therapeutic ratio unknown but margin of safety seems good.
Tribromoethanol Avertin (in *tert.*-amyl alcohol) Bromethol Ethobrom Renarcol	Tribromo ethyl alcohol 2,2,2-tribromoethanol $Br_3C\text{-}CH_2OH$ (solid)	Matheson, Coleman and Bell	$20/100 g 282.79	2.5^{40}	v.s.	v.s. ether v.s. amylene hydrate	Slowly decomposes. Keep tightly stoppered and dry.	Decomposed by water and light to form strong irritants. More stable in amylene hydrate.		Irritant	Irritant. Circulatory collapse at about 7 g.	As for chloral hydrate.	5–50 ppm			High potency means cautious application. Vehicle such as amylene hydrate (q.v.) recommended — also increases narcotic effect.		Because of instability use limited to short-term experiments or as for CO_2. Might be used in conjunction with other anaesthetics.	In humans, action like chloroform. Reduced circulation from depression of myocardium, drop in cardiac output. Vasomotor centre depressed and muscles of peripheral vessels dilated. Might cause hepatocellular damage.	Highest narcotic potency of those tested by McFarland (1959). This may be offset by its instability. Discard tribromoethanol if 1:40 aqueous solution does not give similar colour to Congo red as distilled water.
Tert.-amyl alcohol Amylene hydrate	2-methyl-2-butanol Dimethylethylcarbinol $(CH_3)_2\text{-}C(OH)CH_2\text{-}CH_3$ (liquid: density 0.81 g/ml)	Laboratory supply firms. (Practical Grade)	$0.30/100 ml 88.15	14^{30}	∞	∞ ether	Stable	Stable	Flammable: hot gases explosive. Avoid prolonged inhalation of vapours.	Irritant	Irritant. Headaches. Circulatory collapse at about 30 ml.	As for chloral hydrate.	48 ml/gal 5.5–6.0 ml/gal 5–6 ml/litre	2 8–12 20–25 (4–5-inch sockeye in fresh water at 9°C)	20 20–30 10–15		Relatively long induction period. Some hyperactivity while recovering.	General handling and tagging. R.L. Saunders (pers. comm.) has found this cheap and effective for tagging Atlantic salmon smolts. McFarland (1960) recommends 1–2 ml/gal for transportation.	Action generally like ethanol in humans but it is more toxic and lasts longer. Reduces volume of air breathed. A central nervous system depressant.	In mammals amylene hydrate mostly used as solvent for tribromoethanol. Failed to become established as a hypnotic for humans. Reported to sedate herbivors and excite dogs and cats. Solutions foam on aeration; use antifoam agent.