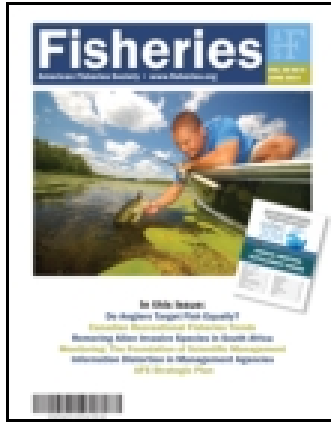


This article was downloaded by: [134.117.108.180]

On: 20 June 2014, At: 11:31

Publisher: Taylor & Francis

Informa Ltd Registered in England and Wales Registered Number: 1072954 Registered office: Mortimer House, 37-41 Mortimer Street, London W1T 3JH, UK



## Fisheries

Publication details, including instructions for authors and subscription information:  
<http://www.tandfonline.com/loi/ufsh20>

### Canadian Recreational Fisheries: 35 Years of Social, Biological, and Economic Dynamics from a National Survey

Jacob W. Brownscombe<sup>a</sup>, Shannon D. Bower<sup>b</sup>, William Bowden<sup>b</sup>, Liane Nowell<sup>b</sup>, Jonathan D. Midwood<sup>bc</sup>, Neville Johnson<sup>d</sup> & Steven J. Cooke<sup>bc</sup>

<sup>a</sup> Fish Ecology and Conservation Physiology Laboratory, Department of Biology, Carleton University, 1125 Colonel By Dr., Ottawa, ON K1S 5B6, Canada. E-mail:

<sup>b</sup> Fish Ecology and Conservation Physiology Laboratory, Department of Biology, Carleton University, Ottawa, ON, Canada

<sup>c</sup> Institute of Environmental Science, Carleton University, Ottawa, ON, Canada

<sup>d</sup> Statistical Services, Fisheries and Oceans Canada, Ottawa, ON, Canada

Published online: 16 Jun 2014.

To cite this article: Jacob W. Brownscombe, Shannon D. Bower, William Bowden, Liane Nowell, Jonathan D. Midwood, Neville Johnson & Steven J. Cooke (2014) Canadian Recreational Fisheries: 35 Years of Social, Biological, and Economic Dynamics from a National Survey, *Fisheries*, 39:6, 251-260, DOI: [10.1080/03632415.2014.915811](https://doi.org/10.1080/03632415.2014.915811)

To link to this article: <http://dx.doi.org/10.1080/03632415.2014.915811>

PLEASE SCROLL DOWN FOR ARTICLE

Taylor & Francis makes every effort to ensure the accuracy of all the information (the "Content") contained in the publications on our platform. However, Taylor & Francis, our agents, and our licensors make no representations or warranties whatsoever as to the accuracy, completeness, or suitability for any purpose of the Content. Any opinions and views expressed in this publication are the opinions and views of the authors, and are not the views of or endorsed by Taylor & Francis. The accuracy of the Content should not be relied upon and should be independently verified with primary sources of information. Taylor and Francis shall not be liable for any losses, actions, claims, proceedings, demands, costs, expenses, damages, and other liabilities whatsoever or howsoever caused arising directly or indirectly in connection with, in relation to or arising out of the use of the Content.

This article may be used for research, teaching, and private study purposes. Any substantial or systematic reproduction, redistribution, reselling, loan, sub-licensing, systematic supply, or distribution in any form to anyone is expressly forbidden. Terms & Conditions of access and use can be found at <http://www.tandfonline.com/page/terms-and-conditions>

# Canadian Recreational Fisheries: 35 Years of Social, Biological, and Economic Dynamics from a National Survey

**Jacob W. Brownscombe**

Fish Ecology and Conservation Physiology Laboratory, Department of Biology, Carleton University, 1125 Colonel By Dr., Ottawa, ON K1S 5B6, Canada. E-mail: jakebrownscombe@gmail.com

**Shannon D. Bower, William Bowden, and Liane Nowell**

Fish Ecology and Conservation Physiology Laboratory, Department of Biology, Carleton University, Ottawa, ON, Canada

**Jonathan D. Midwood**

Fish Ecology and Conservation Physiology Laboratory, Department of Biology, Carleton University, Ottawa, ON, Canada, and Institute of Environmental Science, Carleton University, Ottawa, ON, Canada

