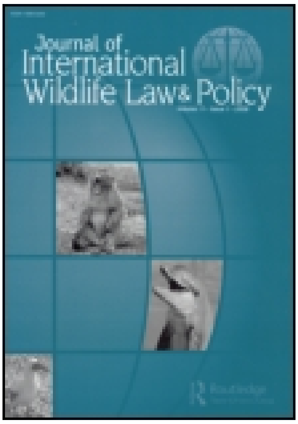

Journal of International Wildlife Law & Policy

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/uwlp20

To Tag or not to Tag: Animal Welfare, Conservation, and Stakeholder Considerations in Fish Tracking Studies That Use Electronic Tags

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Published online: 12 Nov 2013.

Journal of International Wildlife Law & Policy, 16:352–374, 2013
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ISSN: 1388-0292 print / 1548-1476 online
DOI: 10.1080/13880292.2013.805075

Routledge
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1. INTRODUCTION

Biotelemetry and biologging tools have provided unprecedented information on the biology, management, and conservation of wild

Cooke and Fisk are supported by the Canada Research Chairs Program. Cooke and Thiem are supported by the Natural Sciences and Engineering Research Council of Canada (NSERC) HydroNet, and Cooke, Hinch, Fisk, and Donaldson are supported by the Ocean Tracking Network (OTN) Global and Canada through a network project grant (NETGP #375118-08) from NSERC with additional support from the Canada Foundation for Innovation (CFI, Project #13011). This article was developed from a presentation delivered at the First World Fish Telemetry Conference held in June 2011 in Hokaido, Japan and we thank the participants in the conference for providing input and feedback during an open discussion following the presentation.

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fish. [1] Indeed, we are now able to track fish in the depths of the oceans to the shallowest of tidal creeks, under Arctic ice and in Amazonian floodplains, and from high seas to inland rivers, revealing remarkable migrations that span watersheds, oceans, countries, and continents. The Ocean Tracking Network[2] and the Census of Marine Life[3] exemplify these novel technologies and their application to science and management on national and global scales. However, use of these tools is not without controversy. Even when scientific and management objectives may best be achieved using electronic tags, it is increasingly important to consider other factors such as the welfare of tagged animals (e.g., the role of training and science-based surgical guidelines), the ethics of tagging threatened species versus using surrogates, and stakeholder perspectives on tagging, as well as the use of data emanating from such studies. Failure to do so will have the potential to create conflict and undermine scientific, management, and public confidence in the use of this powerful tool. With growing attention to ethical[4] and legal aspects of working with wild animals, especially those that are imperilled, [5] there is a need to thoroughly consider when to 'tag or not to tag' a fish.

Here we present a candid evaluation of several factors that should be considered when determining whether to tag or not to tag fish with electronic tags. The premise for this article is that you have a question you need to address, the objective is best addressed through use of electronic tagging, and you have the funds to do it. In other words, on the surface there is nothing holding you back from proceeding with the tagging study. However, when

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[1] *See* Lucas C. Martyn & Etienne Baras, *Methods for Studying Spatial Behaviour of Freshwater Fishes in the Natural Environment*, 4 Fish Fish, 283–316 (2008); Steven J. Cooke & Glen N. Wagner, *Training, Experience, and Opinions of Researchers Who Use Surgical Techniques to Implant Telemetry Devices into Fish*, 29 Fisheries 10–18 (2004); Barbara A. Block, *Physiological Ecology in the 21st Century: Advancements in Biologging Science*, 45 Integr. Comp. Biol. 305–320 (2005); Steven J. Cooke, *Biotelemetry and Biologging in Endangered Species Research and Animal Conservation: Relevance to Regional, National, and IUCN Red List Threat Assessments*, 4 Endanger. Species Res. 165–185 (2008).

[2] *See* Steven J. Cooke et al., *Ocean Tracking Network Canada: A Network Approach to Addressing Critical Issues in Fisheries and Resource Management with Implications for Ocean Governance*, 36 Fisheries 583–592 (2011).

[3] *See* Ron O'Dor et al., *A Census of Fishes and Everything They Eat: How the Census of Marine Life Advanced Fisheries Science*, 37 Fisheries 398–409 (2012).

[4] *See* Elizabeth J. Farnsworth & Judy Rosovsky, *The Ethics of Ecological Field Experimentation*, 7 Conserv. Biol. 463–472 (1993); Ben A. Minteer & James P. Collins, *Ecological Ethics: Building a New Tool Kit for Ecologists and Biodiversity Managers*, 19 Conserv. Biol. 1803–1812 (2005); Rory P. Wilson & Clive R. McMahon, *Measuring Devices on Wild Animals: What Constitutes Acceptable Practice?*, 4 Front. Ecol. Environ. 147–154 (2006).

[5] *See* Nigel Cooper & Bob Carling, *Ecologists and Ethical Judgements*, 4 Biodivers. Conserv. 783–785 (1995) and Cooke (2008), *supra* note 1.

do you tag and when do you not tag? There are a number of considerations that extend beyond scientific/management objectives and funding such as animal welfare, conservation concerns for endangered/threatened animals, and stakeholder perspectives. Our objective is to stimulate discussion and discourse among scientists, telemetry practitioners, and those that utilize or are informed by telemetry information. We have set up the article as a series of questions that should be considered when thinking about embarking on a tracking study. Many of the issues these questions focus on are specific to intracoelomic surgical implantation procedures,[6] but also relate to other tagging methods such as external and gastric tagging. Not all questions will apply to all electronic tagging studies but they are worthy of consideration when planning such studies.[7]

2. SHOULD YOU TAG IF YOU ARE NOT A VETERINARIAN?

The surgical implantation of electronic tags in mammals and birds is nearly always conducted by licenced veterinarians,[8] which is often a condition of scientific collection permits. Such requirements are much less common for fish.[9] A survey of practicing fish telemetry surgeons revealed that the majority of respondents strongly disagreed (59.4%) or disagreed (35.8%) with the statement that tagging should be restricted to veterinarians (N = 171).[10] Indeed, that sentiment was also held by several of the self-identified veterinarians that completed the survey. One veterinarian stated "... I strongly feel that veterinary consultation is valuable for any fish telemetry implant study to ensure that a high standard of care is maintained. I do not, however, presume to think that only veterinarians are competent to perform the surgeries." In considering the role of veterinarians in the tagging of fish, Harms and Lewbart[11] suggested that the current role of veterinarians participating in the intracoelomic surgical implantation of electronic tags in fisheries research projects

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[6] *See* Christopher J. Bridger & Richard K. Booth, *The Effects of Biotelemetry Transmitter Presence and Attachment Procedures on Fish Physiology and Behavior*, 11 REV. FISH. SCI. 13–34 (2003); Steven J. Cooke et al., *Advancing the Surgical Implantation of Electronic Tags in Fish: A Gap Analysis and Research Agenda Based on a Review of Trends in Intracoelomic Tagging Effects Studies*, 21 REV. FISH BIOL. FISH. 127–151 (2011).

[7] Referenced from the in press book chapter Steven J. Cooke et al., *Chapter 18- Biotelemetry and Biologging, in* FISHERIES 819–860 (Alexander V. Zale, Donna L. Parrish, and Trent M. Sutton eds., 3rd ed. 2000).

[8] *See* Michael Hutchins, Tom Foose, & Ulysses S. Seal, *The Role of Veterinary Medicine in Endangered Species Conservation*, 22 J. ZOO. WILDL. MED. 277–281 (1991); David B. Morton, *Refinements in Telemetry Procedures*, 37 LAB. ANIM. 261–300 (2003); and Penny Hawkins, *Bio-logging and Animal Welfare: Practical Refinements*, 58 MEM. NATL. INST. POLAR RES. 58–68 (2004).

[9] *See* Daniel M. Mulcahy, *Surgical Implantation of Transmitters into Fish*, 44 ILAR J. 295–306 (2003).

