



Symposium II: Use and Challenges of Catch and Release in Recreational Fisheries

H1

Guiding Principles for the Recreational Fishing of Threatened Species for Anglers, Outfitters, and Policy Makers

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Despite the large proportion of the global population that fishes recreationally and the myriad impacts and benefits it generates, recreational fishing continues to be less publicly visible compared to commercial fisheries from a sustainability perspective. This inattention has, in some areas, resulted in a lack of discussion and regulation surrounding the impacts of recreational fishing for species listed as threatened with extinction on the Red List (RL) developed by the International Union for the Conservation of Nature (IUCN), or otherwise listed as threatened, imperilled, or endangered on other state-, national-, or regional-scale listings. To address this gap, the authors have developed a series of guidelines for the recreational fishing of threatened species based on the best available research and practical experience that includes biological, social and economic considerations. It is our intention that anglers, other recreational fishers, fishing organizations, boating clubs, industry partners, managing bodies, non-governmental organizations (NGOs), and authorities responsible for setting national or regional policies will consider incorporating the recommended changes to their practices, including actions to avoid, reduce, or manage risk associated with the recreational fishing of threatened species and evaluate the need for further assessment.



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H2

Catch-and-Release Science for Tomorrow - Needs, Opportunities, and Challenges

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Since the “Catch-and-release fishing as a management tool” symposium held in 1977 in California, there have literally been hundreds of studies covering diverse marine and freshwater fishes. Yet, there remain significant science needs among the management and angling community. Our ability to address the knowledge gaps that remain are often hampered by inherent challenges related to studying catch-and-release science in a manner that findings are reliable and relevant. In this presentation we reflect on key developments in catch-and-release science, identify management needs and science gaps, and provide commentary on how to overcome some of the inherent challenges with catch-and-release science.



H3

Catch-and-Release in the Management of the Taupo Trout Fishery, New Zealand

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Catch and release has become an important component of many recreational fisheries and managers have two main ways of administrating it. It can be compulsory (catch-and-release only) when attempting to offset excessive fishing pressure or it can be banned (no catch and release) when ethical reasons prevail. Between these two extremes, catch-and-release is generally implemented based on individual angler's motivation. However, there are situations where catch-and-release is not desirable for ecological reasons and in more serious cases it can even make the fishery worse, for example, in fisheries where substantial harvests are necessary to maintain fish quality.

Trout were introduced in New Zealand and have quickly become the top predator of many aquatic systems. When predators need to be controlled the challenge for the managers is to communicate to the anglers that their role is to harvest trout and that catch-and-release is not always in the best interest of the fishery. Here two evidences are presented: 1) a substantial harvest is necessary to maintain the quality of trout in the Taupo fishery and 2) the historical trend of catch-and-release doesn't follow a predictable trend based on fish quality and/or changes in the societal evolution of fisheries.



H4

Inserting Anglers into the Catch and Release Angling Science and Practice Improves Their Behaviour and Fish Health and Survival – A Long-Term Intervention on a Marine Shore-Based Competitive Angling League

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While there is general consensus of the importance of inserting anglers into catch and release (C&R) angling science, few studies have successfully documented improved C&R behaviour in response to a scientific intervention. This study is the culmination of a four-year project that aimed to improve the C&R practices in a competitive angling league in South Africa. Limited scientific information was collected during the first two years (2013-2014) of the project. Instead, a team of scientists from Rhodes University joined a C&R competitive angling league, with the aim of immersing ourselves into the angler culture, understanding the league system, and providing assistance (species identification, scoring etc.) where required. By the end of 2014, the team was asked to fulfil a formal role as a scientific advisory group (SAG) and was incorporated into the national structures. The SAG was responsible for scoring, record keeping and rule changes and were tasked with improving the rule structure to improve fish survival. While the group was inclined to implement several rule changes immediately, it made the decision to collect baseline data during the 2015 National competition so that proposed changes would be supported by scientific data and the response to rule changes could be measured in the 2016 National competition. Besides the introduction and amendment of several rules after the 2015 competition, the SAG also promoted improved C&R practices through presentations, instructional videos, an annual scientific report (which explained future rule changes), online content, introduced best handling prizes and had many informal conversations (eg. on the benefits of circle hooks) with anglers. Preliminary results indicated a marked improvement in both the C&R behaviour and fish health and survival by the 2016 National competition. Average air exposure for teleosts and elasmobranchs decreased from 95 sec. to 76 sec. and from 118 sec. to 104 sec., respectively. The average blood glucose concentration of teleosts and elasmobranchs after the C&R event dropped from 2.25 mmol.ml⁻¹ to 1.80 mmol.ml⁻¹ and 3.73 mm.ml⁻¹ to 2.20 mm.ml⁻¹, respectively. The average blood lactate concentrations in teleosts and elasmobranchs decreased from 6.96 mmol.ml⁻¹ to 5.38 mmol.ml⁻¹ and 4.79 mm.ml⁻¹ to 4.17 mm.ml⁻¹, respectively. Although the results of the study do show that inserting the angler into C&R angling science and practice can successfully improve C&R behaviour, we believe that this is best done through long-term engagements that initially aim to build the trust and respect of anglers.



