



## 8th World Recreational Fishing Conference

### Poster Session

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#### Survival of Yellowstone Cutthroat Trout Exposed to Air During Mid-Summer Angling Events

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Despite the success of catch-and-release regulations, exposing fish to air during release is a recent concern. The purpose of this study was to evaluate the effect of mid-summer air exposure on survival of Yellowstone Cutthroat Trout *Oncorhynchus clarkii bouvieri*. Yellowstone Cutthroat Trout were sampled by angling on a tributary of the South Fork Snake River, during August 2016. After capture, fish remained in the water while they were measured and tagged with T-bar anchor tags. Anglers were placed into groups of two to four people. For each angling group, the first fish captured was randomly assigned to and exposed to air for 0, 30, or 60 s. Air exposure treatments were then cycled in ascending order. In total, 327 fish were sampled (0 s, n = 109; 30 s, n = 110; 60 s, n = 108). Two weeks after angling, single-pass backpack electrofishing was used to recapture tagged fish. No difference in survival was observed among treatments (0 s, n = 75, 69%; 30 s, n = 63, 57%; 60 s n = 66, 61%), suggesting that mortality from air exposure is not a concern in catch-and-release fisheries.



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### How to Promote a Recreational Salmon Fishery Under a Cloud of Conservation: Case Study of Canada's Yukon Territory

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While the Yukon has a storied and rich history which involves fishing for many species of salmon, opportunities to participate in these “traditional” recreational fisheries have changed significantly over the past decade. Given the variability and long-term decline experienced with some stocks coupled with an aversion to a “consumptive” harvest of salmon, recreational fisheries in Yukon are at a crossroads. Locally, recreational fishing culture and knowledge has declined with fewer anglers participating or aware of the opportunities available. Further to this, the perception of salmon fishing in Canada’s north is not well understood by tourism interests and is often overshadowed by the mecca of recreational salmon fisheries in neighboring Alaska. This presentation will explore: conservation considerations facing recreational fisheries in Yukon, the “social license” required to fish for salmon in times of conservation, responsible advocacy and promotion of recreational salmon fisheries, renewed, new and emerging recreational fishing opportunities beyond “traditional” fisheries, and targeting and meeting visiting angler expectations in Yukon. With a myriad of potential, emerging and exploratory angling opportunities coupled with a remote and pristine landscape, Yukon offers a diversity and variety of salmon angling opportunities. Increasingly Yukon is recognized as a world-renowned destination for adventure travelers and outdoor enthusiasts, which provides significant opportunities for local economic development. From a recreational salmon fishery perspective, the question for management agencies, First Nation Governments and communities is “are we ready”?



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### Responsible Angling for a Data Deficient Species (*Arapaima arapaima*)

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Globalization has created a scenario in which anglers are constantly pushing boundaries of what is possible for capturing fish. This can outpace formal conservation assessments (e.g. assignment of IUCN status) but must not preclude responsible angling practices. We collaborated with an Amerindian fishing lodge (Rewa Eco Lodge) that specializes in fly fishing for *Arapaima arapaima*, a recently-designated species of Osteoglossiform fish native to Guyana that is considered data deficient by IUCN. We used a temporary accelerometer harness to quantify post-release activity and breathing frequency of arapaima released by anglers to determine post-release survival and assist in the development of best practices for the fishery. Best practices for recreational fishing are essential for sustainable fishing and have benefits that extend from ecological to economic and development goals in many regions around the world.



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### The ASF Freshwater Recovery Strategy: An Angler's Guide for Grassroots Atlantic Salmon Conservation

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Wild Atlantic salmon support significant recreational fisheries that provide substantial social and economic benefits. Atlantic salmon populations have been in general decline since the 1970s, with more precipitous declines occurring in some areas within the past twenty years. Reduced freshwater productivity is one factor contributing to population declines. Improving conditions in rivers and streams is therefore vital to conserving and rebuilding Atlantic salmon populations. The salmon angling community has a long history of active involvement in grassroots conservation, and local angler-led watershed stewardship groups are often the driving force behind watershed rehabilitation and recovery initiatives. However, despite an interest and willingness to engage, many groups and individuals are constrained by a lack of capacity (e.g., knowledge, vision, networks, etc.) to design and implement effective recovery programs. As part of a broader initiative to engage anglers in salmon conservation, the Atlantic Salmon Federation has designed the ASF Freshwater Recovery Strategy to build capacity among watershed groups. The program is designed to help groups evaluate the health of their salmon population, identify and understand the root causes of problems, and develop effective restoration action plans to address them. This poster describes the ASF Freshwater Recovery Strategy and ongoing efforts to increase the capacity of angler-led stewardship groups to engage in effective actions for the conservation and recovery of wild Atlantic salmon and the fisheries they support.



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### Fisheries and Oceans Canada (DFO) Consultation Process with BC Recreational Fisheries Through the Sport Fishing Advisory Board (SFAB)

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The Canadian federal government, through Fisheries and Oceans Canada (DFO), regulates and manages all recreational fisheries in Canadian tidal waters, and also recreational salmon fisheries in fresh water. The Sport Fishing Advisory Board (SFAB) has been the official recreational advisory board to DFO in British Columbia since 1964. The SFAB provides an inclusive and broadly representative process for the views of the recreational fishing community. This process provides formal advice and recommendations to DFO on matters relating to tidal recreational fisheries and non-tidal anadromous fisheries. An overview will be provided on the structure, roles and responsibilities, and operational procedures of the consultation process between government and non-government representatives. Further information will be provided on how engagements between DFO and the recreational sector flow through local Sport Fishing Advisory Committees (SFAC) to the SFAB then to higher level harvest planning processes with all interested parties (First Nations, commercial fisheries associations, Non-Governmental Organizations, and the Government of the Province of British Columbia) at the Salmon Integrated Harvest Planning Committee (IHPC) and the sub-committees and working groups within.