[10] *See* Cooke & Wagner, *supra* note 1.

[11] Craig A. Harms & Gregory A. Lewbart, *The Veterinarian's Role in Surgical Implantation of Electronic Tags in Fish*, 21 REV. FISH BIOL. FISH. 25–33 (2011).

is limited, but could be expanded. Indeed, they argue that veterinary training is broadly applicable to conducting surgeries on any species. Some have argued that veterinarians lack relevant training on fish,[12] however, there are an increasing number of veterinarians with fish-specific experience.[13] Harms and Lewbart further suggest that veterinarians can advise on surgical instrument selection and acquisition, interface with Institutional Animal Care and Use Committees (IACUCs), offer input on anaesthesia, give direction on disinfection and sterilization, and provide individualized surgery instruction.[14] Remarkably, most states and provinces in North America do not have any legal means to prohibit recreational anglers with no veterinary or scientific training from implanting electronic tags in fish.[15] In general, there seems to be little evidence supporting the notion that surgical implantation of tags should only be conducted by veterinarians, however, they do have much to offer in training of fish surgeons and should be consulted and engaged to improve the welfare of tagged fish and consequently the scientific integrity of fish tagging studies.[16]

3. SHOULD YOU TAG IF YOU DO NOT HAVE AN ADEQUATE LEVEL OF TRAINING TO CONDUCT INTRACOELOMIC IMPLANTATION?

Training is a fundamental part of all scientific and technical disciplines, and this is particularly true for surgeons irrespective of whether working on humans or other animals. The purpose of such training is to develop skills to reduce the likelihood of mistakes and provide the trainee with the most extensive yet standardized set of problem solving and technical skills to deal with challenges that can arise.[17] In some professions (e.g., veterinarians, physicians), there is also a legal framework under which they must operate and there is always the potential for malpractice litigation. This is not the same for fish surgeons in most jurisdictions. There is however evidence in the fish tagging literature that training does matter and influences the outcome (i.e., a higher level of surgeon training results in a better retention of electronic tags).[18] Cooke et al. used an expert and a novice surgeon to evaluate outcomes

[12] *See* Cooke & Wagner, *supra* note 1.
[13] *See* Harms & Lewbart, *supra* note 11.
[14] *Id*.
[15] *See* Kevin L. Pope, *Anglers Tagging and Marking Fish: Provincial and State Fishery Agency Views*, 26 Fisheries 23–27 (2001).
[16] *See* Harms & Lewbart, *supra* note 11.
[17] *See* Cooke et al., *supra* note 6.
[18] *See* Katherine A. Deters et al., *Performance Assessment of Suture Type in Juvenile Chinook Salmon Surgically Implanted with Acoustic Transmitters*, 139 Trans. Am. Fish. Soc. 888–899 (2010); Katherine A. Deters et al., *Optimal Suturing Technique and Number of Sutures for Surgical Implantation of Acoustic Transmitters in Juvenile Salmonids*, 141 Trans. Am. Fish. Soc. 1–10 (2012).

for tagged fish.[19] Despite having received the basic training prior to the actual experiment, the novice surgeon took significantly longer to complete the surgeries, had reduced suture precision, and experienced higher fish mortality relative to the expert surgeon.[20] For that reason, 'surgeon' should be used as a factor in analyses when multiple surgeons are used, or ideally, a single trained surgeon would conduct all surgeries.[21] Aside from several jurisdictions in Europe, there are relatively few places where there is mandatory training required to undertake fish surgeries; however it is becoming more common for some funding agencies and IACUCs (e.g., in the Pacific Northwest of the United States).

Based on a survey of practicing fish tagging surgeons, the majority learned surgery from direct observation, mentoring, and the literature rather than formal in-class training.[22] In the Pacific Northwest there have been efforts to develop formal training programs with evaluation of surgical ability (to identify and correct mistakes).[23] In addition, training is increasingly being offered through continuing education courses at professional conferences. What constitutes an 'adequate level' of training is somewhat subjective, but Cooke et al. suggest a number of core competencies that should be demonstrated.[24] Given the immense value in doing hands-on surgeries and then holding such animals to monitor their survival and healing (termed feedback training), such an approach seems ideal for informing the development of competent fish surgeons.[25] Even when making changes to surgery technique, such as using a new knot type, feedback training has been critical to ensuring adequate suture and tag retention.[26] Deters et al. identified that even among surgeons with a relatively large amount of experience, feedback training could influence the retention of both sutures and tags.[27]

4. SHOULD YOU TAG IF YOU ARE UNABLE TO MAINTAIN STERILE SURGICAL CONDITIONS IN THE FIELD?

One commonly debated aspect of fish surgical technique is the level of sterility or aseptic technique that is used or to be expected. Some researchers opine

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[19] *See* Steven J. Cooke et al., *Effects of Suture Material on Incision Healing, Growth and Survival of Juvenile Largemouth Bass Implanted with Miniature Radio Transmitter: Case Study of a Novice and Experienced Fish Surgeon*, 62 J. FISH BIOL. 1360–1380 (2003).

[20] *See* Cooke et al., *supra* note 19.

[21] *See* Cooke et al., *supra* note 6.

[22] *See* Cooke & Wagner, *supra* note 1.

[23] *See* Deters (2010) and (2012), *supra* note 18; Cooke et al., *supra* note 6; and METHODS FOR SURGICAL IMPLANTATION OF ACOUSTIC TRANSMITTERS IN JUVENILE SALMONIDS: A REVIEW OF LITERATURE AND GUIDELINES FOR TECHNIQUES (Richard S. Brown et al. eds., 2010).

[24] *See* Cooke et al., *supra* note 6.

[25] *See* Deters (2010), *supra* note 18, and Cooke et al., *supra* note 6.

[26] *See* Deters (2012), *supra* note 18.

[27] *See* Deters (2010) and (2012), *supra* note 18.

that maintaining any level of sterility is not realistic since the surgery tools and tags will touch the skin of the fish and aquatic pathogens will then be transferred into the coelom. Also, after fish are released, non-sterile water will likely enter the coelom through any incision or injection site. On the other end of the spectrum, others suggest that surgical implantation of non-sterile transmitters or the use of non-sterile surgical instruments is inhumane.[28]

When tagging a relatively small number of fish, surgeons can easily take packets of sterile transmitters and surgery tools into the field. However, some studies require large numbers (thousands) of fish that need to be surgically implanted with transmitters or injected with passive integrated transponders in a short period of time.[29] Because of costs and logistics of these studies, multiple fish are thus often tagged with the same set of surgical tools which could allow aquatic pathogens to be spread among fish. In some studies, effort has been made to ensure that some level of disinfection is attained when using tools on multiple fish. Several techniques have been used to disinfect or sterilize surgery tools such as the use of liquid chemicals, or by placing tools in hot bead, ultraviolet units (UV), or use of small portable autoclaves.[30] Part of the cost of conducting most tagging studies is the purchase of multiple sets of surgical tools (including relatively expensive sutures) and purchasing fluids or electronic units to kill aquatic pathogens. Therefore, for aseptic techniques to be used on some studies, costs could be prohibitive. Thus, the cost of purchasing or treating surgery tools should be balanced with the benefits of the research. Researchers want to maintain high levels of cleanliness of surgery tools but also recognize that maintaining aseptic technique could be cost-prohibitive (thus limiting or precluding research aimed at improving fish populations) and may not result in improved wound healing or overall survival.[31] Use of a disinfecting solution or a hot bead or UV unit between surgeries may be adequate for killing certain pathogens.[32] However, relatively little research has been done to determine the benefits of aseptic technique versus use of disinfected or uncleaned tools on healing or survival of fish.

In a field setting, it may also be very difficult to conduct surgery in an aseptic manner. To conduct surgery on fish, surgical gloves must touch the sutures that pass through the body wall of the fish. Thus, to attain aseptic conditions, gloves would need to be changed or sterilized between surgeries

[28] *See* Mulcahy, *supra* note 9.