**Neville Johnson**

Statistical Services, Fisheries and Oceans Canada, Ottawa, ON, Canada

**Steven J. Cooke**

Fish Ecology and Conservation Physiology Laboratory, Department of Biology, Carleton University, Ottawa, ON, Canada, and Institute of Environmental Science, Carleton University, Ottawa, ON, Canada

**ABSTRACT:** Fisheries and Oceans Canada has collected a unique, long-term data set on the social, biological, and economic dynamics of Canada's recreational fisheries. Starting in 1975, these data were collected through mail surveys to recreational anglers at 5-year intervals. A longitudinal analysis revealed that there was an average of 4.5 million licensed anglers catching an annual average of 255 million fish. Release rates were relatively high (53% of fish released on average), with recent survey data (2010) suggesting that release rates had exceeded 60%. Recreational anglers also contribute an average of \$8.8 billion each year to the Canadian economy. However, recreational angling has become less popular over time, and the average age of participants has increased. The data were also useful for characterizing Canada's fisheries, including species-specific catch and harvest. Canada is one of the few countries to collect such extensive recreational fisheries data at a national scale and to do so at regular intervals, an approach that could be modeled by other countries.

## INTRODUCTION

Recreational fishing is commonly defined as an activity where fish are caught for leisure or personal consumption, and the primary objective is not to produce food or generate income through the sale or trade of fishing products (Arlinghaus and Cooke 2009). Recreational fisheries represent the dominant use of fish stocks in the inland waters of most developed countries (Arlinghaus et al. 2002) but are also increasingly prevalent in coastal marine waters, which have been traditionally dominated by commercial fisheries (e.g., Coleman et al. 2004). In addition, recreational fisheries are considered essential in emerg-

## Pesca recreativa en Canadá: 35 años de dinámica social, biológica y económica a partir de un sondeo a nivel nacional

**RESUMEN:** la agencia de Pesquerías y Océanos de Canadá ha recolectado una base de datos históricos de la dinámica social, biológica y ecológica de las pesquerías recreativas de Canadá. Esta información, que comienza en 1975, fue compilada a través de sondeos por correo postal, realizados a intervalos de cinco años, dirigidos a pescadores. Un análisis longitudinal reveló que existen en promedio 4.5 millones de pescadores con licencia, que capturan una media de 255 millones de peces. Las tasas de liberación fueron relativamente altas (53% de peces liberados) y los datos del sondeo más reciente (2010) indican que la tasa de liberación excede el 60%. Asimismo, los pescadores recreativos contribuyen, en promedio, con \$8.8 mil millones anuales a la economía canadiense. Sin embargo, con el tiempo, la pesca recreativa se ha vuelto cada vez menos popular y el promedio de la edad de los participantes se ha incrementado. Los datos también fueron útiles para caracterizar las pesquerías de Canadá, incluyendo captura y cosecha por especie. Canadá es uno de los pocos países que recolectan datos de pesca recreativa de forma tan extensiva a nivel nacional y lo hace en intervalos regulares, algo que pudiera ser imitado por otros países.

ing economies where they provide employment security and economic benefits through the development of tourism sectors (Cowx 2002; Ditton et al. 2002).

Compared to the commercial fishing sector, which is well studied and monitored (particularly in marine waters; Pauly and Palomares 2005; Welcomme et al. 2010), recreational fisheries are poorly understood (Cooke and Cowx 2004). Currently the magnitude of recreational fishing and its quantitative attributes are largely unknown, chronically underreported, and thus unappreciated (Food and Agriculture Organization of the United Nations, Fisheries and Aquaculture Department 2012). Quantitative statistical information is essential to monitor temporal trends related to exploitation, value the fishery, and identify emerging issues (e.g., shifts in angler demographics, target species, effort, etc.) or opportunities (e.g., increased fisheries tourism). However, even basic information on participation is lacking in most countries (Arlinghaus and Cooke 2009). Few national-scale recreational fishing surveys exist, and those that do rarely consider social, biological, and economic data concurrently.