H5

Let's Get Real: Air Exposure Time of Wild Trout in a Catch-and-Release Fishery

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Fishing regulations are used by natural resource agencies to accomplish a variety of management objectives. Catch-and-release regulations are one of the most commonly implemented types of fishing regulations. Catch-and-release regulations have largely been successful in reducing exploitation, and increasing density and size structure of fish populations. Recently, concerns have been raised regarding anglers exposing fish to air during catch-and-release angling. To date, only one study has explicitly focused on air exposure times of angled fish. Our study evaluated the length of time angled fish were exposed to air by anglers in a typical catch-and-release fishery. Anglers were observed on the South Fork Snake River from May through August 2016. Observations were conducted discreetly as to not alter angler behavior. We recorded a number of angler characteristics including air exposure duration, fight time, approximate age of the angler, sex of the angler, how the angler accessed the river, whether the angler was guided, whether the angler took a picture, and whether the angler used a landing net. Air exposure duration was considered from the time the fish left the water until the fish was returned to the water. In total, we observed 312 individual anglers. The longest air exposure interval averaged 18.8 s (SE = 0.8), and fight time averaged 40.5 s (3.5). Results of this study suggest that anglers typically do not expose fish to air long enough during catch-and-release angling to incur the negative effects associated with prolonged air exposure.



H6

Catch-And-Release Angling Can Enhance the Fishery Benefits of MPAs: Evidence from the Isimangaliso Wetland Park in South Africa.

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While the success of no-take MPAs has been widely promoted for biodiversity conservation, their use in fisheries management has been criticized, partly due to their inability to provide short term benefits to local fisheries. However, it has been suggested that recreational catch-and-release (C&R) angling could be compatible with no-take area management. A long-term (15 years) fish monitoring and tagging project in the iSimangaliso Wetland Park (South Africa) provided a unique opportunity to evaluate the compatibility of C&R angling within a no-take conservation area. Research shore angling, using best practise C&R methods, took place in a previously exploited area (with a recovering fish community) and in an adjacent no-take sanctuary area (with an undisturbed fish community). Catch trends revealed a significant increase in targeted fish species abundance and biomass in the previously exploited area, while catches were generally more stable in the no-take area during the first 10 years of monitoring. This suggested that C&R research angling was not having a negative effect on surf-zone fish populations, some of which were highly resident species. Furthermore, effects of deep-hooking, multiple captures and other environmental impacts often associated with recreational C&R shore angling were also shown to have a relatively low impact. These findings are discussed in terms of opportunities for improved conservation of this and other MPAs in South Africa and further afield.



H7

Modeling Intentions to Sanction Among Anglers in a Catch-And-Release Recreational Fishery for Golden Dorado (*Salminus brasiliensis*) In Salta, Argentina

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Catch-and-release (C&R) is a potentially powerful tool for minimizing impact on recreationally targeted fishes. Although C&R can and frequently is mandated in fisheries through regulation, voluntary adoption of best practices is often critical due to minimal enforcement opportunities. In recreational fisheries where formal enforcement is lacking, anglers themselves may play an important role in increasing C&R adoption through interpersonal sanctioning, i.e., self-policing. To date, little research has examined factors that predict anglers' willingness to sanction others' behavior in C&R fisheries. We conducted in-person and online surveys with anglers who participate in a C&R fishery in northern Argentina to explore sanctioning behavior. Results show that a combination of intrinsic values, demographics, and fishing behaviors predicted anglers' intentions to sanction others. In particular, anglers with the strongest intentions to sanction were younger and more open to adopting best-practices, identified fishing as important to their lifestyle, and expressed high environmental concern relative to other anglers. Ultimately, our findings highlight the important role that anglers can play in promoting C&R best practices via interpersonal sanctioning and help identify some of the barriers to these types of engagement.



H8

Best Angling Practices for Catch-And-Release Fisheries: State of the Art and Research Needs

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The majority of recreationally angled fish are released in many fisheries due to harvest regulations and conservation ethics of anglers. However, post-release survival rates can be highly variable, and are often related to interactions between angler behaviours (including gear choices) and environmental conditions. I will synthesise our current knowledge of best angling practices, i.e., those that have the least negative impacts on fish and result in the highest rates of post-release survival. On the forefront, reflex impairment tests are reliable tools for anglers to assess fish condition upon capture to make educated decisions about the fate of their catch. When fish are in poor condition, anglers often employ recovery techniques (e.g., maneuvering fish through the water by hand), yet there is currently limited evidence for their efficacy.



H9

Development of an Integrated Rapid Assessment Approach for Recreational Fisheries: A Case Study of the Mahseer Catch-And-Release Fishery of the Cauvery River, India

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There is increasing recognition among researchers that the recreational fishing sector is growing around the world, that sizeable data deficiencies exist for numerous target species, and that multidisciplinary research is required to address fisheries issues. The question remains: how do we address these data deficiencies from multiple perspectives (biological, social, economic) in a timely manner, given scarce resources, for a multitude of fisheries? Our team has developed an integrated rapid fishery assessment that layers the use of stakeholder involvement and participatory research approaches on to existing biological and sociological assessment tools to generate crucial baseline data for emerging or poorly studied fisheries. We applied this approach to a pre-existing but un-studied catch-and-release recreational fishery targeting mahseer (*Tor spp.*) on the Cauvery River in Karnataka, India. We identified fishery stakeholders and co-generated a research agenda. We then embarked on physiological and behavioural studies to measure immediate and delayed responses of mahseer to catch-and-release. Angler behaviours and perspectives were measured using surveys, and interviews of key personnel served to clarify the history and context of management issues in the fishery. Community surveys were designed to assess the amount of support for recreational fishing activity and to identify areas of potential conflict. Finally, a coarse estimate of expenditures generated by recreational fishing activity was developed. We discuss the methodologies applied, assessment costs, the findings they generated, and the issues encountered along the way in an effort to help others consider how this approach may be relevant to other fisheries.