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### Isotopic Composition of Otoliths Between Yelloweye Rockfish and Canary Rockfish

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Yelloweye rockfish *Sebastes ruberrimus* and canary rockfish *Sebastes pinniger* are important rockfish species along the United States Pacific coast. Yet little is known about their life history and stock structure from a geochemical perspective. In this project we collected 200 otoliths of yelloweye rockfish and 120 otoliths of canary rockfish from waters off the Washington and Oregon coast, and carried out stable carbon and oxygen isotope ratio analyses (d13C and d18O). Two aragonite powder samples were taken from the surface of each otolith: one came from the nucleus of the otoliths, and the other came from the 5th annual zones. Data from otolith nuclei can provide information on the natal sources and spawning stocks, while isotopic variations from age-1 to age-5 indicate changes in fish habitat associated with growth. Overall, the d13C values of these rockfish otoliths ranged from -6.5 to -1.4‰ VPDB (Vienna Peedee belemnite) whereas d18O values of the same otoliths ranged from -0.5 to +2.2‰. There were no isotopic differences in otolith nuclei, suggesting there may be a single spawning stock or population for both rockfish species along the WA and OR coast. From age-1 to age-5, these fish might change their habitat or associated bottom substrates for different levels of food. The isotopic results and interpretation seemed in agreement with genetic studies on yelloweye rockfish and underwater observations for both rockfish.



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### South Puget Sound Coho Salmon *Oncorhynchus kisutch* Barging Study

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Juvenile salmon survival rates in Puget Sound/Salish Sea are depressed from a historical perspective (<http://marinesurvivalproject.com/>). Anecdotal evidence and results from current studies indicate potential areas with increased mortality on juvenile salmonids, among other factors result in decreased numbers of returning adult salmonids, including Coho Salmon. Coded-wire tags (CWT) are used coast-wide to determine contribution to state and tribal fisheries and estimate survival rates used by fishery managers to evaluate hatchery programs and fisheries. Squaxin Island (Tribal) Net Pen hatchery operations provides a high value opportunity to fishers for both state and tribes as greater than 80% of adults are harvested within Puget Sound. Its location is conducive to fishing as returning Coho Salmon must swim through many seasonal fisheries. The purpose of this study is to determine what are the costs and benefits of (i.e., contribution, survival, straying) physically moving south Puget Sound net-penned Coho Salmon past mortality hot spots by means of barging in saltwater. The first phase of this study began with the release of barged Coho Salmon being released in May 2016 and will continue for a minimum of three years.



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### Fangstjournalen; A Nationwide Electronic Catch Log Book and Citizen Science Platform for Anglers

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Recognizing the potential in using anglers as source of citizen science data, DTU Aqua, Technical University of Denmark launched “Fangstjournalen” in 2016. This platform (browser and mobile apps) allows anglers to report, not only catches and fishing trips, but also additional observations from their fishing trips (e.g., temporal development of spawning grounds in streams, presence of invasive species, barriers to migration, water clarity). The platform is also used to engage anglers in citizen science by allowing them to play the lead role in data collection under supervision of researchers and managers. Examples are tissue sampling for genetic analyses of selected species, mark-recapture experiments on the local or national scale, and reports of bite marks from predators. Last but not least, the platform collects standardized information about recreational reel and rod and spear fisheries. Several approaches are used to motivate the anglers to join the platform, and some of these are presented including new initiatives such as increased focus on keeping anglers informed about fish biology, national and local fisheries regulations, and site-specific information about fisheries and environmental status.





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### Moving Beyond Habitat Suitability to Assess Climate Change Risks to Aquatic Invasive Species Establishment: A Case of Ontario's Great Lakes and Inland Waters

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Aquatic invasive species (AIS) pose one of the most serious threats to maintaining biodiversity and ecosystem services from aquatic environments. In northern environments like Ontario, Canada, climate change can exacerbate AIS establishment and spread by altering thermal habitat and, thus, the ability of water bodies to host AIS. Consequently, researchers typically develop species distribution models to predict changes in habitat under future climate change scenarios. We argue that this approach is too narrow as it does not account for the mechanisms by which AIS arrive. Here, we illustrate an interdisciplinary research project focused on predicting the establishment of AIS across the Great Lakes and inland waters of Ontario under three climate change scenarios. A novelty with our work is that we evaluate both habitat suitability and the human-facilitated arrival mechanisms for AIS. In this poster we focus on the recreational boating pathway (including recreational fishers) to illustrate how the size and location of origins (e.g., towns) and the quality and locations of destinations (e.g., lakes) can influence the likelihood of AIS arrival now and into the future.



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### Spearfishing Lab: An Interface Between the Spearfishing World and Fisheries Science

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The spearfishing lab is a new website (<http://www.spearfishinglab.org>) created with the idea to facilitate the transfer of knowledge between fisheries scientists and the practical spearfishing world. Spearfishing is a popular recreational activity and consists of using exclusively free-diving techniques to catch fish with a speargun. Spearfishing is the only fishing technique where the fisher has a direct visual contact with the prey and thus can apply a near perfect selective choice (similar to hunting). Such selectivity allows applying powerful measures of management if fishers are integrated in the process. Historically, there are no strong connections among fishery scientists, the spearfishing world and managers. The main content of spearfishing lab is a blog where the most recent scientific discoveries are discussed using a very simple language to make them available to people not trained in fisheries science. The ultimate aim is to forge the next spearfishing generation in the context of the social-ecological system in which they act and thus improve the practice of a sustainable spearfishing. The World Recreational Fishing Conference (WRFC) is a unique opportunity to receive feedbacks, engage possible collaborators, and introduce the website to a global network. Moreover, one of the goals of the website is interviewing the most influent recreational fishery scientists of the world, which will be done at the meeting.



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### Using a Simple Multi-Attribute Rating Technique to Prioritize Release Mortality Needs

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NOAA Fisheries has created a simple multi-attribute rating technique (SMART) tool that can be used by managers, scientists, and other stakeholders to identify high-priority release mortality estimate needs. This tool was tested at a 2015 workshop that brought together a varied group of experts to evaluate a limited list of species from different regions of the United States. The SMART tool is designed to be an objective, repeatable, and fairly quick assessment of the need for improved release mortality estimates for certain species. Results of the SMART tool are not meant to be prescriptive but are intended to provide a starting point for discussions of release mortality research priorities. The SMART tool incorporates a "management sensitivity filter" and five criteria:

- Restricted or rare
- Vulnerability
- Economic impact
- Political sensitivity and stakeholder engagement
- Discard ratio

This presentation will describe the scoring procedure for an example recreational fish species. In general, the SMART tool can:

- Be customized based on regional needs.
- Be utilized by a wide group of regional stakeholders, including anglers.
- Evaluate multi-species complexes, overlapping fishery sectors, and/or gear types to help address larger ecosystem-based factors.