Home to over 2 million lakes, thousands of kilometers of rivers, and three coasts (i.e., Pacific, Arctic, and Atlantic),

Canada supports a popular recreational fishery in each province and territory and is one of the few countries in the world to collect relevant recreational fisheries data at a national scale (Fisheries and Oceans Canada [DFO] 2012). Beginning in 1975, the then Department of Fisheries and Oceans (now Fisheries and Oceans Canada) in Canada instituted a voluntary mail survey of recreational anglers at 5-year intervals designed to provide a high-level overview of recreational fishing throughout the country (DFO 2012). Not only is the Canadian recreational angling survey process unique globally, it has yet to be analyzed in its entirety across sampling periods. By performing such a synthesis, this article will identify metrics of interest that may serve as an example for future studies, answer wide-ranging questions about the recreational fishing sector, and provide information pertaining to demographics, biological impacts, and economic patterns through time. Moreover, because these surveys collect diverse information (e.g., economic, ecological, and social), they may facilitate the integration of different aspects of recreational fisheries research and sound strategic policy (Haapasaari et al. 2012). This multifaceted approach may serve as a model for research and analysis that can be used to guide national and international recreational fisheries management in the future.

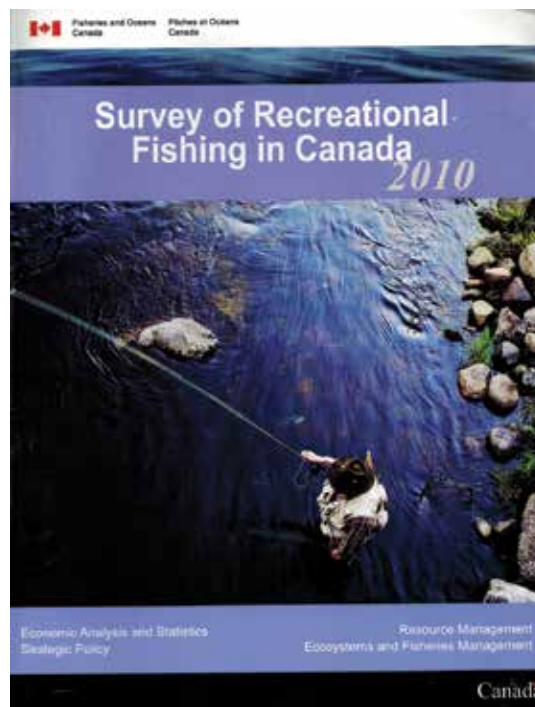
## METHODS

### Canadian Recreational Fishing Surveys

#### *Data Collection*

Mail surveys were conducted by the DFO from 1975 to 2010 in 5-year intervals on a jurisdiction-specific basis (i.e., provinces and territories). Surveys had a set of core questions consistent across jurisdictions relating to angler demography (i.e., age, gender), angling activity (i.e., effort, catch, harvest), and angling-related expenditures (i.e., gear, travel), as well as questions unique to each jurisdiction. The results from the majority of these surveys (from 1990 onwards) are available online ([www.dfo-mpo.gc.ca/stats/rec/canada-rec-eng.htm](http://www.dfo-mpo.gc.ca/stats/rec/canada-rec-eng.htm); Photo 1). In most jurisdictions, surveys were sent to a random subset of licensed anglers in Canada. However, in Québec and Newfoundland information from licensing bases were limited, so surveys were mailed to households identified as angling households in a randomized telephone survey.

Surveys were stratified into Canadian resident (fishing in their own jurisdiction) and nonresident anglers, as well as fresh- and saltwater licensed anglers in coastal jurisdictions. From 1990 forward, nonresident anglers were further stratified into Canadian nonresident (fishing in a jurisdiction outside of their own) and non-Canadian angler categories. Unless specified, “nonresident” refers to both Canadian nonresident and non-Canadian anglers combined. The total number of respondents nationwide ranged from 32,000 to 38,557. Prescreening phone calls and postsurvey reminder cards were implemented in 1990 and 2000, respectively, to identify likely respondents and mitigate declining response rates. There were no data collected for nonresident anglers in Québec in 2005 or 2010, which undoubtedly resulted in underestimated nationwide values for



**Photo 1.** Fisheries and Oceans Canada report on recreational fishing in Canada in 2010. Photo credit: Fisheries and Oceans Canada.

this angler type in those years. Generally, reports also collected more detailed information in later years, including more in-depth information on species-specific catch and harvest, which were omitted in early surveys.