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H10

Forced Marriage or Perfect Union: Collaboration Between Science and Recreation for Conservation

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The iconic Fraser River White Sturgeon in British Columbia is significant to communities all along the Fraser River. It holds cultural, social and economic significance for First Nations heritage, recreational enthusiasts and sport fishing professionals. In order to ensure the long-term sustainability of this species, all user groups need to adopt best practices in encountering and handling White Sturgeon. The FRSCS uses its scientific research to help develop best practices and affect change in industry practices. A successful example of science being applied to affect change in industry practices is the Fraser River Sturgeon Conservation Society's (FRSCS) recently released "Can You Handle It? Guidelines for Angling White Sturgeon in British Columbia" online tutorial. This resource is based on the guidelines developed in partnership with the FRSCS, the Province of British Columbia, Fisheries and Oceans Canada, Fraser Valley Angling Guides Association. Employing these best handling practices in this catch and release fishery is a key part of long-term conservation strategies. However, successful conservation depends angler buy-in and change in industry practices. The "Can You Handle It?" program, in collaboration with local regulation enforcement, encourages best handling practices and affects change in industry practices.



H11

Effects of Common Angler Handling Techniques on Florida Largemouth Bass Behavior, Feeding, and Survival

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Black Bass *Micropterus spp.* anglers commonly adopt catch-and-release as a conservation practice. However, handling practices following capture have the potential to affect fish feeding behavior and survival following release by an angler. The act of lifting bass for handling, hook removal, and photography may cause stress and injury, and the degree of injury could be influenced by fish size. For trophy bass, jaw musculature and tendons may not support the fish's body weight out of the water. We conducted an experiment with Florida Largemouth Bass *M. salmoides floridanus* to evaluate the relative differences in survival, jaw mechanics, and feeding success following use of 3 commonly observed handling treatments: 1) vertical lip grip device, 2) tilted, one-handed grip using only the lower jaw, and 3) two-handed horizontal support. The time it took for bass to regain equilibrium and resume normal swimming behavior after handling differed across handling treatments, being shortest in the two-handed support treatment (mean \pm SD, support 7 ± 10 sec; vertical 33 ± 74 sec; horizontal 12 ± 16 sec). Minor injuries (e.g., abrasions and sores) and diseases (e.g., tumors and fungus) tended to increase following handling across all treatments. Results suggested no evidence of handling-specific differences on fish feeding behavior, jaw adjustments, and mortality across the treatments. However, based on differences in recovery time, we recommend Florida Largemouth Bass anglers handle fish with a two-handed support treatment to minimize the time required for fish to regain equilibrium following an angling event.



H12

Effects of Air Exposure on Survival and Fitness of Yellowstone Cutthroat Trout

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Recently, concerns over the negative effects of exposing fish to air during catch-and-release angling have become more prevalent. Current literature has focused on the effects of air exposure on mortality. However, few studies have evaluated its effects on fitness. Our objective was to evaluate the effects of air exposure on survival and fitness of Yellowstone Cutthroat Trout *Oncorhynchus clarkii bouvieri*. Pre-spawn adult fish were sampled at a velocity-barrier weir on a tributary of the South Fork Snake River during May through October 2016. While the gills remained underwater, each fish was tagged with a passive integrated transponder tag (PIT), a tissue sample was taken, the fish was measured, and hooked through the lower jaw. Fish were released upstream of the weir and played to simulate angling. After angling, fish were randomly assigned an air exposure treatment of 0, 30, or 60 s. In total, 1,523 adult fish were sampled (0 s, n = 488; 30 s, n = 499; 60 s, n = 536). Adult fish were detected at two PIT-tag antennas located downstream of the weir as they out-migrated to the SFSR. We detected 217 tagged fish (0 s, n = 58, 12%; 30 s, n = 71, 14%; 60 s, n = 88, 16%). Additionally, age-0 fish (n = 2,924) were collected and tissue samples were taken for parentage analysis to evaluate the effects of air exposure on fitness. Results of this study will provide insight on how catch-and-release angling influences survival and fitness of Yellowstone Cutthroat Trout.