[29] For an example *see* Geoffrey A. McMichael et al., *The Juvenile Salmon Acoustic Telemetry System: A New Tool*, 35 Fisheries 9–22 (2010).

[30] *See* Glenn N. Wagner et al., *Surgical Implantation Techniques for Electronic Tags in Fish*, 21 Rev. Fish Biol. Fish. 71–81 (2011) and article in press by Riccardo W. Walker et al., *Ultraviolet Radiation as Disinfection for Fish Surgical Tools*, 142 Animal Biotelemetry 156–170 (2013).

[31] Luara Chomyshyn, Sarah H. McConnachie, & Steven J. Cooke, *Evaluation of Water Entry into the Coelom and Different Levels of Aseptic Technique during Surgical Implantation of Electronic Tags in Freshwater Fish*, 21 Rev. Fish Biol. Fish. 61–70 (2011).

[32] *See* article in press by Walker et al., *supra* note 30.

on multiple fish. Scalpel blades would also need to be changed or cleaned between surgeries to diminish transfer of aquatic pathogens to maintain aseptic conditions. This could be achieved by simply changing the disposable blade in a scalpel handle, or through the use of single-use disposable scalpels. However, better results are often attained with relatively expensive 'stab' scalpels (such as the Becton-Dickinson Micro-Unitome knife),[33] which do not have disposable blades. Instead, the blades are fixed to protrude a set distance out from a plastic handle. This can reduce the likelihood that a surgeon would accidentally cut internal organs by placing the blade too deep into the coelom. However, the plastic stab scalpels melt if autoclaved, so liquid or UV disinfection or sterilization methods must be used.[34]

We suggest that further research be done to determine the effectiveness of differing levels of disinfection or sterilization of surgical tools on healing or survival of fish. We also suggest that research be conducted to find cheap, quick techniques or systems to disinfect or sterilize surgery tools. This could provide a more science-based platform for bodies (such as animal care committees) that regulate researchers to determine which surgical techniques are appropriate and humane. In the interim, it appears prudent to take reasonable efforts to maintain clean conditions during intracoelomic implantation procedures. Determining the reasonable risks for a given situation (e.g., is it a species of concern, is there a history of disease, etc.) and developing reasonable strategies to manage should be part of such considerations.

5. SHOULD YOU TAG IF THERE IS NO EFFECTIVE, LEGAL OR PHYSIOLOGICALLY REASONABLE ANAESTHETIC METHOD AVAILABLE?

Anaesthetics are physical or chemical agents that, when applied, result in a loss of sensation through the depression of the central and peripheral nervous system.[35] The use of anaesthetics is considered standard practice for the humane handling of fish during invasive procedures such as the intracoelomic implantation of electronic tags.[36] It has been argued that any procedure that causes more than "momentary pain or discomfort" (i.e., beyond a needle stick and brief holding) requires anesthesia.[37] There are, however, a number of

[33] Described in Wagner et al., *supra* note 30.

[34] *See* article in press by Walker et al., *supra* note 30.

[35] *See* George K. Iwama & Paige A. Ackerman, *Anesthetics*, *in* BIOCHEMISTRY AND MOLECULAR BIOLOGY OF FISHES, VOLUME 3—ANALYTICAL TECHNIQUES 1–15 (Peter Hochachka & Thomas Mommsen eds., 1994).

[36] *See* GUIDE TO THE CARE AND USE OF EXPERIMENTAL ANIMALS, VOLUMES 1 AND 2 (Ernest D. Olfert, Brenda M. Cross & A. Ann McWilliam eds., 2nd ed. 1993) and American Fisheries Society, GUIDELINES FOR THE USE OF FISHES IN RESEARCH 1–58 (2004).

[37] *See* Mulcahy, *supra* note 9.

situations that make finding a physiologically reasonable, effective, or legal anaesthetic a challenge. These cases are presented below.

The most common method of administering anaesthetics in fish is through immersion. In this process, chemical anaesthetics are absorbed through the gills and/or respiratory organs during the process of respiration and are passed to the central nervous system.[38] For some exceptionally large fish species (i.e., one metre or longer; e.g., elasmobranchs, various tuna species, billfish), the size of the bath and the amount of the chemical required to anesthetise the fish would be neither practical nor economically feasible. Immersion anaesthetics can also present challenges to obligate ram ventilators such as tuna, which would suffocate if the gills were not sufficiently perfused with water during induction, surgery, and recovery.[39] For recovery of ram ventilators, these animals either need to be moved manually in a forward motion or held in water with sufficient flow until they can swim on their own.[40] Recovery from immersion anaesthetics is also a concern for cold-water fish (i.e., Arctic fish) where anaesthetic clearance and recovery may be quite slow. In such instances, use of anaesthetics could be problematic when there is a chance of the fish being consumed because of the more extensive duration of time it takes for chemicals to be cleared from the body.

The clearance of chemical anaesthetics from the body of fishes occurs though metabolism and excretion, but until those processes are complete, chemical residues in the tissue can make the fish unfit for human consumption.[41] The law is very specific (at least in most developed countries) about which drugs can be used on potential food fish, and their use is highly regulated, putting particular restraints on field-based applications.[42] Until recently, the only legal chemical anaesthetic legislated for use on food fish in North America was tricaine methanesulfonate, commonly known as MS-222 or Aqualife TMS. Treated fish required a withdrawal period of five days at water temperatures of 10°C or higher in Canada,[43] and a 21-day holding period in

[38] *See* Donald L. Neiffer & M. Andrew Stamper, *Fish Sedation, Anesthesia, Analgesia, and Euthanasia: Considerations, Methods, and Types of Drugs*, 50 Ilar J. 343–360 (2009).

[39] *See* Peter G. Bushnell & David R. Jones, *Cardiovascular and Respiratory Physiology of Tuna: Adaptations for Support of Exceptionally High Metabolic Rates*, 40 Environ. Biol. Fish. 303–318 (1994).

[40] *See* Richard W. Brill & Peter G. Bushnell, *The Cardiovascular System of Tunas, in* Tuna: Physiology, Ecology, And Evolution 79–119 (Barbara A. Block & Ernest D. Stevens eds., 2001).

[41] *See* Leif L. Marking & Fred P. Meyer, *Are Better Anesthetics Needed in Fisheries?*, 10 Fisheries 2–5 (1985).

[42] *See* Mulcahy, *supra* note 9, and article in press by Jesse T. Trushenski et al., *Issues Regarding the Use of Sedatives in Fisheries and the Need for Immediate-Release Options*, 00 Trans. Am. Fish. Soc. 00 (0000).

[43] *See* Health Canada, *List of Veterinary Drugs That Are Authorized for Sale by Health Canada for Use in Food-producing Aquatic Animals* (2010), http://www.hc-sc.gc.ca/dhp-mps/vet/legislation/pol/aquaculture_anim-eng.php (visited).

the United States.[44] While required holding times may not present challenges to tagging studies confined to the laboratory, such constraints have challenged field-based studies aimed at examining behaviour and physiology on free-swimming fish. However, in September 2012, Aqui-S®20E (10% eugenol, a derivative of clove oil) was approved by the Food and Drug Administration (FDA) as an immediate release sedative, which will improve fish welfare and field-based research in the United States. For countries that do not have an immediate release chemical anaesthetic, other methods of anesthesia need to be considered specifically for use in the field.