#### *Data Analysis*

In most jurisdictions, the data collected from angler mail surveys were extrapolated to the total number of licensed anglers of each angler type (resident, nonresident and saltwater, freshwater) using an inverse weighting by stratum function (DFO 2012). However, due to the lack of standard provincial recreational angler licensing, the number of anglers in Québec and Newfoundland were estimated based on the ratio of anglers to nonanglers that responded to the prescreening surveys and the population sizes from provincial census data (DFO 1975–2010). Coefficients of variation (CV) are standard error measurements of the extrapolation estimates that were used by Statistics Canada to assess the statistical reliability of survey data (as per Searls 1964) as a measure of reproducibility, where  $CV = (\text{Standard error of the mean}/\text{mean}) * 100$ . CV values greater than 33.5 reflect a high degree of dispersion around the estimate and were excluded from further analysis due to low reliability/reproducibility (as per Statistics Canada guidelines [Statistics Canada 2009]). The majority of values were lower than 16.5, which suggest low dispersion and, as such, are considered to be highly reliable, with low probability of bias (Hendricks and Robey 1936; Maarof et al. 2012; DFO 2012).

#### *Longitudinal Analysis*

Social (number of anglers, total days fished, age, gender, and catch per unit effort [CPUE]), biological (catch, harvest,

percentage caught and released), and economic (expenditures, major purchases related to angling) recreational fishing variables were compared on a national scale from 1975 to 2010 or within time periods where data were available. Though species-specific catch and harvest data became more detailed in later years, species were combined into more general groups as they were in early survey years for longitudinal comparison from 1985 to 2010 (Table 1). In some instances, species from disparate taxonomic groups had to be grouped together due to the generality of angler reports in early years of the survey. For example, the bass category included both Centrarchid and Moronid bass. Catch per unit effort was calculated based on the total number of fish caught and the total number of angler days fished. All economic values were converted to 2010 Canadian dollars as per Statistics Canada and Bank of Canada guidelines using the Consumer Price Index (Statistics Canada, Operations and Integration Division 1996). The relationships between the number of recreational anglers in Canada and total fish catch and harvest were analyzed using linear regression analysis, as were the relationships between angler effort (total days fished) and fish catch and harvest. Assumptions of normality were tested prior to analysis. Analyses were conducted using R statistical programming language (ver. 2.15, R Foundation for Statistical Computing, Vienna, Austria).

## RESULTS

### Social

From 1975 to 2010 there were on average of 4.5 million licensed anglers in Canada, of which 94% were active. After peaking in 1985 at 5.2 million, the number of licensed anglers in Canada declined consistently to 3.5 million in 2005 then rose again to 3.6 million in 2010 (Figure 1a). Overall, licensed anglers included 79% Canadian residents, 17% non-Canadians, and 4% Canadian nonresidents. The average age of all anglers has increased over time from 41 in 1975 to 50 in 2010 (Figure 1b) and nonresident anglers were an average of 4.4 years older than Canadian residents. Recreational anglers were also predominately male for both Canadian residents (79%) and nonresidents (85%), with relatively stable gender ratios over time (Figure 1b).

Similar to the trend for licensed anglers, the total number of days fished by recreational anglers in Canada declined from 74 million in 1980 to 43 million in 2005 and 2010 (Figure 1c). For all survey years combined, the majority of angling effort occurred in freshwater (93%). Angler CPUE remained stable over time (Figure 1d). Canadian residents and Canadian nonresidents had similar CPUE at 4.0 and 4.3 fish/day, respectively, whereas CPUE for non-Canadians was much higher at 10.4 fish/day.

### Biological

An average of 255 million fish were caught in Canada by recreational anglers each year from 1985 to 2010. Over time, catch declined from over 330 million in 1985 to 193 million in 2010 (Figure 2a), with a 44% decline in Canadian resident

**Table 1 . A list of the nine selected species groups and the species included in each group according to common and scientific names. Note that in some cases species are grouped in ways that would be expected of anglers (e.g., putting Centrarchid and Moronid Bass together) rather than consistent with taxonomic standards.**