H13

Post-Release Condition, Pathogen Loading, and Survival of Atlantic Salmon

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Catch-and-release is a common practice in recreational fisheries to comply with harvest regulations or voluntarily as a result of angler conservation ethic. Understanding how fisheries interactions – including exhaustive exercise, air exposure, and handling – impacts post-release condition and survival is necessary for developing appropriate management strategies and angler outreach materials. The impacts of fisheries stress may vary with changing environmental conditions, such as increasing temperature. Here, an in-river holding study was used to understand how exercise, air exposure, and handling in warm and cold waters influence the post-release health and condition of wild Atlantic salmon. In the Campbellton River, Newfoundland, adult salmon migrating back to fresh water were collected at a counting fence and subject to experimental exhaustive exercise, air exposure, and handling, biopsied for gill and blood, then placed in an in-river holding pen for monitoring. RNA extracted from gill biopsies were used to screen for pathogen loads and Atlantic salmon immune and osmoregulatory gene expression. By combining in-situ fisheries simulations and gene expression technologies, we explore the relationship between fisheries related stressors, salmon condition, microbial pathogen productivity, and post-release survival.



H14

Physiological Response and Post-Release Movements of Wild Steelhead Following Catch-And-Release in the Recreational Fishery of the Bulkley River, British Columbia

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Steelhead, *Onchorynchus mykiss*, is one of the most coveted recreationally targeted salmonids worldwide, and catch-and-release is commonly used as a conservation tool to protect wild stocks. Nevertheless, very little research has looked at how steelhead respond to capture and handling, particularly on wild Steelhead. During the 2016 summer run on the Bulkley River, British Columbia, we assessed the physiological stress response and post-release movement patterns of wild steelhead that were angled and then exposed to three air exposure treatments (i.e., 0 s, 10 s, 30 s). Radio-telemetry was used to assess the immediate movement of steelhead for 20 mins post-release as an indication of fish condition. Subsequent relocations of steelhead 30 days after capture provided an estimate of migration rate (m/day) prior to overwintering and indicated probable mortalities. Fish were then identified during the spawning period in April of 2017 to look at the potential long-term effects of various angling practices on spawning site choice. Ongoing lab work implementing qRT-PCR will relate host gene expression following a stressor to the physiological stress response variables measured (glucose, lactate, pH). This study is among the first to evaluate the factors that influence the outcome of catch-and-release on wild steelhead, and will be used to develop species-specific best practice guidelines to be shared throughout the angling community.



H15

Assessing Anglers' Intentions to Adopt and Communicate Best Practices in a Catch-And-Release Fishery for Steelhead in British Columbia, Canada

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The intersection of species survival and angling behavior has driven a recent upswing of research examining how catch-and-release (C&R) angling manifests to affect post-catch mortality and fitness. Perhaps less salient to ascertaining evidence-based C&R best practices is the anglers' ability and willingness to advocate for best practices within their angling communities. This is important because prior research indicates that various forms of interpersonal communication (e.g., social sanctions) can increase cooperative and pro-environmental behavior. Informal angling communities, such as those that operate under limited enforcement, could benefit not only from anglers' adopting best practices, but also from anglers playing an active role in communicating for best practices amongst their peers (e.g., in-person, on social media). We conducted in-person and online surveys to examine social-psychological and demographic factors that may shape anglers' willingness to adopt best practices and sanction others' practices in a prominent Steelhead C&R fishery in British Columbia, Canada. Results reveal that anglers who most strongly endorse sanctioning were younger, expressed higher concern compared to others, were concerned about their reputation, and perceived scientific research and sanctioning as effective. Further, the majority of respondents felt anglers are responsible for conserving steelhead populations, but perceived that only about half of other anglers engage in C&R best practices. Our study further sheds light on anglers' attitudes towards C&R angling (e.g., perceived trade-offs), and their willingness to change their current practices to evidence-based best practices, while underscoring the critical role of anglers in maintaining effective C&R fisheries and outlining potential pathways for engagement.



H16

Water Temperature and Air Exposure Interactions Influence Recovery and Reflex Action Mortality Predictors in Angled Brook Trout

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Fish that are angled and subsequently released can be subject to perturbations to homeostasis, which may result in ecologically relevant physiological or behavioural consequences. Understanding the fate of caught-and-released fish remains a central objective of recreational fisheries research, and can directly inform management practices. There is growing need to understand the mechanisms governing fish recovery from angling events, particularly the effects of angler behaviour. The physiological capacities of fish to perform exhaustive exercise and mediate stressors under varied environmental conditions are well known, however the interactive effects of angler behaviour are less well documented. Here we examine the interactive effects of water temperature and air exposure on recovery and reflex impairment of brook trout *Salvelinus fontinalis* in eastern Canada. We demonstrate that fish reflex impairment and recovery are correlated with water temperature and duration of air exposure, and identify limits for air exposure at incremental water temperature thresholds. The results of this study provide an empirical basis for claims that angler behaviour should be responsive to environmental conditions, and demonstrate a broadly applicable method for evaluating interactive effects of angling stressors.