Non-chemical anaesthetics (which are arguably sedatives rather than true anaesthetics) such as electroanaesthesia and carbon dioxide (CO_2) have the advantage of not requiring a withdrawal period. Electroanaesthesia has been found to induce similar physiological effects to chemical anaesthetics[45] and also has the benefit of rapid induction and recovery times.[46] Pulsed direct current electroanaesthesia was successful in quickly inducing stage-4 anesthesia[47] in adult walleye (*Sander vitreus*) with no evidence of vertebral abnormalities in a study by Vandergoot et al.[48] Vertebral abnormalities, however, were documented for electronarcosis studies on northern pike (*Esox lucius*)[49] and lake trout (*Salvelinus namaycush*).[50] Carbon dioxide can be introduced into the water directly via compressed gas tanks bubbled through an air stone, or indirectly through the use of biocarbonate-of-soda antacids.[51] While CO_2 is an immediate-release sedative, it is considered slow-acting and difficult to apply uniformly.[52] Also, due to the physiological consequences associated with hypercapnia in fish,[53] CO_2 is not an ideal sedative.

[44] *See* Trushenski et al., *supra* note 42.

[45] *See* Jane A. Madden & Arthur H. Houston, *Use of Electroanaesthesia with Freshwater Teleosts: Some Physiological Consequences in the Rainbow Trout, Salmo gairdneri Richardson*, 9 J. FISH BIOL. 457–462 (1976); Erika Henyey, Boyd Kynard, & Pengfei Zhuang, *Use of Electronarcosis to Immobilize Juvenile Lake and Shortnose Sturgeons for Handling and the Effects on Their Behavior*, 18 J. APPL. ICHTHYOL. 502–504 (2002).

[46] *See* Amir Sattari et al., *Comparison of Electroanaesthesia with Chemical Anesthesia (MS222 and Clove Oil) in Rainbow Trout (Oncorhynchus mykiss) Using Plasma Cortisol and Glucose Responses as Physiological Stress Indicator*, 4 J. ANIM. VET. ADV. 306–313 (2009).

[47] *See* Robert C. Summerfelt & L. S. Smith, *Anesthesia, Surgery and Related Techniques*, *in* METHODS FOR FISH BIOLOGY 213–272 (Carl B. Schreck & Peter B. Moyle eds., 1990).

[48] *See* Christopher S. Vandergoot et al., *Evaluation of Two Forms of Electroanaesthesia and Carbon Dioxide for Short-term Anesthesia in Walleye*, 31 N. AM. J. FISH. MANAGE. 914–922 (2011).

[49] Mary K. Walker, Elizabeth A. Yanke, & William H. Gingerich, *Use of Electronarcosis to Immobilize Juvenile and Adult Northern Pike*, 56 PROG. FISH-CULT. 237–243 (1994).

[50] Mark P. Gaikowski, William H. Gingerich, & Steve Gutreuter, *Short-duration Electrical Immobilization of Lake Trout*, 21 N. AM. J. FISH. MANAGE. 381–392 (2001).

[51] *See* Stephan Peake, *Sodium Bicarbonate and Clove Oil as Potential Anesthetics for Non Salmonid Fishes*, 18 N. AM. J. FISH. MANAGE. 919–924 (1998).

[52] *See* Trushenski et al., *supra* note 42.

[53] *See* FISH RESPIRATION, 17 (Steve F. Perry & Bruce L. Tufts eds., 1998).

Tonic immobility, an unlearned response consisting of a state of immobility and torpor,[54] has been used to surgically implant electronic tags in a number of elasmobranch species, for example, lemon sharks (*Negaprion brevirostris*),[55] tiger sharks (*Galeocerdo cuvier*),[56] Caribbean reef sharks (*Carcharhinus perezi*),[57] and nurse sharks (*Ginglymostoma cirratum*).[58] While further research is needed on the underlying physiological, psychological, and neurological processes behind tonic immobility, even this method of immobilizing fish for surgery has been found to produce stress-associated changes in blood chemistry for lemon sharks.[59]

While the debate continues on whether or not fish feel pain,[60] it is essential to take animal welfare and compliance with drug laws into account in concert with facing challenges on finding physiologically reasonable, effective, and legal anaesthetics for any study. The reality is that the scientific community has a rather rudimentary understanding of the function of anaesthetics or knowledge of whether some (e.g., CO_2, electroanaesthesia, or tonic immobility) do anything more than immobilize fish. In some unique cases (e.g., exceptionally large specimens), use of anesthesia may simply not be possible. Clearly, the researchers in consultation with their institutional animal care committees would need to accept the fact that it is possible that tagging procedures would cause discomfort if no anesthesia was used. Is it more acceptable to not obtain tracking related information on a species or for the fish to potentially experience discomfort during the procedure? This is as much an ethical issue as it is a scientific one.

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[54] *See* Gordon G. Gallup, *Animal Hypnosis: Factual Status of a Fictional Concept*, 81 PSYCHOL. BULL. 836 (1974).

[55] *See* Karen J. Murchie et al., *Spatial Ecology of Juvenile Lemon Sharks (Negaprion brevirostris) in Tidal Creeks and Coastal Waters of Eleuthera, The Bahamas*, 89 ENVIRON. BIOL. FISH. 95–104 (2010).

[56] *See* Kim N. Hollan et al., *Movements of Tiger Sharks (Galeocerdo cuvier) in Coastal Hawaiian Waters*, 134 MAR. BIOL. 665–673 (1999).

[57] *See* Ricardo C. Garla et al., *Movement Patterns of Young Caribbean Reef Sharks, Carcharhinus perezi, at Fernando de Noronha Archipelago, Brazil: The Potential of Marine Protected Areas for Conservation of a Nursery Ground*, 149 MAR. BIOL. 189–199 (2006).

[58] *See* Demian D. Chapman et al., *Marine Reserve Design and Evaluation Using Automated Acoustic Telemetry: A Case-study Involving Coral Reef-associated Sharks in the Mesoamerican Caribbean*, 39 MAR .TECHNOL. SOC. J. 42–55 (2005).

[59] *See* Edward J. Brooks et al., *The Stress Physiology of Extended Duration Tonic Immobility in the Juvenile Lemon Shark, Negaprion brevisrostris (Poey 1868)*, 409 J. EXP. MAR. BIOL. ECOL. 351–360 (2011).

[60] *See* Kristopher P. Chandroo, Ian J.H. Duncan, & Richard D. Moccia, *Can Fish Suffer?: Perspectives on Sentience, Pain, Fear and Stress*, 86 APPL. ANIM. BEHAV. SCI. 225–250 (2004); James D. Rose, *The Neurobehavioral Nature of Fishes and the Question of Awareness and Pain*, 10 RES. FISH. SCI. 1–38 (2002); VICTORIA BRAITHWAITE, DO FISH FEEL PAIN? (2010); James D. Rose et al., *Can Fish Really Feel Pain?* 00 FISH FISH. 000–000 (in press).

6. SHOULD YOU TAG IF YOU HAVE NOT DONE A TAGGING VALIDATION STUDY FOR A GIVEN SPECIES/TAGGING SCENARIO?

Given the number of practitioners currently using electronic tags, a growing body of literature exists detailing aspects of the surgical procedures applied to fish in the field.[61] As a result of this increased field application and subsequent scrutiny of techniques, the number of published tagging validation studies is growing rapidly.[62] A recent review[63] identified 108 intracoelomic tagging effects studies covering 53 different fish species, and although the review did not cover external tag attachment, or gastric or ovipositor tagging,[64] its major findings are presumably transferable to these techniques. The majority of tagging effects studies focus on salmonids, cyprinids, ictalurids, and centrarchids, and typically aim to determine whether tagging causes a negative effect in comparison to controls in the context of mortality, growth, healing, and tag retention.[65] Less frequently, studies focus on the sublethal effects of tagging on swimming ability, predator avoidance, physiological costs, or fitness, and evaluations of long-term effects of tagging on individual behaviour and physiology are largely lacking. Literature reviews as well as best practice surgery guidelines for fish from a veterinary perspective[66] centralise information and can provide knowledge transferable to all species (e.g., recommending use of monofilament over multifilament suture material for wound closure). However, even for the most commonly studied species, numerous knowledge gaps remain in terms of surgical procedures and measured endpoints.[67] Further, many field studies operate under a set of conditions unique to that particular situation (e.g., water quality including temperature, physiological status of individuals including maturation stage, etc.), which all have the potential to influence individual responses to tagging. Clearly, caution should be exercised when transferring techniques to previously untagged species (see examples from the literature in use of surrogates below) due to possible species- or

[61] *See* review of intracoelomic implantation technique reporting in field studies by Jason D. Thiem et al., *Trends in the Reporting of Tagging Procedures for Fish Telemetry Studies That Have Used Surgical Implantation of Transmitters: A Call for More Complete Reporting*, 21 REV. FISH BIOL. FISH. 117–126 (2011).