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## Evaluating Fishing Effort Estimates Derived from Remote Traffic Counters on a Small Local Lake: Opportunities and Challenges

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Estimating fishing effort on inland lakes is a difficult but necessary task for effective management. There is currently a variety of options for monitoring lakes remotely, each more or less well suited to different types of lakes (local, regional, remote, subalpine) and each with its own set of assumptions and uncertainties in estimating actual fishing effort. In many cases first hand creel surveys, aerial monitoring, or remote cameras are costly or impractical, and thus unappealing from a management perspective. On a small but active lake local to Hope, British Columbia, we used magnetic traffic counters mounted the boat ramp access road, physical counts of cars with and without boat trailers entering the boat ramp area, boats engaged in angling and not on the lake on an hourly basis, and creel survey data to determine the relationship between vehicles entering the boat ramp area according to traffic counters and actual fishing effort over the course of several months. We estimated fishing effort from traffic data using a delta-lognormal model to evaluate uncertainty in estimates. We further evaluated how varying levels of sample size would impact estimates to explore the utility of this technology for other fisheries. On doing so, we evaluate whether magnetic traffic counters or other traffic data at lakes with boat ramp access is a viable alternative to other existing methods for estimating fishing effort.



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## Emerging Life-Histories from Links Between Behaviour and Energy Budgets in Selective Recreational Fisheries

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A growing number of evidences support that recreational fishing entails unintentional but strong differential selection for a large number of traits. For example, the outcomes on fish body size at the population level have been repeatedly reported. Recent studies are also suggesting the existence of behavioural-related selection, which, among other potential drivers, may be related with between-fish differences in the encounter rate with gears. In home range behaving fish, the encounter rate may depend on the extent of the home range area and/or on the rate at such an area is explored. Moreover, the specific movement features are known to be plastic and to vary with environmental conditions in response, for example, to changes in foraging opportunities. Thus, the assimilation rate may be the ultimate link between vulnerability to recreational fishing and a wide range of life history traits. In spite that the underlying rationale for this link is persuasive and has received some support from correlational studies, here we go a step further by proposing the existence of explicit, mechanistic links between vulnerability, movement and assimilation rate. Specifically, we take advantage of Dynamic Energy Budget (DEB) models, which provide a well-supported framework linking energy dynamics with growth, potential reproductive output and other traits susceptible to be selected by recreational fishing. Finally, given the expected differences in fitness displayed by fish with different movement behaviour, we explore the optimal strategies that are expected to emerge at different contexts of recreational fishing pressure.



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### Emergent Properties of Recreational Fisheries

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A complex system exhibits nontrivial emergent and self-organizing behaviors. A recreational fishery is a complex system. Therefore, logic dictates that a recreational fishery exhibits emergent and self-organizing behaviors. We propose four emergent properties—resilience, adaptive capacity, wellbeing, and equity—that we consider fundamental to the dynamics and behavior of recreational fisheries. As hierarchical structures and cross-scale interactions are inherent to recreational fisheries (e.g., a waterbody nested within a network of waterbodies nested within a network of networks), emergent properties are expected within and across multiple spatiotemporal scales. Identifying and monitoring the scale-specific parts of the complex system that interact and generate emergent properties are important first steps toward operationalizing a complex-systems approach to recreational fishery science and management.



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### REKREA –Evaluating Survey Methods for Danish Marine Recreational Fishery

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This poster introduces the REKREA project which aims to test, develop and combine different types of surveys on four species important to the Danish marine recreational fishery (DMRF) and to implement the collected data where relevant in stock assessments. Fisheries managers often lack information about the biological impact of the recreational fishery on fish populations, e.g. the recreational fishing mortality. This can become critical when a decreasing fish stock is targeted by both recreational and commercial fishery and the stock assessment only includes data from the commercial fishery. The DMRF is currently monitored by an off-site interview/questionnaire based recall survey providing catch estimates for different species. The sampling frame is a list of valid annual license holders for either passive gear fishing (gillnets and fyke nets) or angling. A random subsample of ca. 2500 is drawn and contacted biannually and questioned on their catches of cod (*Gadus morhua*), eel (*Anguilla Anguilla*), sea trout (*Salmo trutta*) and salmon (*Salmo salar*). These catch estimates are however believed to be biased as respondents are likely to be more avid anglers than non-respondents resulting in an overestimation. Therefore this project test different methods that can evaluate the present recall survey and give more accurate estimates. This includes traditional methods, e.g. access-point surveys combined with video surveillance and/or aerial counts but also more novel methods such as electronic catch log books. The project is believed to provide new and better guidelines for the sampling of the most important species in the DMRF and thereby support the future management strategies for DMRF.



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### Understanding Wild Populations of Rainbow Trout and Mountain Whitefish for Sustainable Recreational Fishing

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The effective management of wild fisheries for sustainable recreational fishing requires an in-depth understanding of the population structures of these fisheries. In north-central British Columbia wild rainbow trout (*Oncorhynchus mykiss*) and native mountain whitefish (*Prosopium williamsoni*) populations form an integral part of local recreational fishing. To characterize these two species we compared the genetic and morphological differences of populations within each species from five rivers. Based on four microsatellites rainbow trout populations did show an overall  $F_{st}$  value of 0.262 ( $p < 0.001$ ). Principal component analysis revealed that rainbow trout populations differed in morphological features involved in foraging and swimming. These data were consistent with morphological features of mountain whitefish involved in foraging as well. Analyses of the macro-invertebrate density per square metre of river bottom revealed that streams with low-density macro-invertebrates have rainbow trout and mountain whitefish with more pronounced morphological features involved in foraging than a stream with a high density of macro-invertebrates. Rainbow trout with morphological features consistent with piscivory and mountain whitefish with morphological features (elongated noses) that allow them to disturb the stream bottom to access macro-invertebrates seem to be more prevalent in streams with low densities of macro-invertebrates. The data suggest that the availability of macro-invertebrates contribute to the natural selection of rainbow trout and mountain whitefish in the Prince George area.