Species group name	Common name(s) of included species	Scientific name(s) of included species
Northern Pike	Northern Pike	<i>Esox lucius</i>
Walleye	Walleye	<i>Sander vitreus</i>
Salmon	Atlantic Salmon, Chinook Salmon, Coho Salmon, Pink Salmon, Sockeye Salmon, Chum Salmon	<i>Salmo salar</i> , <i>Oncorhynchus</i> spp.
Trout and Charr	Arctic Charr, Lake Trout, Brook Trout, Brown Trout, Rainbow Trout, Golden Trout, Bull Trout, Dolly Varden, Cutthroat Trout, Splake	<i>Salvelinus</i> spp., <i>Salmo trutta</i> , <i>Oncorhynchus mykiss</i> , <i>O. clarkii</i>
Perch	Yellow Perch, White Perch	<i>Perca flavescens</i> , <i>Morone americana</i>
Cod	Atlantic Cod, Tomcod, Lingcod	<i>Gadus morhua</i> , <i>Microgadus tomcod</i> , <i>Ophiodon elongatus</i>
Smelt	Smelt	<i>Hypomesus olidus</i> , <i>Osmerus mordax</i>
Whitefish	Mountain, Lake and unspecified Whitefish	<i>Prosopium</i> spp., <i>Coregonus</i> spp.
Muskellunge	Muskellunge	<i>Esox masquinongy</i>
Bass	Largemouth Bass, Smallmouth Bass, Striped Bass	<i>Micropterus salmoides</i> , <i>Micropterus dolomieu</i> , <i>Morone saxatilis</i>

catch and a 25% decline in nonresident catch. With all years combined, Canadian residents accounted for 88% of catch and nonresidents 12%, where Canadian nonresidents represented 2% of catch and non-Canadians represented 10% of catch.

From 1975 to 2010, an average of 133 million fish were harvested in Canada each year by recreational anglers. Harvest peaked in 1985 at over 228 million fish and declined by 75% to 58 million in 2010, with similar levels of decline in both Canadian residents and nonresidents (Figure 2b). The release rate of fish caught by anglers has increased by 37% from 1985 to 2010, a consistent trend in both Canadian residents and nonresidents (Figure 2c). Nonresidents exhibited more catch-and-release activity than Canadian residents consistently over time, releasing an average of 23% more of their catch. There was a strong positive relationship between the number of licensed anglers and the number of fish caught ( $R^2 = 0.92$ ,  $F_{1,4} = 45.6$ ,  $P = 0.003$ ) and harvested ( $R^2 = 0.85$ ,  $F_{1,4} = 22.5$ ,  $P = 0.009$ ; Figure 3). There was an even stronger relationship between number of days fished and the number of fish caught ( $R^2 = 0.98$ ,  $F_{1,4} = 160.4$ ,  $P < 0.001$ ) and harvested ( $R^2 = 0.95$ ,  $F_{1,4} = 78.3$ ,  $P < 0.001$ ).

The group including all Trout and Charr species (Photo 2, Table 1) represented the highest number of caught and harvested fishes in Canada from 1985 to 2010, and Walleye (*Sander vitreus*) was the most frequently caught and harvested individual species (Figure 4). Muskellunge (*Esox masquinongy*; Photo 3) and Bass (Photo 4) fisheries were primarily catch-and-release, whereas Smelt, Cod, Trout, and Charr were harvest-dominated. Perch, Northern Pike (*Esox lucius*), Salmon, and Whitefish were

subject to more intermediate levels of harvest, whereas Walleye and Northern Pike became more catch-and-release dominated due to declines in harvest and/or increases in catch over time. Longitudinal trends show general declines in harvest for all species/groups, with large declines in Smelt (-82%), Whitefish (-74%), Trout and Charr (-43%), and Cod (-27%) catch. Cod catch dropped by 88% from 1990 to 1995 but increased moderately by 2010.