[62] *See* Cooke et al., *supra* note 6.

[63] *Id*.

[64] *See* Bridger & Booth, *supra* note 6; Jill M. Janak et al., *The Effects of Neutrally Buoyant, Externally Attached Transmitters on Swimming Performance and Predator Avoidance of Juvenile Chinook Salmon*, 141 TRANS. AM. FISH. SOC. 1424–1432 (2012).

[65] *See* Cooke et al., *supra* note 6.

[66] *See* Mulcahy, *supra* note 9; Craig A. Harms, *Surgery in Fish Research: Common Procedures and Postoperative Care*, 34 LAB. ANIM. 28–34 (2005).

[67] *See* Brown et al., *supra* note 23.

context-specific responses.[68] We also suggest that at least, a cautious interpretation of results should be used when interpreting data emanating from field applications of telemetry when thorough tagging validation studies have not been undertaken as part of that particular project.

7. SHOULD YOU TAG WHEN YOU HAVE USED SUBSTITUTE SPECIES TO EVALUATE TAGGING TECHNIQUES FOR FISH?

Often in biology surrogate species are used to infer/predict responses of another species, or to represent a broader group.[69] The use of surrogates appears logical for a number of circumstances, including when measuring the response of the broader group (i.e., numerous species) is not feasible. For single species substitutions, use of surrogates is appealing, particularly when substituting for threatened or endangered species or populations. In these cases, adequate sample sizes of the target (threatened) group may not be available for initial testing, and use of the target group may endanger its long-term viability.[70] Clearly, the use of a surrogate group brings into question the transferability of information, and often requires a number of assumptions to be made. In some cases, these assumptions can be tested, enabling an information feedback loop to occur.[71] In the context of telemetry tagging, there is little doubt that using surrogate groups can provide a valuable tool for improving surgical techniques prior to field application (see surgical training section). However caution is warranted when transferring information. For example, Ebner et al.[72] demonstrated that transfer of surgical implantation techniques from the surrogate golden perch (*Macquaria ambigua*) to the endangered Macquarie perch (*M. australasica*) resulted in mortality and/or tag rejection in the latter. A follow-up study by Broadhurst et al.[73] identified

[68] For example, *see* Brendan C. Ebner et al., *A Cautionary Tale: Surrogates for Radio-tagging Practice Do not Always Simulate the Responses of Closely Related Species*, 60 Mar. Freshwater Res. 371–378 (2009).

[69] *See* Mi T. Caro & Gillian O'Doherty, *On the Use of Surrogate Species in Conservation Biology*, 13 Conserv. Biol. 805–814 (1999); Jorie M. Favreau et al., *Recommendations for Assessing the Effectiveness of Surrogate Species Approaches*, 15 Conserv. Biol. 3949–3969 (2006); John A. Wiens et al., *Using Surrogate Species and Groups for Conservation Planning and Management*, 58 Biosci. 241–252 (2008).

[70] *See* Jim J. Groombridge et al., *An Attempt to Recover the Po'ouli by Translocation and an Appraisal of Recovery Strategy for Bird Species of Extreme Rarity*, 118 Conserv. Biol. 365–375 (2004).

[71] For example, *see* Linda C. Sappington et al., *Contaminant Sensitivity of Threatened and Endangered Fishes Compared to Standard Surrogate Species*, 20 Environ. Toxicol. Chem. 2869–2876 (2001).

[72] *See* Ebner et al., *supra* note 68.

[73] *See* Ben T. Broadhurst, Brendan C. Ebner, & Rhian C. Clear, *Effects of Radio-tagging on Two-year-old, Endangered Macquarie Perch (Macquaria australasica: Percichthyidae)*, 60 Mar. Freshwater Res. 341–345 (2009).

the suitability of Macquarie perch to telemetry tagging via modification of the original technique that Ebner et al. used.[74]

Numerous examples of species-specific behavioural and physiological responses to telemetry tagging exist; for example, stream dwelling fishes exhibiting cryptic behaviours including the occupation of interstitial spaces preclude the use of external tags due to snagging on rocks.[75] Other fish and some cyprinids, are known to expel telemetry tags through their body wall, even after complete healing of surgical wounds; modifications to surgical techniques including anchoring tags to the pelvic girdle did not improve retention.[76] Ebner et al. provide a useful framework to aid decision-making when considering tagging threatened species, including the incorporation of information gained from conducting tagging trials on surrogate species.[77]

8. SHOULD YOU TAG FISH WHEN THE CAPTURE TECHNIQUES CAUSE SIGNIFICANT INJURY AND/OR STRESS?

One of the challenges inherent to conducting electronic tagging research on wild organisms in the field is the necessity to capture, tag, and release animals. The capture event itself typically requires the use of one of many capture methods such as netting, hook-and-line, trot line, electrofishing, or trapping. Following capture, there is generally some form of handling and restraint both prior to and during tagging, and typically brief air exposure as individuals are transferred from capture gear to holding tanks in preparation for tagging. In many cases, individuals are also held on board vessels in holding totes or net pens for some time prior to tagging, which may involve confinement or crowding stress[78] that can have post-release consequences.[79] These stressors associated with capture and handling, no matter how brief or gentle, still result in physiological disturbances that require time and energy for the fish to recover.[80] Injury and scale loss resulting from capture and

[74] *See* Ebner et al., *supra* note 68.

[75] Ben T. Broadhurst, Brendan C. Ebner, & Rhian C. Clear, *Radio-tagging Flexible-bodied Fish: Temporary Confinement Enhances Radio-tag Retention*, 60 MAR. FRESHWATER RES. 356–360 (2009); Etienne Baras & Denys Jeandrain, *Evaluation of Surgery Procedures for Tagging Eel Anguilla anguilla with Biotelemetry Transmitters*, 371 HYDROBIOLOGIA 107–111 (1998).

[76] Adam J. Daniel et al., *Acoustic and Radio-transmitter Retention in Common Carp (Cyprinus carpio) in New Zealand*, 60 MAR. FRESHWATER RES. 328–333 (2009).

[77] *See* Figure 2 in Ebner et al., *supra* note 68.

[78] *See* Donald E. Portz, Christa M. Woodley, & Joseph J. Cech, *Stress-associated Impacts of Short-term Holding on Fishes*, 16 REV. FISH BIOL. FISH. 125–170 (2006).

[79] *See* Michael R. Donaldson et al., *The Consequences of Angling, Beach Seining, and Confinement on the Physiology, Post-release Behaviour and Survival of Adult Sockeye Salmon during Upriver Migration*, 108 FISH. RES. 133–141 (2011).

[80] *See* review by Eric W. Oldenburg et al., *Holding of Juvenile Salmonids for Surgical Implantation of Electronic Tags: A Review and Recommendations,* 21 REV. FISH BIOL. FISH. 35–42 (2011).

handling may make organisms more susceptible to pathogen transmission and disease development.[81] While steps can be taken to minimize the effects of capture, handling, and tagging on fish, it is nearly impossible to completely avoid these effects when conducting research on wild animals. In effect, many studies inadvertently include a bycatch or catch-and-release component every time fish are tagged, even if that is not the intended focus of the study.