H17

Physiological Effects of Temperature, Dissolved Oxygen and Handling on Recovery of Largemouth Bass from Simulated Angling Stress

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Post-release survival of angled black bass may vary due to cumulative physiological effects of multiple, sub-lethal stressors, notably ambient water temperature, live well water temperature, dissolved oxygen content and handling. Although tournaments for Largemouth Bass, *Micropterus salmoides*, are common, connections between typical procedures, physiological stress and mortality are not well established. Therefore, the objectives of this study were to examine: 1) effects of acute temperature change (-4, 0, +4 °C) and handling stress over a range of acclimation temperatures (17, 25, 33 °C) and 2) effects of dissolved oxygen concentration (2.0, 5.5, 8.5 mg/L) and handling stress over a range of acclimation temperatures (25, 29, 33 °C) on physiological responses to stress and post-stress recovery in Largemouth Bass. Bass were initially reared in tanks and later in ponds, with a finishing diet of live forage 4-6 weeks prior to experimentation. Following acclimation to treatment conditions, fish were stressed by chasing to simulate angling, transferred to 4 replicate live wells where temperature and dissolved oxygen were manipulated for 8 hours, subjected to a simulated weigh-in procedure, and released into recovery tanks at acclimation conditions. At each stage, blood was sampled from a subset of fish and measured for hematocrit, plasma cortisol, lactate, glucose, osmolality, and pH, and leukocytes were quantified pre- and post-stressor to evaluate immune responsiveness. Results of this experiment will provide information on the stress response and recovery of Largemouth Bass subjected to a range of tournament and catch and release conditions.



H18

Fish Air Exposure and Landing Times in Various Idaho Fisheries

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Fish caught and released by anglers, whether voluntary or otherwise, may experience elevated but rarely lethal physiological stress, or (under extreme conditions) acute mortality, due to capture or handling stress. How much stress or mortality occurs depends in part on how long it takes anglers to land fish (fight time), and how long they hold fish out of water (air exposure). In a recent study, 95% of trout anglers in Idaho exposed fish to < 120 s of fight time (mean = 53 s) and < 60 s of air exposure (mean = 26 s) before releasing their catch. While these results suggest that fight and air exposure times for fish landed by trout anglers may be biologically inconsequential, this study appears to be the first to measure such information for anglers unaware that their capture and handling behaviors were being monitored. Building upon these findings, we measured fight and air exposure times for anglers in a variety of additional fisheries, including those targeting hatchery trout, salmon and steelhead, and warm water species (i.e., bass and panfish). On average, fight times were minimal for bass and panfish (mean = 13 s) and much longer for salmon and steelhead (164 s), whereas air exposure times were similar for bass and panfish (28 s), hatchery trout (35 s), and salmon and steelhead (36 s; data collection ongoing). These findings will be placed in the context of studies investigating fish stress and mortality due to exhaustion and air exposure.



H19

Singles vs. Treble Hooks – Potential Tissue Damage and Unhooking Techniques in Brown Trout

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The supposed advantages of single over treble hooks in relation to injury are often discussed without considering the effect of hook size and unhooking techniques: When shifting from treble to single on a lure of a given size anglers will often choose singles 3-4 hook sizes larger to compensate for the smaller effective hook gape. This could cause more damage than initially believed. Based on hook measurements, we calculated potential depths and volumes of hook wounds from singles and trebles, finding that the hook wounds from singles can be 30-100 % more severe than those of trebles fished traditionally on same lure. The situation further deteriorates when microtrebles are fished on novel mounting techniques on artificial lures. Moreover, by overlaying different-sized hooks on X-ray photos in 1:1 from cross-sections of trout heads, we document that large singles can penetrate through the soft layers between the palate bones into critical areas such as brain and eyes of < 50 cm trout (*Salmo trutta*). By contrast, small trebles with shallower hook holds are physically not capable of reaching such vital tissues. Large singles are also more difficult (flies/natural bait) or even impossible (splitting-mounted artificial baits) to be removed with a pushback disgorging while the fish is submerged under water. Depending on the rig used, this can be possible with small trebles fished on lures. These results suggest that a more detailed focus on fishing methods, hook sizes and unhooking techniques is warranted when evaluating the welfare-benefits of hook types.



H20

Indifly: An Alternative Model for the Development of Sustainable Catch-And-Release Recreational Fisheries

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In many recreational fisheries, science and management is developed and implemented after the fishery has become popular, especially for those in remote locales or emerging economies. This can lead to scientists and managers struggling to ensure the sustainability of the fishery and the need for post-hoc regulations and management plans. We present an alternative model whereby baseline assessments are conducted before the establishment of the recreational fishery and in collaboration with local stakeholders. The model is also dependent on the conversion of some local fishers from artisanal fishers to recreational fishing guides, community based management, and local ownership of recreational fishing operations. We provide examples from Guyana and French Polynesia, with operations at different stages of development.



H21

A Terminal Gear Innovation in Lure Fishing Strongly Improves Landing Rates and Reduces Injury and Unhooking Time in Brown Trout and Northern Pike, With Implications for Catch-And-Release Fishing

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Optimal choice of terminal gear in hook-and-line fishing shall maximize landing rates and minimize injury to the fish. We hypothesized larger hooks on artificial lures to cause impaired penetration and hookhold leading to lower landing rates, plus increased degree of injury and bleeding compared to smaller hooks on the same lure types. To test these hypotheses, we present observational large-N data comparing traditional lures with the same lures fished on so-called release-rigs, where it is possible to drop down 4-5 hook sizes on any type and size of lure. Using this rig, the landing rates of searun brown trout (*Salmo trutta*) and northern pike (*Esox lucius*) doubled from about 40% with traditional artificial lures or flies to about 85 % when the same lure types were fished on release-rigs. In pike, the traditional mounting techniques with larger hooks also produced significantly more injury and significantly elevated dehooking time compared to release rigs. The latter also allow keeping deeply hooked fish under water while dehooking with a pushback-disgorger. To conclude, release-rigs on artificial lures benefit both anglers and the fishes that are to be released and overall offer a substantial innovation over traditional techniques.