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### Sustainable Salmon Angling Tourism in a Changing World (SALMONCHANGE)

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The SALMONCHANGE project investigates the social and economic consequences of changes in the salmon sport fisheries, such as diminishing and fluctuating salmon runs in different regions, closed /shortened seasons, stricter harvest quotas and fishing regulations in Norwegian rivers. Data are based on national and local surveys of anglers, as well as landowner (supplier/manager) surveys and interviews with anglers, landowners and tourism operators. The last 10 years salmon angler numbers in Norway has gone down with 15%, and certain areas have lost market shares while others have increased their share. We find that the fishery is changing and anglers adapt to these changing conditions in a number of dynamic ways both in time and space. A catch & release norm is emerging due to stock concerns and social norms. As catch & release is growing so is also the conflict between polarized angler groups and the struggle over hegemony and power in salmon management. Some anglers quit fishing because of this, while others adapt by changing their behavior or move on to other rivers with less strict harvest regulations. Managers should be aware of this conflict and try to allow for a diversity of anglers in the rivers, within sustainable harvest quotas. Many landowners are pessimistic about future stock status, probably linked to the general decline in salmon abundance, but also to large and random local fluctuations. This clearly is negative for angling tourism. Strengthening stocks is therefore the most important action for developing salmon angling tourism in Norway.



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### Understanding the Physiology and Behavior of Angled and Air Exposed Striped Bass (*Morone saxatilis*) Using a Rapid Assessment Approach

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Striped bass (*Morone saxatilis*) support an extremely valuable recreational fishery along the US east coast. Managed through implementation of minimum size restrictions and possession limits, fish not meeting the regulatory criteria for harvest must be released. Many anglers also voluntarily practice catch-and-release of striped bass as a conservation measure.

Unfortunately, despite angler's best intentions, managers estimate that 8% of striped bass caught and released in saltwater die, which may be due to a general lack of understanding regarding how angling techniques can injure and physiologically stress fish. Many anglers assume that fish that appear healthy and swim away survive, unaware that capture and handling practices could result in sub lethal impacts or post-release mortality.

Post-capture air exposure is an important stressor across gear types and locations in the striped bass fishery. The duration of air exposure influences recovery time of released fish and can lead to behavioral impairments or mortality. To evaluate the effects of angling and air exposure on striped bass intended to be released we are employing Reflex Action Mortality Predictor Assessment (RAMP) and Physiological Stress Assessment (PSA) procedures during surf fishing outings with fishing clubs. The RAMP includes an Injury Symptom Assessment which uses easily observed injury symptoms as indicators of stress and a Reflex Impairment Assessment which uses observations of reflex actions typically present in unstressed fish. The PSA analyzes blood lactate, glucose, and pH levels. Our goal is to develop scientifically-based recommendations on maximum time out of water for striped bass intended to be released.



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## Recreational Trophy, Commercial Fisheries Savior, or Apex Predator? Blue Catfish in Atlantic Coastal Rivers

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Blue Catfish were introduced to Virginia waters of the Chesapeake Bay watershed over forty years ago and expanded into many Virginia and Maryland tributaries of the Chesapeake Bay. The Atlantic States Marine Fisheries Commission (ASMFC) resolved that: “additional research should be conducted to more fully understand the ecological impacts of non-native catfish on species managed by the Atlantic States Marine Fisheries Commission” and ASMFC “...supports the development and implementation of a strategy to minimize the population and ecological impacts of non-native invasive catfish species throughout the Chesapeake Bay watershed.” We quantified diets of the Blue Catfish and examined demographic trends based on estimates of juvenile abundance, commercial harvest, and electrofishing surveys. A popular recreational fishery that targeted trophy size Blue Catfish has developed and attracted many avid recreational fishers. Populations of large, trophy size Blue Catfish have peaked in abundance and Blue Catfish growth has declined in recent samples. Blue Catfish have broad, omnivorous diets, consuming an array of prey types that include aquatic vegetation; they are not apex predators. Only the largest individuals, those targeted by recreational anglers, appear to consume native species of concern. Although the American Eel, Blue Crab, American Shad, and river herring are consumed by Blue Catfish, occurrence in the diet is low during most months and in most locations. At the present time the Blue Catfish populations are lightly exploited by commercial harvesters. Interagency collaborations will be needed in order to develop and implement a strategy to minimize ecological impacts of Blue Catfish while appeasing the interests of recreational anglers.



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### Test Drive Canada's Internet Recreational Effort and Catch ("iREC") Survey

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Canada's "iREC" survey, begun in July 2012, is an internet-based survey of recreational licence holders that provides estimates of recreational effort and catch in tidal waters of Canada's Pacific Region. Established recreational monitoring programs do not cover all areas, months and methods used in this fishery. The primary objective of the iREC survey is to provide reasonable quality effort and catch estimates covering all months, areas, methods and species, providing separate estimates of total effort and kept and released catch for each combination of month, management area, fishing method and species. Each month, a new random sample of licence holders is selected and contacted by email explaining that they are required (by licence condition) to complete the survey regarding their catch and fishing activities, in that month. Participants are provided a personal survey link that allows multiple entries throughout the month. Reminder emails after the survey month end prompt fishers to use the survey link to complete the survey by confirming that all fishing information has been completed or that the participant did not fish. Personalized survey links support analysis that is stratified by licence type. To minimize survey fatigue, licence holders can only be selected for one monthly survey per year. The poster provides details on the conduct of the survey and analytic methods including bias correction, and provides results from the first 4+ years of the survey. As well, participants can 'test-drive' the survey on computers at the poster.



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### Learn to Fish - Reducing Barriers to Recreational Fishing Through Educational Outreach

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The Learn to Fish program was developed by the Freshwater Fisheries Society of BC in 2006 in response to the documented decline in freshwater angler participation which, in 2005, was down 30% since its peak in the mid 1990's. A British Columbia school curriculum advisor was consulted in the development of the program curriculum, and since Learn to Fish has been delivered to individual families, at risk youth groups, school groups, special needs, boys and girls clubs, and other organized groups in urban centres as well as rural communities. Learn to Fish is provincial in scope, delivered primarily by university students hired as auxiliary employees, to over 25,000 youth and their families annually in partnership with municipalities' parks and recreation departments, BC Parks, fishing clubs, and various industry corporate sponsors. The program includes instruction designed to break down barriers to fishing including; fish identification and biology, regulations, ethics, and technical angling, as well as time spent fishing. Biennial surveys of parent/ guardians post Learn to Fish participation have been used to measure effectiveness of achieving the programs primary objective of recruiting new and lapsed anglers and secondarily its effectiveness at increasing environmental awareness. Survey results indicate that the Learn to Fish program contributes significantly to the recruitment of new youth anglers, as well as the recruitment of new and lapsed adult anglers, and is effective at increasing environmental awareness.