There are ways to minimize or at least attempt to account for the effects of capture techniques on tagged individuals. First, since the magnitude and duration of a capture stressor influences the time required to recover,[82] rapid capture, tagging, and release can reduce consequences of researcher handling. Anaesthetics can expedite handling and tagging once fish have been caught. However, when anaesthetics are used, a recovery period is needed, which may not always be appropriate (e.g., gastric tagging studies on Fraser River, B.C., Canada sockeye salmon, *Oncorhynchus nerka*, where tagged fish may be re-captured in food fisheries; see above).[83] As an alternative to rapid release, fish can be recovered briefly in captivity, such as using well-aerated and temperature appropriate holding vessels,[84] which could provide optimal conditions for physiological recovery and which eliminates the effects of predators. However, these methods may inadvertently contribute to mortality[85] if density, water flow, or temperature is not rigorously monitored. Keeping careful notes on each individual fish on time of capture, on-board holding, and tagging may enable these variables to be included as covariates in statistical models if these factors are expected to influence post-release behaviour and survival of tagged fish.

Awareness of how environmental conditions can exacerbate negative effects of capture is extremely important and should be considered when planning study designs. If a study's goal is to quantify mortality associated with capture (e.g., a bycatch study), then comparative methods can be used wherein individuals are captured using two or more capture techniques to 'control' for, or at least assess, the relative effect of a study's capture method

[81] *See* Francois S. Chopin & T. Arimoto, *The Condition of Fish Escaping from Fishing Gears—A Review*, 21 FISH. RES. 315–327 (1995).

[82] Reviewed in Steven J. Cooke & Cory D. Suski, *Do We Need Species-specific Guidelines for Catch-and-release Recreational Angling to Conserve Diverse Fishery Resources*?, 14 BIODIVERS. CONSERV. 1195–1209 (2005).

[83] *See* Steven J. Cooke et al., *Coupling Non-invasive Physiological Assessments with Telemetry to Understand Inter-individual Variation in Behaviour and Survivorship of Sockeye Salmon: Development and Validation of a Technique*, 67 J. FISH BIOL. 1–17 (2005).

[84] *See* Anthony P. Farrell et al., *Successful Recovery of the Physiological Status of Coho Salmon Onboard a Commercial Gillnet Vessel by Means of a Newly Designed Revival Box*, 58 CAN. J. FISH. AQUAT. SCI. 1932–1946 (2001).

[85] For example, *see* Donaldson et al., *supra* note 79.

(e.g., angling versus beach seine).[86] Finally, for species amenable to laboratory conditions, controlled studies and tagging validation studies can accompany field studies to understand and account for the effects of capture, handling, and tagging to minimize tagging effects.

9. SHOULD YOU TAG WHEN YOU KNOW THAT TAGGING MORTALITY IS 'HIGH'?

Beyond the stress of capture techniques, which can contribute to post-release mortality, one needs to consider the effects of water temperature on tagged fish. All fish species have a temperature range within which individuals do not exhibit any signs of stress and/or abnormal behaviour,[87] but as temperatures increase, metabolic rates rise[88] and the stress response is intensified.[89] Perhaps where water temperatures are of greatest concern to a telemetry study are for those working in sub-tropical or tropical locales, where fish may be exposed to temperatures close to their thermal maxima.[90] Indeed, Murchie et al. found that when working with bonefish (*Albula vulpes*), a circumtropically distributed group of fishes (i.e., *Albula spp*.), the survival rate of tagged individuals decreased to less than 43 per cent for fish tagged in the summer (when August water temperatures were 29°C) compared to a survival rate of 80 per cent for fish tagged in the cooler waters of November–March (20–25°C).[91] While bonefish naturally occupy these warmer waters, the combination of capture and tagging stress was exacerbated by thermal stress.[92] Thermal tolerance data are particularly limited for tropical marine species[93] and therefore can be a knowledge gap for researchers planning studies on such species. Without these data, however, we can suggest that tagging be avoided at peak water temperatures.

[86] *See* Lisa A. Thompson et al., *Physiology, Behavior and Survival of Angled and Air Exposed Largemouth Bass*, 28 N. AM. J. FISH. MANAGE. 1059–1068 (2008); Michael R. Donaldson et al., *Enhancing Catch-and-Release Science with Biotelemetry*, 9 FISH FISH. 79–105 (2008).

[87] *See* Portz, Woodley, & Cech, *supra* note 78.

[88] *See* John R. Brett, *Energetics*, *in* PHYSIOLOGICAL ECOLOGY OF PACIFIC SALMON 1–68 (Cornelis Groot, L. Margolis, & William Craig Clarke eds., 1995).

[89] *See* Michael P. Wilkie, *Influences of Temperature upon the Post Exercise Physiology of Atlantic Salmon (Salmo salar)*, 54 CAN. J. FISH. AQUAT. SCI. 503–511 (1997).

[90] *See* Thomas L. Beitinger, Wayne A. Bennett, & Robert W. McCauley, *Temperature Tolerances of North American Freshwater Fishes Exposed to Dynamic Changes in Temperature*, 58 ENVIRON. BIOL. FISH. 237–275 (2000).

[91] *See* Karen J. Murchie et al., *Considerations for Tagging and Tracking Fish in Tropical Coastal Habitats: Lessons from Bonefish, Barracuda, and Sharks Tagged with Acoustic Transmitters*, *in* HANDBOOK OF FISH TELEMETRY 389–412 (American Fisheries Society, 2012).

[92] *See* Daniel W. Beyers & James A. Rice, *Evaluating Stress in Fish Using Bioenergetics-based Stressor-Response Models, in* BIOLOGICAL INDICATORS OF AQUATIC ECOSYSTEM STRESS 289–320 (S. Marshall Adams ed., 2002).

[93] *See* Andrés F. Ospina & Camilo Mora, *Effect of Body Size on Reef Fish Tolerance to Extreme Low and High Temperatures*, 70 ENVIRON. BIOL. FISH. 339–343 (2004).

Temperature can also play a role in the rate of healing of surgical incisions in fish as it influences both the immune and inflammatory response.[94] At warm water temperatures, wound healing can be accelerated,[95] however opportunities for infection are increased and absorbable sutures break down quickly.[96] These considerations are important for both temperate and tropical teleosts. Walsh et al.[97] found higher water temperatures (22–29°C) influenced wound irritation, infection, and mortality in hybrid striped bass (*Morone saxatilis* × *Morone chrysops*) when compared to fish surgically implanted at low (12–18°C) water temperatures. Adult bluegill (*Lepomis macrochirus*) radio tagged and held at 6°C and 20°C experienced 10 per cent mortality and 15 per cent tag loss for fish surgically implanted at the higher water temperature.[98] Given that the success of a telemetry study will be influenced by the number of tagged fish at-large for a longer period of time, any factor that is known to influence the mortality rate on your species should be given special consideration when planning your study.

10. DOES THE POTENTIAL BENEFIT TO THE POPULATION ARISING FROM TAGGING OUTWEIGH THE POTENTIAL NEGATIVE CONSEQUENCES TO THE INDIVIDUAL?

The benefits of the information gained at the population level must be balanced with the potential costs associated with the welfare of the tagged individuals. This issue is inherently polarizing and not easily reconciled. This very notion represents an ethical dilemma where it could be argued that the costs to the individual are undermined by the important information gained at the population level. For example, tagging of a fraction of individuals in a population to determine their migration routes and reproductive behaviour may yield important information on reproduction and fitness that could be used to improve management and conservation of that population or species. However, it could be argued that the capture and tagging of individuals results in an animal welfare issue in which the researchers cause stress or distress to the individuals in their study. This could potentially lead to longer-term effects and increased

94 *See* Mulcahy, *supra* note 9.