H22

Estimating and Mitigating Post-Release Mortality of European Eel (*Anguilla anguilla*) In Recreational Fisheries

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Globally, several anguillid eel populations have experienced severe declines in recent decades. This is particularly relevant for the European eel, a socio-economically important fishery target species which has been listed as critically endangered. Thus, several European countries have introduced stricter eel angling regulations which increased the likelihood of regulatory catch-and-release (C&R) in recreational fisheries. A C&R mortality study was conducted using pre-tagged eels (110 angled and 38 control fish) in a semi-natural environment to (i) estimate post-release mortality rates for different treatments, (ii) examine factors affecting mortality and (iii) investigate sublethal effects of C&R on eel. Additionally, a 1-year diary study was conducted with 70 eel anglers providing information on 389 specific eel angling trips regarding angling effort, harvest and release rates, and hooking location including hook types used. Short-term mortality (≤ 72 h) ranged from 0.0%-18.2% and adjusted total mortality rates from 8.4%-64.4% (after 43-65 d) depending on hook size, hooking location, and unhooking treatment. Mean absolute weight changes per day did not differ between treatments. The diary study showed that anglers can significantly decrease the catch of sublegal eels and thus release rates by using large J-hooks. Using large J-hooks or circle hooks instead of small J-hooks also reduced the likelihood of deep hooking. Both studies showed that there is a need to combine different research designs and their corresponding results to develop best-practice guidelines reducing post-release mortality and catch of sublegal fish, thereby mitigating negative effects of C&R and promoting fish conservation in recreational fisheries.



H23

Determinants of Angling Catch of Northern Pike (*Esox lucius*) - The Role of Abiotic and Biotic Factors, Spatial Encounters and Lure Type

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Studies on catches of anglers usually rely on observational data and are thus uncontrolled with respect to angler skill, bait/lure choice and site choice. We performed a controlled angling experiment targeting northern pike (*Esox lucius*) in a 25 ha, weakly eutrophic natural lake to understand abiotic, biotic and gear-related factors determining catch rates and size of pike. The experiment was conducted over two one-week long fishing campaigns where boat-based anglers randomly sampled 30 pre-determined sites. Sites were systematically exposed to two standardized lure types (soft plastic shad or spoon). We found catch rates of pike per 15 min to be significantly higher in shallow water and when soft plastic shads were used compared to deeper water and when spoons were used. Catch rates significantly dropped over the course of seven days, suggesting either learning or other reasons moving pike from vulnerable to invulnerable pools. Catch rates varied by season and across anglers and sites. There was no lure effect on the size of the pike captured, but we found a seasonal effect and a day effect, suggesting larger fish were captured first. Pike captured in sublittoral areas were significantly smaller than those captured in other habitats. Our study documented a novel effect of lure type on catch rates of pike, but the explanatory power of the predictors was only moderate. Our results support the idea that the best fishing ingredients are investing time and maximizing encounter probabilities with only moderate additional effects of abiotic conditions, day time and lure type.



H24

Factors Influencing Post-Release Predation for a Catch-And-Release Fishery with a High Predator Burden

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Post-release predation is an increasingly recognizable component of post-release mortality across fisheries sectors. Although predators of all taxa have declined in abundance worldwide, emerging fisheries in remote parts of the world can be at odds with predators when there is significant risk of post-release predation on fish that are released. We studied bonefish *Albula glossota* in a remote Pacific atoll with dense blacktip reef sharks to quantify post-release predation and identify best practices. Our research on angled bonefish focused on identifying how air exposure influenced the probability of post-release predation by sharks. Recognizing and accounting for post-release predation in these remote fisheries is the key to sustainability in the fishery. Our findings and suggestions for future research will contribute to best practices for fishing in regions with high predator burden.



H25

Capture Stress and Post-Release Survival of Southern Bluefin Tuna from Recreational Fishing

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Southern Bluefin Tuna (SBT) are an iconic large pelagic species. The demand for this species led to significant commercial overfishing in the past. Australia currently holds the largest quota share of SBT with the species found in relative abundance off the western, southern and southeastern coastline of the continent. At times of the year schools of SBT migrate along the coast of Australia within range of recreational fishing boats. In recent years the popularity of the recreational fishery for SBT has increased significantly. Given this increase in fishing effort and the stringent international management of this species gaining an understanding of the Australian recreational fishery is seen as filling a crucial knowledge gap. Here we investigate capture stress and post-release survival of SBT caught using recreational fishing techniques. For 233 fish we assessed factors such as fight time, hooking damage and handling duration against physiological stress indicators including glucose, lactate, pH, cortisol and osmolality levels in blood plasma. For 59 of these fish we then assessed survival post-release by attaching pop-up satellite archival tags to monitor the fish's behavior and movement for up to 180 days and assessed these results against potential explanatory factors of mortality listed above. The results have been used to develop a scientifically robust code of practice for the handling of SBT and the post-release survival rates are available in conjunction with planned surveys to estimate the un-accounted mortality from the national recreational fishery for integration into stock assessment models and consideration.