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## Marine Recreational Fisheries in Southern Sweden: A Data Limited Survey

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Recreational fisheries are a significant component of fishing mortality in many parts of the world. Yet, marine recreational fisheries in Europe are still scarcely characterized when compared to their commercial counterparts including in cases where they are known to target valuable commercial stocks like, e.g., cod, lobster, eel, salmon and trout. Along the southwestern and southern coasts of Sweden, recreational fisheries are increasingly recognized as an important component of the analytical assessment of Western Baltic Cod (*Gadus morhua*), a marine resource targeted by several countries and where recent estimates available (from one country) are as high as 30% of total catches. In 2017 the Institute of Marine Research (Swedish University of Agricultural Sciences) initiated a pilot survey to improve the characterization of the recreational fishery targeting Western Baltic Cod and increase its ability to deliver complete estimates of Swedish commercial and recreational catches and fishing effort on this stock. The information available for designing the survey was very limited, e.g., no reference information on catches or effort of charter boats, privately-own boats or shoreline fishers, and no existing site-, boat- or fishers-registers; and additional complexity was introduced in survey design by the need to quantify effort along the strong seasonal cycles typical of higher latitudes (e.g., large seasonal variations in day length). The final survey design that was adopted combines a mixture of field-surveys (privately own boats, shore fishery) and logbook schemes (head-boats and charter boats) that attempts to tackle some of these issues.



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## Rearing Environment is More Influential in Shaping the Behavioural Repertoire and Subsequent Survival of Yellow Perch (*Perca flavescens*) Than Population Source – Consequences for Wild Stock Management

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Management of wild fisheries is increasingly challenging given the multiple stressors fish populations now face. Behaviour should be key in predicting stock effects since it is often an individual's first line of response that allows them to adapt to environmental change. Because an individual's behaviour is a product of environmental conditions, including local adaptation and rearing experience, and internal processes such as condition and pace-of-life, there remains much uncertainty about the consistency and plasticity in behavioural responses, the concomitant population dynamics, and therefore how fisheries should be managed within- and among stocks. We examined the effects of early rearing experience, population differences, and ontogeny on the behavioural repertoire of yellow perch, an important recreational freshwater species in Ontario. Individuals were sampled from three environments differing in habitat complexity and in time since removed from the original source. Fish were raised in a common garden experiment and tested in behavioural assays at three time points to quantify activity, neophilia and anti-predator responses over ontogeny. Fitness correlates were used to explain behavioural differences, and survival was quantified to examine consequences of various behavioural types. Early rearing environment had the greatest effect on perch behaviours, which were additionally modified by body size. Behaviours were consistent over ontogeny with the exception of anti-predator responses; and an individual's level of neophilia, degree of behavioural flexibility and morphology were predictive of early and longer-term mortality (post 1-year). These findings suggest effective management of perch populations should be at the stock- rather than species level, with consideration given to the habitats in which these fish live.



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### Exposing Undergraduate Students to Recreational Fisheries Through the Involvement of Stakeholders

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Recreational fisheries are an important part of fisheries management particularly within State waters, the economic value of which now exceeds that of commercial harvest within Washington State (WA). However, until recently, a course on recreational fisheries was lacking at the University of Washington, despite an internationally recognized fisheries science instructional and research program. The new course provides an overview of contemporary issues and perspectives dealing with the science, management, and policies surrounding recreational shellfish and finfish fisheries within WA and adjacent waters and is suitable for undergraduate students without a science background. The challenges in developing the course were the complexity of the management of recreational fisheries in WA that is shared among the Co-managers (Washington Department of Fish and Wildlife and the Treaty Tribes) and the large number of additional stakeholders. As a result, students are exposed to guest lectures/seminars by those intimately involved in recreational fisheries including the Co-managers, other State or Federal management agencies, recreational fishing groups, NGOs, the media, and recreational fishers. Students select from four different credit options. Those selecting the 5-credit option develop a position paper on a controversial recreational fisheries topic provided by the WA Fish and Wildlife Commission, present their position to standing Commission members, and have the opportunity to submit an editorial/commentary to The Reel News (monthly regional [Northwest] newspaper). The course as designed would not be possible without the continued significant support of the stakeholders providing students with a more holistic understanding of the challenges in managing these fisheries.





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### Challenges and Opportunities in Establishing Recreational Fisheries in Remote Northern Communities

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Alongside increased ice-off periods in Northern regions emerges opportunity to advance community-based commercial and recreational fisheries. Ensuring such fisheries are established in culturally appropriate and sustainable ways is integral for their long-term economic feasibility. The Towards a Sustainable Fishery for Nunavummiut research project is a trans-disciplinary, community based initiative that seeks to understand factors necessary to establish culturally, environmentally, and economically sustainable fisheries in the hamlet of Gjoa Haven, Kitikmeot, Nunavut. Our goal is to use Traditional Knowledge to guide biological sampling, while harvest studies, workshops, and surveys will identify economic opportunities and barriers to subsistence harvest and community perceptions of commercial and recreational fisheries. Genomic analysis will be used to delineate unique fish stocks to ensure new fisheries do not affect populations important for local subsistence harvest. Here, we discuss the potential economic benefits of establishing mixed-species recreational fisheries alongside commercial fisheries in the North, and the potential cultural and logistic barriers that exist specifically for creating and maintaining recreational fisheries in Northern communities.



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### Gene Banking of Sperm as a Powerful Conservation Tool

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The holding of wild caught broodstock in designated “live” gene banks is the most common method for conservation of endangered wild fish populations. These hatcheries are used to produce fry for re-stocking while safeguarding a constant genetic contribution of the original wild population to the aquatic system. In addition, this effort is often supplemented by storing of tissue samples for DNA analysis.

Cryopreservation of sperm cells is an option that is being carried out more routinely alone and as a supplementation to existing methods. Sperm cells are uniquely suited for cryopreservation purposes due to their small size and ability to retain their fertilization ability even after freezing and thawing. Collection of sperm is simple and can be done with minimal harm to the fish. Since storage of cryopreserved sperm is not subject to the same capacity constraints as live gene banks, one can potentially collect genetic material from a larger number of individuals. This ensures more of the total genetic variation in the population is conserved.