95 *See* C.D. Anderson & R.J. Roberts, *A Comparison of the Effects of Temperature on Wound Healing in a Tropical and a Temperate Teleost*, 7 J. Fish Biol. 173–182 (1975); Jennifer L. Panther et al., *Influence of Incision Location on Transmitter Loss, Healing, Incision Length, and Suture Retention of Juvenile Chinook Salmon*, 140 Trans. Am. Fish. Soc. 1492–1503 (2011).

96 *See* Cooke et al., *supra* note 19.

97 *See* Maureen G. Walsh, Kimberly A. Bjorgo, & Jeffery J. Isely, *Effects of Implantation Method and Temperature on Mortality and Loss of Simulated Transmitters in Hybrid Striped Bass*, 129 Trans. Am. Fish. Soc. 539–544 (2000).

98 *See* Brent C. Knights & Becky A. Lasee, *Effects of Implanted Transmitters on Adult Bluegills at Two Temperatures*, 125 Trans. Am. Fish. Soc. 440–449 (1996).

likelihood of predation or tagging-related mortality. In fact, there is a growing awareness and appreciation for the ethical considerations and animal welfare of study organisms, including those studied in the field.[99] This issue is particularly problematic when it comes to making decisions on whether or not to conduct tagging studies on threatened wildlife, especially species in regions without permitting agencies. In such cases, engaging international conservation organizations such as International Union for the Conservation of Nature specialist groups as well as any researchers with experience on tagging similar taxa would be helpful.

There are important considerations to take into account that may help researchers, managers, conservation bodies, and funding agencies to decide when it is appropriate to conduct electronic tagging studies on wild organisms, although admittedly, such questions should be asked on any study involving animals. First, is the study based on a sound research question that will advance our understanding of the fundamental biology of an organism? Also, will the research inform important management and conservation strategies to ensure the sustainability of the population or species? For example, researchers could consult with managers and conservation agencies to jointly decide on the most pressing research questions that have the potential to tackle both basic and applied research questions. Second, is the study design conservative in sample size, utilizing the lowest number of tagged individuals to provide the greatest return of information? For example, if similar research has been done in the past, a power analysis could be used to help improve study design and to tag the minimum number of individuals that will provide the maximum information for a particular research question.[100] However, this does require a relevant set of data being available from which future results can be implied.

Third, is the research team well trained and experienced and using appropriate equipment, including using appropriately sized tags, to minimize stress and maintain animal welfare in the capture and tagging of individuals? Consultations with animal welfare committees at universities or agencies and individuals with experience in tagging, and engaging veterinarians in cases where invasive tagging procedures are used, would be beneficial and tend to be the norm in academic and government institutions. In cases where these three considerations cannot be met, there are potential alternatives such as mining the existing literature, exploring statistical modelling approaches, or tagging taxonomically similar species to address specific research questions. Finally, are there inherent biological factors of the species of interest that may make them more susceptible to tagging-related mortality (e.g., likely to be

[99] *See* R.J. Putman, *Ethical Considerations and Animal Welfare in Ecological Field Studies*, 4 BIODIVERS. CONSERV. 903–915 (1995).

[100] *See* Randall M. Peterman, *Statistical Power Analysis Can Improve Fisheries Research and Management*, 47 CAN. J. FISH. AQUAT. SCI. 2–15 (1990).

injured by capture, prone to infections at incision sites, susceptible to post-release predation)? In all cases, caution and sound judgement must be used for populations or species that are imperilled or vulnerable to ensure that the research efforts do not further contribute to population declines.[101]

11. SHOULD YOU TAG IF THERE IS THE POTENTIAL FOR THE DATA TO BE USED BY FISHERS TO EXPLOIT FISH?

Historically, when a scientist published a paper in the peer-reviewed literature, it was unlikely that it would find its way into the hands of stakeholders. However, changes in information technology (i.e., the Internet), online journals, open access, data sharing, and social media mean that stakeholders are more able to find and access published papers as well as archived datasets. To our knowledge, there has been little thought about what these innovations mean with respect to how information from tracking studies could be used. Consider an instance where scientists study the spatial ecology of a fish species in an effort to identify seasonal habitat use. Those same data could be desirable to the fishing community given that they would provide insight into where high densities of fish could be found for exploitation, particularly if geo-spatial (e.g., GPS locations) position of fish aggregations were also provided. This notion is more than just hypothetical. Writing in a popular fishing magazine, Grover presents an example from the midwestern United States where anglers attempted to obtain information from a telemetry study of a gamefish.[102] The argument was largely based on the notion that the research was conducted using taxpayer dollars and thus they should rightfully have access to such information.

Similar situations can develop in a commercial fishing context where knowledge of fish distribution informs exploitation.[103] When knowledge of fish distributions from telemetry is combined with the many other technical innovations that exist in both recreational and commercial fisheries (e.g., GPS, depth finders, sonar, detailed bathymetric maps, etc.), one may wonder what chance the fish have.[104] Whenever conducting research that will reveal the spatial distribution of fish, one must consider the various ways in which the information will potentially be exploited for not only good, but for harm. At

[101] *See* Cooke, *supra* note 1.

[102] *See* J.Z. Grover, *One Cast Beyond - The Public's Right to Know—Radiotelemetry*, 26 In-Fisherman 18–22 (2001).

[103] For example, *see* Fredric M. Serchuk & Ronald J. Smolowitz, *Ensuring Fisheries Management Dysfunction: The Neglect of Science and Technology*, 15 Fisheries 4–7 (1990); Heidi Dewar, *Revealing Secrets of Fishing Using High Technology*, 2 Current 25–29 (1998).

[104] *See* Rita L. Hummel & Gary S. Foster, *A Sporting Chance: Relationships between Technological Change and Concepts of Fair Play in Fishing*, 18 J. Leisure Res. 40–52 (1986); Serchuk & Smolowitz, *id*.

times, efforts may need to be taken to prevent the dissemination of specific locations (especially GPS coordinates) to ensure that the tracking data that may have been generated to inform conservation and management do not themselves lead to conservation and management problems. Great thought should be put into the release of these types of sensitive data since a single angler could potentially wipe out a majority of an entire population of fish if, for example, the locations of winter aggregations of fish in small rivers or streams are known. Researchers and managers may want to consider such data sensitive and not include them in the reports that are made available to the public.

12. DO YOU TAG WHEN YOU KNOW THAT ABORIGINAL PEOPLES ARE UNCOMFORTABLE WITH THE NOTION OF PUTTING ELECTRONIC TAGS IN/ON FISH?

One of many considerations with tagging animals is obtaining support from surrounding aboriginal communities, and respecting their cultural practices and beliefs. It is our assertion that when Aboriginal peoples are present in a region and have territorial rights, you should not tag without their permission. Many concerns that Aboriginal peoples have with biological research are rooted in deep cultural and spiritual values and beliefs. As responsible biologists, we should be aware of these beliefs because attitudes and actions of researchers toward nature in general and their study of animals can influence their credibility in the aboriginal community and lead to challenges for future research.[105] We provide two examples of interactions with Aboriginal groups and concerns about the effects of the electronic tags on animals. The first involves an Aboriginal group (British Columbia First Nations) that is directly concerned with the animal to be tagged (Pacific salmon). The second group (Baffin Island Inuit) was more concerned about the potential impact electronic tags and receivers have on other species that were not tagged (marine mammals).

During our own research (co-authors Cooke, Nguyen, and Hinch), we encountered apprehension from some BC First Nation communities/elders regarding the use of electronic tagging technology to study Pacific salmon—a highly valued species for subsistence that also has cultural significance and spiritual connections to the Aboriginal peoples.[106] Concerns that were often voiced included the idea that tagging is 'playing with food,' a perspective that

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[105] *See* Tim Byers, *Perspectives of Aboriginal Peoples on Wildlife Research*, WILDLIFE SOC. B 671–675 (1999).