H26

Trade-Offs and Lessons Learned in Deriving Fishery-Scale Discard Mortality Estimates and Best Catch-And-Release Guidelines in the Gulf of Maine Recreational Groundfish Fishery

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Deriving reliable discard mortality estimates and best catch-and-release guidelines that are scalable to the fishery level can be difficult in recreational fisheries given the multitude of interacting biological, technical, and environmental factors that govern the fate of discarded fish. This is especially evident when a recreational fishery includes a wide range of target species, fishing gear/tackle, handling practices, and angler experience levels. In the Gulf of Maine recreational groundfish fishery, the discard mortality rates of key demersal fishes, specifically Atlantic cod, haddock, and cusk, were identified as sources of uncertainty in recent stock assessments and fishery management plans. To fill these data gaps, we used a combination of acoustic telemetry and fishery-dependent data to estimate discard mortality and also establish guidelines to reduce the mortality of these species. Given the inherent challenges with acoustic telemetry (e.g. cost, emigration, data resolution) and difficulties with scaling study results to a fishery level, robust study design and analytical approaches were crucial. Acoustic array designs and systems, for instance, were designed to align with each species' anticipated spatial ecology to maximize the likelihood of transmitter detection. Mortality events were designated quantitatively using vertical and horizontal movement data from positive and negative controls. Finally, longitudinal survival modelling determined which capture factors influenced mortality in tagged specimens, allowing for survival results to be extrapolated onto regional recreational survey data to derive fishery-scale discard mortality estimates. These projects were valuable for establishing objective procedures that can be applied to future recreational discard mortality studies.



H27

Evaluating Physiological Consequences of Catch-And-Release on Atlantic Halibut

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Atlantic halibut (*Hippoglossus hippoglossus*) is a popular recreational target species in the North Atlantic. In Norwegian waters, this species is regulated by a minimum landing size, which requires the release of all sublegal halibut. This species has become one of the most popular voluntary catch-and-release (C&R) species for recreational anglers due to its large size and powerful endurance during the fight. Recently, C&R practice for halibut has received substantial public critique questioning the sustainability and ethical tenability of this fishery. Currently, the Norwegian Food Safety Authority is considering a ban of voluntary C&R practice due to potential fish welfare issues. Even though a recent post-release mortality study showed that post-release survival can be very high, potential fish welfare issues were not included. Thus, a study focusing on sublethal effects of C&R (particularly fighting time and air exposure duration) on halibut was conducted. Seventy halibut were caught with angling gear, and exposed to different air exposure treatments (0, 4 and 10 minutes). Blood samples were either taken directly after capture (baseline) or after a one hour holding period. Moreover, RAMP (reflex action mortality predictor) testing was performed on all individuals after blood sampling. The blood was analyzed in the field (glucose, lactate, and hematocrit) and in the laboratory (cortisol, chloride, potassium, osmolality, and pH). The results of the post-release mortality study and of the present study enable to evaluate C&R of halibut from a fish welfare perspective, and contribute to the development of best practice guidelines to minimize negative C&R impacts.



H28

Reducing Post-Release Mortality in Florida Keys Flats Fisheries Through Research, Angler Education, and Regulation Implementation: A 5-10 Year Plan

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For many recreational fisheries, the practice of catch and release (C&R) has replaced harvest as the top outcome of fishing effort. However, mortality can still occur as a result of C&R, and as such, reducing post-release mortality has become the focus of conservation efforts. The Florida Keys (U.S.) recreational flats fishery functions as one of the major drivers of the regional economy. Despite these fisheries being primarily C&R, declines of flats species have been documented and anecdotally observed. Though the mechanism behind these declines are not fully understood, fishing pressure and post-release mortality may play a role. Here we: 1) review the history of the Keys flats fishery and its transition from harvest to C&R; 2) summarize the current state of ecological knowledge of flats species and plausible sources of their declines in the Florida Keys; 3) propose research designed to provide actionable knowledge that will inform education programs and regulation aimed at improving angler ethics and reducing post release mortality. We focus on the three flats species (Bonefish, Permit, and Tarpon) and a common cause of fishing-related mortality - predation. The goal is to identify spatio-temporal interactions between angler effort and predation risk, and to use this information to alter angler behavior by reducing effort in locations and time periods when predation risk is high. Given the economic importance of the fishery to the region, and the fishery's continued growth, C&R practices that minimize loss must be adopted for the fisheries to remain sustainable.