The use of cryopreserved sperm can also be beneficial for maintenance of the live gene bank. Depending on the cryopreservation volume, the cryopreserved sperm can be used for either large or small scale fertilizations. Typically, the cryopreserved sperm will be used when the live males are unavailable or not yet mature. Having sperm available from males with genetic information can also be utilized for prevention of inbreeding.



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### Fresh Water Hatchery Management Practices Which Could Be Incorporated to Rebuild Wild Stocks of Chinook Salmon

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The West Coast of Vancouver Island has many streams with extremely low escapement numbers of wild stocks of Chinook Salmon. Intervention will be required to rebuild these numbers. Conventional enhancement currently releases all progeny at the same time as an s0 smolt (i.e. eggs spawned in fall, juveniles released the following spring). Wild stocks naturally have offspring going to the ocean as s0, s1, s2 or s3 (i.e. first spring up to 3 years in fresh water before they go to the ocean). Genetics, freshwater temperatures and feed availability are factors which determine when a smolt is ready to migrate to the ocean. Limited resources and difficulties in capturing the few returning Chinook make it essential if brood stock is captured, that they and their offspring be managed to minimize the risk of loss and ensure maximum gains from the progeny release. Best management requires one operate by adopting “an every fish is valuable principal” and incorporate a preventative management approach.” i.e. why did a fish die, what else do we know that can affect the fish negatively, what can be done to prevent loss, ensure survival in the future,” Some key management tools incorporates proper adult handling, transportation and spawning of eggs, adult disease screening, surface disinfection of eggs, smolt health checks, ensuring osmoregulation competency of early entries to net pens in estuaries, hatchery competency in view of water quality, incubator and rearing containers, multi age release strategy ( integrate the s1 superiority) , captive freshwater brood stock program (insures available eggs from year 4 to 7), cryopreservation of milt (saving a genetic pool) and feminization . It is important to use all management tools available and incorporate a multi strategy plan to minimize risk and maximize results when tackling the rebuilding of these stocks.



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### Exploring Growth and Effort Response in B.C. Small Lakes Rainbow Trout Populations Following Kokanee Introductions.

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We developed a two-species stock assessment model for Rainbow trout (*Oncorhynchus mykiss*) based on data obtained from gillnet sampling. The growth model included density dependence in Rainbow trout population based on both Rainbow trout and kokanee densities. A large proportion of angling effort in kokanee is realized as ice-fishing in the winter months. The effort model therefore allowed partitioning between winter and open-water season. We found that the growth response in Rainbow trout to kokanee stocking varied between lakes based on lake characteristics. Effort response to kokanee stocking differed between different regions in B.C.



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### Determining How Differences Between Avid and Lapsed Anglers Can Improve Licence Sales and Angler Satisfaction

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A substantial proportion of anglers in British Columbia are lapsed, meaning that they do not purchase a license every year. Maintaining fishing license sales (participation) is an important objective of fisheries management and leads to stable revenue for conservation and management. To sustain participation, we must better understand the motives of lapsed anglers, as well as differences between lapsed and avid anglers. We employed a survey distributed to random British Columbian anglers stratified by participation (number of licenses purchased in the past 5 years). The survey included a questionnaire to better understand demographic variables that effect anglers' purchasing decision and to evaluate how fishing habits of anglers differ by dedication level. The survey also incorporated a choice experiment to determine fishing site preferences of the two participation groups. Since online surveys are known for their often low response rates, we also carried out a follow-up survey to assess potential non-response bias. As expected, the results of the questionnaire showed that there are indeed differences in demographics between lapsed and avid anglers; gender, age, fishing skills and knowledge, and availability of a fishing partner influenced anglers' likelihood to belong to either of the two groups. Choice modeling work identified differences in fishing preferences (e.g. fish size, amenities) by dedication level and revealed what type of fishing opportunities would maximize the benefits for both groups.



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### Tag-Team: Building New Research Initiatives Using Sampling Data Results

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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, launched its award-winning, volunteer driven Lower Fraser White Sturgeon Monitoring and Assessment (LFWSMA) (Nelson et al. 2016) program in 1999.

The science-based stewardship program has relied greatly on the in-kind effort and contributions from angling guides, recreational, commercial, and Aboriginal fishermen, test fishery and enforcement personnel, students and academics, and various fishery monitors. Volunteers from each of these sectors perform all sturgeon sampling activities, and record, secure, and transfer data to the field program manager.

The program has resulted in one of the best baseline datasets on a species like this in the world and internationally recognized population model. It has also created the basis for supporting new research initiatives, exploration of emerging questions and research areas, identification of key priorities for sturgeon survival and the new application of research technologies.

Building on the success of the LFWSMA program, the FRSCS launched acoustic telemetry studies, a multi-year side-scan sonar study to identify spawning sites, and supports ongoing multi-jurisdictional programs with partner organizations.



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### Nutrient Additions to Compensate for Dam Footprints to Restore Fish Stocks in a Lake and a Reservoir in the Interior of British Columbia

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Kootenay Lake and Arrow Lakes Reservoir have been influenced by several anthropogenic stressors. These include the introduction of Mysid shrimp (*Mysis diluviana*), and the construction of upstream hydroelectric impoundments. These impoundments caused nutrient retention leading to oligotrophication of both systems and declines in kokanee salmon (*Oncorhynchus nerka*). To address this, nitrogen and phosphorus have been added as part of a large scale adaptive management experiment to restore pelagic productivity and rebuild kokanee salmon. Kokanee are the primary food source for piscivorous rainbow trout (*Oncorhynchus mykiss*) and bull trout (*Salvelinus confluentus*) and are considered keystone species of this ecosystem. Results show the varying response in trophic levels from phytoplankton, zooplankton, mysid shrimp (an introduced exotic crustacean that competes with kokanee for zooplankton) and kokanee.