[106] *See* J. Lichatowich, L. Mobrand, & L. Lestelle, *Depletion and Extinction of Pacific Salmon (Oncorhynchus spp.): A Different Perspective,* 56 ICES J. MAR. SCI. 467–472 (1999).

Aboriginal peoples often have towards catch-and-release angling.[107] Additionally, during a human dimensions component of our own telemetry research, we documented concerns among BC native fishers about the 'stressful techniques associated with tagging,' and the potential of disturbing natural migration patterns with handling procedures and tags.[108] These perspectives were similar to those found among other Canadian Aboriginal groups about tagging mammals.[109] Despite these apprehensions, we found that a large proportion of respondents were open to telemetry research, albeit some were supportive with scepticism (e.g., concerns of effects of tags on fish, fish welfare, and 'who' is conducting the research).[110]

Following two successful years (2010–2012) of electronic tagging studies of Greenland halibut (*Reinhardtius hippoglossoides*) in Cumberland Sound, lower Baffin Island, our (co-author Fisk) request to continue this research was denied by the community of Pangnirtung, Nunavut. As required by permitting agencies (Department of Fisheries and Oceans), we had submitted a project proposal in English and Inuktitut to the Hunter and Trappers Organization (HTO) of Pangnirtung months (2–6) prior to research in 2010, 2011, and 2012.

In addition, a principal investigator of the research team met with the HTO in person at least once before the field season, reports on the results of research were submitted in both languages to the HTO, and local fishers were hired every year of the project. Although the goal of these meetings and proposals were to inform the community and get approval for research, important information was also learned about the animals and ecosystem and resulted in some changes to the research plan based on feedback. In 2012, the HTO rejected the request to continue to leave acoustic receivers, marine mammal listening devices, and oceanography equipment in Cumberland Sound (which were deployed for a full year in 2010 and 2011). Elders in the community felt that ringed seals (*Pusa hispida*) were more difficult to find in 2011 and 2012 and that the instruments were the cause. Despite a community presentation in both languages, led by Fisk, that demonstrated that the instruments were silent, deployed >1,000 m deep and well beyond the normal dive depths of these seals (<150 m), and were in the middle of Cumberland Sound >10 km from hunting areas, elders in the community felt the seals could 'sense' the instruments and that they scared them away.

[107] *See* N. Haggan, C. Ainsworth, T.J. Pitcher, & J.J. Heymans, *Life in the Fast Food Chain: Où Sont les Poisons D'antan?*, *in* Resetting the Kitchen Table: Food Security, Culture, Health and Resilience in Coastal Communities 51–74 (C.C. Parrish, N. Turner & S. Solberg eds., 2007).

[108] *See* in press article by Vivian M. Nguyen et al., *Aboriginal Fisher Perspectives on Use of Telemetry Technology to Study Adult Pacific Salmon*, 408 Knowl. Manag. Aquat. Ec. (2012).

[109] *See* Byers, *supra* note 105.

[110] *See* Nguyen et al., *supra* note 108.

The research on the halibut was important for plans to develop an artesian-based commercial fishery and was strongly supported by young fishers from the community and the Government of Nunavut. In this case, the concern was not about the Greenland halibut but rather about a non-tagged species, ringed seals, which are an important native food and a key cultural species. This project has moved to Scott Inlet, Baffin Island, near the community of Clyde River, which fully supports the research. Additionally, in a separate project in the high arctic community of Resolute Bay, Nunavut, there has been no concern from the HTO or community about the impact of a much larger set of receivers and tags in shallower water (<50 m) on ringed seals and whales.

Through engaging and consulting Aboriginal fishers in research, it is possible to gain insight and understanding about specific concerns with tagging. In turn, this interaction can help identify misunderstandings, misconceptions, and knowledge gaps about the research through increased education/awareness, and information sharing of project goals, findings, usefulness of findings, and future directions. Furthermore, in the case of Nguyen et al.[111] and research by co-author Fisk in Arctic communities, the authors learned that despite the views of some Aboriginal elders, there was greater support for telemetry research than we anticipated from the fishers. However, despite open and complete communication between researchers and Aboriginal group organizations, concerns by native peoples about the impact of electronic instruments on animals can stop research projects.

Another important consideration is the inclusion and use of indigenous environmental knowledge/traditional knowledge. Many Aboriginal peoples feel that their knowledge should be consulted more than it usually is when biological field studies are designed and conducted.[112] Conservation initiatives arising from electronic tagging studies often require buy-in from Aboriginal groups to succeed, especially if changes to fishing practices or management zones are involved. Including local Aboriginal representatives as part of the research crew provides a positive and effective link to communicate research rationale and methods to the aboriginal communities as well as providing appropriate direction when it comes to potential conflict and sensitive issues.[113] We suggest that involving Aboriginal peoples in the research project from start to finish can increase support for your research and enrich your work, such as promoting participation in tag return programmes. The improved dialogue between researchers and Aboriginal peoples can ensure on-going collaboration

[111] *See* Vivian M. Nguyen et al., *Differences in Information Use and Preferences among Recreational Salmon Anglers: Implications for Management Initiatives to Promote Responsible Fishing*, 17 HUM. DIMENS. WILDL. 248–256 (2012).

[112] *See* Byers, *supra* note 105.

[113] *Id.*

for future tracking studies and encourage stakeholders to embrace findings originating from the use of such technology. Through such dialogue, it will be apparent whether you should put an electronic tag in or on fish when it comes to respecting Aboriginal views and beliefs. That said, success cannot always be ensured as has been observed by recent work (by co-author Fisk) in the Cumberland Sound region of the Arctic.

13. SYNTHESIS AND CONCLUSION

Our objective was to present a candid evaluation of key factors that should be considered when determining when to tag or not to tag fish with electronic devices. By doing so, it was our desire to stimulate debate and discussion regarding the use of electronic tags to study fish. Such an exercise has the potential to improve welfare practices related to tagging, improve the quality of the data obtained, and ensure that the data collected are embraced by stakeholders but not abused. As noted above, for most of the questions posed here, there is no right or wrong answer. Instead there are a range of options available to the researcher. In many cases, the burden still lies on the telemetry practitioner[114] as not all countries (or institutions) regulate or require ethical approval to conduct research on wild animals.[115] Even when there are Institutional Animal Care and Use committees, as well as government natural resource agencies and stakeholder groups, it tends to be the researcher who is ultimately left with selecting an appropriate path. At a minimum, we would hope that this article will lead to researchers thinking about the various questions we have identified. Another means by which the scientific community has the potential to influence fish tagging studies is through the granting and peer-review processes. Problems could be identified at these stages by peer reviewers who would either prevent funding from being delivered or impede the ability to publish research findings in reputable peer-reviewed outlets (e.g., the Fisheries Society of the British Isles now requires that contributors to the *Journal of Fish Biology* complete an ethics survey). There is also a need for more research to address these questions (e.g., what level of cleanliness is needed when conducting surgeries, what level of training is needed and how is it best delivered, under what circumstances does it make sense to rely on surrogates). Also needed are human dimensions studies to understand perspectives of different actors, including society as a whole, with respect to tagging studies.

Biotelemetry and biologging tools have provided unprecedented information on the biology, management, and conservation of wild fish but are not

[114] *See* Minteer & Collins, *supra* note 4.

[115] *See* Frances R. Peck & Richard C. Simmonds, *Understanding Animal Research Regulations: Obligations of Wildlife Departments and Field Researchers*, 23 Wildlife Soc. B 279 (1995).

without controversy. Even when scientific and management objectives may be best achieved using electronic tags, it is important to consider other factors (e.g., welfare, conservation, stakeholders). Failure to consider these factors has the potential to create conflict and undermine scientific, management, and public confidence in the use of electronic tags. It is our assertion that too often tagging studies forge ahead without careful thought about these issues. As electronic tagging and tracking becomes more affordable, accessible, and common, it will be critical to ensure that we think carefully about when to tag and when not to tag.