H29

Tipping the Scalability: Proactive Guidelines to Enhance the Management Application of Discard Mortality Studies in Recreational Fisheries

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Discard (i.e. “release”) mortality (DM) estimates are routinely used by fisheries managers to, among other key functions, inform stock assessments, set allowable catch limits, and establish accountability measures in a fishery. In recreational fisheries most notably, DM investigations can also indirectly help derive best catch-and-release guidelines to reduce any evident DM. In a fishery where discard rates hold management implications, and/or for species most susceptible to stress and injury from capture/handling, rigorous DM studies are imperative. However, given the often-considerable cost and logistical burdens for DM studies to account for the full range of variables in a given fishery, resulting DM estimates are often not commensurate with the broader fishery, yielding inadequate DM estimates or ranges. To address this, studies are increasingly combining more costly but effective direct methods (e.g., electronic tagging) with indirect and cheaper strategies (e.g., RAMP or vitality indexing) to amplify the power of results per unit cost. The use of combined parametric, semiparametric, and non-parametric survival models are now published for this specific application. Additional methods to increase DM applicability in recreational fisheries include, but are not limited to, early and regular communication with DM data recipients (managers) to ensure study design and execution are properly aligned with need, and data collection under fishery dependent conditions that employ a wide range of angler experience levels. Calling on recent lessons from the Gulf of Maine (GOM) recreational groundfish fishery, this talk will review suggested practices and tradeoffs that help maximize the applied value of DM estimates.



H30

Paradoxically High Mortality in a Catch-And-Release Fishery

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Inland recreational fisheries in North America are often managed using passive harvest regulations such as length and bag limits, rather than active strategies that limit angler effort. The most stringent passive regulation is catch-and-release; however, restrictive regulations may fail in situations where discard mortality and/or angler effort is high. One such example is the Lower Bow River (LBR) in Alberta, which supports a world-renowned and economically valuable Rainbow Trout (*Oncorhynchus mykiss*) sport fishery. Creel surveys suggest that effort is high relative to other Alberta fisheries (>161 angler hours/ha), and nearly all captured fish are immediately released. Although release rates approached 100%, preliminary analyses indicated that total instantaneous mortality of Rainbow Trout in the LBR were high (i.e., > 1.17). Thus, our objective was to determine whether catch-and-release regulations were capable of maintaining this high-effort fishery. We conducted an integrated analysis of Rainbow Trout demography in the LBR, and used this information to parameterize an age-structured model and explore management tradeoffs via Monte Carlo simulation. Our findings indicated that moderate discard mortality could result in population decline, thus challenging the universality of the catch-and-release paradigm. We discuss the implications of our findings for high-effort inland recreational fisheries in general, and suggest active management restrictions may provide an important tool for conserving high-effort inland recreational fisheries in the future.



H31

Survival and Fitness of Atlantic Salmon in Recreational Fisheries

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Atlantic salmon are one of the most recognizable species on earth and have a long history of cultural, economic, and recreational importance. Atlantic salmon is now a species at risk in many jurisdictions and there are diverse strategies used to manage these recreational fisheries to ensure sustainability. We implemented diverse tools including biotelemetry and biologging to measure the survival and migration success of Atlantic salmon in different phases of the freshwater migration. Our findings identify significant predictors of post-release mortality of salmon captured by anglers, changes in behaviour of fish captured and release by anglers, and management regulations that influence the proportion of salmon released by anglers.



H32

Estimating Delayed Mortality of Gray Triggerfish Using Surface and Bottom Tagging

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The number of discarded gray triggerfish (*Balistes capriscus*) in the US southeast has nearly doubled in recent decades, perhaps as a result of stricter management measures and increased effort. High numbers of discards represent large sources of uncertainty in stock assessments, necessitating robust estimates of discard mortality. We used conventional tagging of gray triggerfish in depths of 35-40 m, a depth common to the fishery in the US southeast. We tagged one group of triggerfish on the seafloor (by SCUBA divers via traps) and another group at the surface (via traps and hook-and-line) to estimate discard mortality by observed condition. Discard mortality in best-condition surface-released gray triggerfish was ~ 40% (relative to the assumed zero mortality for seafloor tagged fish) and was higher for fish with outward signs of barotrauma (~ 66%). Preliminary application of these condition-specific values to numbers-by-condition for released fish from a survey of for-hire vessels indicates a substantial increase in overall discard mortality with depth of capture. On average, overall discard mortality may be 45% or higher for triggerfish discarded in the US southeast which is substantially higher than the value (12.5%) assumed in the most recent assessment. These findings will be important in calculating the number of dead discards required as input into stock assessments for gray triggerfish in the US southeast and other areas of the world where they are fished.



H33

The Knowledge, Perceptions, and Use of Barotrauma Mitigation Tools by Florida Saltwater Anglers

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Fisheries management measures such as seasonal closures, size and bag limits are reliant on the successful release (survival) of fish. Some species, such as deepwater reef fish, are particularly susceptible to mortality from barotrauma, the bloat and internal organ damage caused by pressure change. The mortality associated with these releases is of key concern for fisheries managers; however, there is a conspicuous gap in understanding anglers' awareness of barotrauma and their knowledge, acceptance and current use of barotrauma mitigation tools. The purpose of this study was to provide some insight into the current understanding of barotrauma by anglers in Florida and to characterize patterns of use and non-use by these anglers. A statewide survey was conducted in 2014 using a list of saltwater license holders in Florida. The online survey generated 737 completed surveys. This presentation will describe the findings of this survey, focusing upon respondents' fishing patterns, awareness of barotrauma, understanding and knowledge of the physiological effects of barotrauma, the current use of barotrauma mitigation tools, and the reasons for use and non-use of these tools. The findings will be presented across angling depth zones, experience and avidity levels, and region of the state.