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### The Use of Descending Devices in Fisheries Management to Reduce Discard Mortality: Regional Experiences and Considerations

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Without an open fishing season, the South Atlantic red snapper fishery continues to be overfished and experience overfishing. Red snapper are caught incidentally when anglers target other species in the snapper grouper complex. The amount of discards continues to exceed the acceptable biological catch resulting in a systematic closure of the fishery. To prevent overfishing as mandated by National Standard 1 of the Magnuson Stevens Fishery Conservation and Management Act, councils have implemented short seasons, size limits, and area closures with the intent to stay within acceptable biological catches and annual catch limits. In spite of increased regulations, barotrauma, a pressure-induced condition caused when a fish ascends from depth to the surface often occurs. The combination of increased regulations and the effects of barotrauma have resulted in high discard mortality rates of bottom fishes. Anglers can use descending devices, which reduce symptoms of barotrauma, to increase the survivability of discarded fish by returning fish to or near their original capture depth. This practice can lower discard mortality rates and potentially prevent overfishing. This study identified and analyzed the challenges and opportunities of using descending devices in the South Atlantic red snapper fishery by investigating the success of descending device utilization in three species of Pacific rockfish. Findings from this mixed-methods study indicate outreach, cohesion, and coordination of the fishery council with state and federal government made accounting for the use of descending devices in the Pacific successful. While incentives for use of descending devices was similar across groups, study participants in the South Atlantic discussed the challenge of the multispecies complex and lack of scientific data regarding red snapper and descending devices. Pacific respondents indicated descending devices were effective as a means for flexibility in management, allowed for more accurate data collection, and created more opportunities for recreational anglers. Groups across the Pacific and Atlantic all agreed descending devices should be used as a best practice by anglers.





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### Providing Science-Based Recommendations for Management of Upper Fraser Watershed Fluvial Bull Trout (*Salvelinus confluentus*)

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Winter angling for Bull trout (*Salvelinus confluentus*) within the upper Fraser River watershed (UFW), British Columbia, Canada is known for high catch rates and large fish size. The region also contains important overwintering habitat for mixed stocks of fluvial bull trout. The species, a large-bodied salmonid, is thought to be highly susceptible to overharvest due to a combination of its size, late maturity, potential for large-scale migrations (up to ~250km), aggressive feeding, and aggregative behaviour. Current fishing regulations in the region are catch and release, however anglers are requesting a retention fishery. At present, poor understanding of stock structure and strong conservation concerns are making it difficult for regional fisheries managers to make a robust management choice regarding this request. This project is the first to quantitatively assess compensation in juvenile survival for bull trout to determine species productivity and capacity to support harvest. It will be also be the first to comprehensively assess large-scale movement dynamics and determine natural mortality rates for a meta-population of fluvial bull trout. This project will contribute to filling knowledge gaps for delivery of sound management advice for UFW fluvial bull trout by verifying times and locations where fish may be accessible to angling, and thus vulnerable to harvest. Information gained will be applied within a quantitative evaluation of regulatory options for the recreational bull trout fishery in the UFW, to evaluate relative utility to anglers if different management options while still conserving stock structure of the meta population.



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## Sensitivity Analysis of Single Nucleotide Polymorphism Number and Informativeness for Differentiating Advanced-Generation Hybrid Classes in Recently Diverged Stocks of Sockeye Salmon

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Molecular markers represent powerful tools for assigning individuals of unknown ancestry to parent stock and/or hybridization class, especially in cases where divergence of parent stocks is high, hybridization is recent, or level of required assignment resolution is shallow (e.g. pure stock versus F1 or unspecified hybrid). When those conditions are not met, increasing numbers and informativeness of molecular markers are required to achieve fisheries management-relevant levels of assignment accuracy. The Okanagan River sockeye salmon (*Oncorhynchus nerka*) reintroduction program to Skaha Lake provides one such example, where anadromous sockeye salmon have been effectively isolated from native kokanee (freshwater-obligate *O. nerka*) since the building of McIntyre dam in 1916. A recent study using genotypic data at 32 highly-informative single nucleotide polymorphisms (SNPs) and samples collected across the life of the program found the reintroduction of wild-spawning anadromous sockeye salmon into Skaha Lake has succeeded, however, hybridization is occurring with resident kokanee, increasing markedly in recent years. The original SNP panel was highly informative for assigning individuals to parent stock or F1 hybrid, but rapidly lost resolution at more advanced-generation hybrid classes, an ability that will be increasingly important as the program matures. Here, we conducted a simulation-based study using data at >10,000 SNPs collected for Okanagan River sockeye salmon and Skaha Lake kokanee pre-sockeye reintroduction to evaluate the accuracy, power and cost-effectiveness of varying subsets of the data to assign individuals to advanced-generation hybrid classes. These results will help inform the design of future genetic monitoring of this program and will have broader relevance for other Pacific salmon reintroduction/monitoring programs where hybridization with native stocks is of management concern.



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### Effects of the Long-Term Marine Closure and Reopening of an Area of the Coastal Florida Everglades on Fishes and Recreational Fisheries

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The sustainability of coastal marine ecosystems is a global concern due to exploitative fishing practices, destructive coastal development and climate change. While the use of marine protected areas has been touted as a valuable conservation tool, the effectiveness of MPAs has been mixed. Joe Bay, a large coastal embayment in northeastern Florida Bay has been closed to public access since the creation of a crocodile sanctuary in 1980, but the Everglades National Park recently opened it to non-motorized access and catch-and-release fishing. This decision provides a unique opportunity to evaluate the effects of a long-term marine closure by describing the baseline fish community composition and recreational fishing conditions in Joe Bay, and how this area may change as a result of opening it to fishing and recreational use. We have employed a non-invasive fish sampling technique using baited underwater remote video stations (BRUVS) to conduct fishery independent sampling and have developed a fisheries dependent component that includes a paper-based and online survey, mobile application and a motion activated camera monitoring system. This reporting system aims to track fishing pressure, angler catches, fish metrics, angler preferences, as well overall visitor experience, motivations and preferences. Preliminary results will be presented.



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### Using Deep Learning to Automate Boat Detection for Fishing Effort Estimates

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Estimating angling efforts is an important statistical measure for managing recreational fishing on lakes. One common strategy is to capture lake images over long periods of time and count the number of anglers. However, analyzing lake images takes a vast amount of human effort and time. We are developing a Computer Vision algorithm that attempts to perform these counts automatically, and here we report on our progress to date. Using fully-convolutional neural networks (with the help of data augmentation) the system learns and then determines the regions where boats are located in the lake images. When comparing the algorithmic results with manual counting, our results over a single set of lake images were reasonably accurate: about 10% false positive rate and false negative rate were seen. Our work to date has exposed many challenges that remain to be overcome, but the progress is promising. Our future work will test the algorithm on a variety of data sets and will analyze images for shore anglers as well as boats. If successful, we expect automation to significantly reduce the workload on human experts, where their job is to confirm or reject predictions rather than laboriously search for and count anglers and boats in lake images.



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### Economic Impacts of Recreational & Commercial Salmon Fisheries in the Pacific Northwest

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This work for the Pacific Salmon Commission analyzes the income and employment impacts of recreational and commercial salmon fisheries from SE Alaska south to Oregon: 1) for each state, province and nation, 2) for both saltwater and freshwater components, and 3) for each of four years 2012 to 2015. In total, the recreational and commercial salmon fisheries of the Pacific Northwest produce an annual average economic contribution of \$4.8 billion in Output, \$2.8 billion in Gross Domestic Product, \$1.7 billion in Labor Income and 39,000 full-year equivalent jobs to the North American economy (all values in USD and all impacts refer to the sum of direct, indirect supplier and induced consumer responding impacts).

For the two countries in total, the economic impacts are evenly split between recreational and commercial sectors with the commercial sector being relatively more important in the United States and the recreational sector being relatively more important in Canada. The substantial economic impacts occur not only in the regions where the salmon fisheries occur. There are substantial spillover impacts on the whole North American economy through the selling of salmon in stores and restaurants across the continent and through the multiplier effects in both recreational and commercial sectors. In addition to their economic importance, salmon are especially important to the native peoples of the Pacific Northwest for whom salmon is not only an important food for sustenance but also a strong spiritual symbol and central to longstanding traditions and cultural expression.



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## Management of Aquatic Invasive Species in British Columbia

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Introduced aquatic invasive species pose substantial ecological risks and management challenges to fisheries worldwide. While most of these species pose direct threats to recreational fisheries, some are valued and even introduced by recreational fishers. In British Columbia, governments, committees, and interest groups collaborate to manage aquatic invasive species through activities aimed at minimizing the likelihood of introductions, maximizing awareness of risks associated with introductions, and early detection and rapid response to mitigate effects if introductions do occur. British Columbia's provincial government coordinates this collaborative process through three general approaches involving several government and non-government partners.

The *Clean, Drain, Dry* program encourages boaters to use proper techniques to remove aquatic animal and plant material from their boats, trailers, and boat gear. A key component is the provincial Invasive Mussel Defence Program which aims to keep invasive freshwater Zebra and Quagga mussels out of B.C. waters, and is supported by legislation that gives conservation officers the authority to detain, inspect, quarantine, and decontaminate watercraft in B.C. that pose a risk of carrying aquatic invasive species. Operation of the *Clean Drain Dry* program is shared between the B.C. government, and the [Invasive Species Council of B.C.](#) in partnership with the Freshwater Fisheries Society of B.C., the B.C. Wildlife Federation, lakeside stewardship groups, and regional invasive species committees. Since the Invasive Mussel Defence Program began in 2015, more than 30,000 watercraft have been inspected, and 37 have been found to carry adult invasive mussels.

The *Don't Let it Loose* campaign educates the public on the need for responsible release or disposal of unwanted pets, such as exotic fish or amphibians. It targets the aquatic pet trade, and illegal introductions of exotic fish by sport fishers (species such as Snakeheads and Asian carp). The *Don't Let it Loose* campaign has been adopted in B.C., and other Canadian provinces and U.S. states.

The B.C. government leads several internal programs aimed at aquatic invasive species management across the province. These include an Inter-ministry Invasive Species Working Group (IMISWG), a GIS-based Invasive Alien Species mapping and reporting tool, an Early Detection / Rapid Response program, as well as production of several publicly accessible fact sheets on invasive species that are controlled or prohibited under provincial legislation.



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## Are Systems Approaches an Effective Tool for Integrated Marine Management – The Case of the European Seabass (*Dicentrarchus labrax*)

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Integrated marine management that takes into account the environmental sustainability, social benefits and economic impacts from all uses of the marine environment is central to the delivery of all national and European legislation. An ecosystem services approach is often used, but incorporating feedback between environmental, social, and economic systems is difficult. This is an issue because feedback loops are important for making accurate predictions of the response of systems to both the pressures exerted and the management measures applied. Systems dynamics provides an alternative complementary approach that is gaining support in fisheries economics, and research applications exist for marine management. Exploitation of the European seabass (*Dicentrarchus labrax*) is unsustainable with large reductions in catch required, but a method is needed to partition catch between recreational and commercial fishers that accounts for socio-economic benefits. In this study, we review and test systems approaches for integrated marine management using management of European seabass stocks as an example. A short summary of the strengths and weaknesses of systems approaches is provided. Then a systems approach is applied to the European seabass and the potential for this methods to be used in support of management assessed. The results will be discussed in the context of management of seabass.



## 8th World Recreational Fishing Conference

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### Responsible Recreational Fishing

RUSSELL CONWAY

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"Responsible Recreational Fishing" should be an aspirational target for all responsible fishers.

Australia has developed a number of programs, educational campaigns and grass-root initiatives focussed on teaching our recreational fishers the benefits to be achieved by fishing in a responsible manner.

Other countries around the world have also developed similar responsible fishing programs targeted at current and future recreational fishers.

However, attempting to locate this information has been a difficult process because this valuable information is held on numerous internet sites spread across the world wide web. Also, there is a large amount of content duplication on these sites due to the difficulty to easily collaborate with other fisher organisation and recreational fishers.

The "Responsible Recreational Fishing" Program aims to create one central location on the world wide web for the development, storage and access to responsible recreational fishing practices.

It will allow collaboration between individuals, fishing Clubs, Industry Peak Bodies, Government Departments and Kindred interest groups to create programs and products that enhance our ability to develop a common understanding of responsible recreational fishing practices.

The Program includes a website ([www.ResponsibleRecreationalFishing.com](http://www.ResponsibleRecreationalFishing.com)), a quiz based educational course, a "Train The Trainer" competency based training program and a web based "App" providing a quick reference resource for fishers to assist participants to look after the fish they capture, whether they intend to release the fish or keep it to feed the family.

The centralised model for the web site provides enormous leveraging opportunities to develop products and educational programs that cross multiple jurisdictions, multiple species and multiple capture techniques.

I look forward to representatives from other countries engaging in this initiative to help create a shared resource that benefits all recreational fishers.