**A “lack of time” may reflect that fishing is becoming less of a priority, especially for young people. With the increasing popularity of technology and social media, young people in particular are spending more of their time interacting through virtual means, which has resulted in a general lack of participation in outdoor activities and an overall lack of connectivity to nature, a phenomenon termed “nature deficit disorder.”**

## Economic

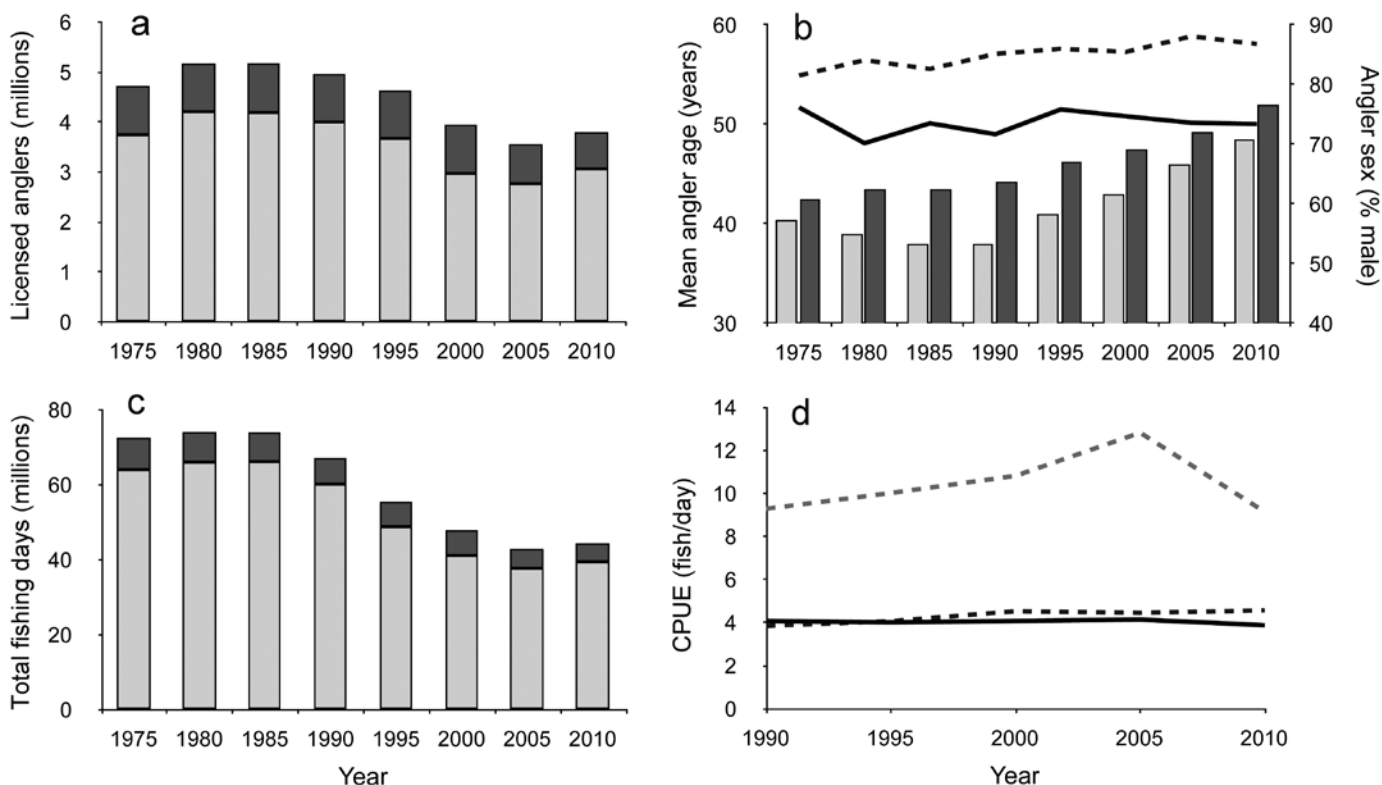
Major purchases wholly or partly related to recreational angling (related major purchases; RMP) averaged \$5.6 billion CAD per year from 1975 to 2010, with Canadian residents responsible for 95% of RMP (Figure 5a). Related major purchases increased from \$3.8 billion in 1975 to its maximum, \$7.9 billion, in 1990 and subsequently declined to \$5.8 billion in 2010.

Total expenditures directly related to angling (direct expenditures; DE) averaged \$3.2 billion from 1975 to 2010, with Canadian residents responsible for 72% of DE (Figure 5b). Direct expenditures followed a similar longitudinal pattern to RMP, increasing to its maximum in 1985 at \$4.6 billion and declining steadily to \$2.5 billion in 2010. Overall, recreational angling contributed an average of \$8.8 billion in revenue per year to the Canadian economy from 1975 to 2010 through RMP and DE.

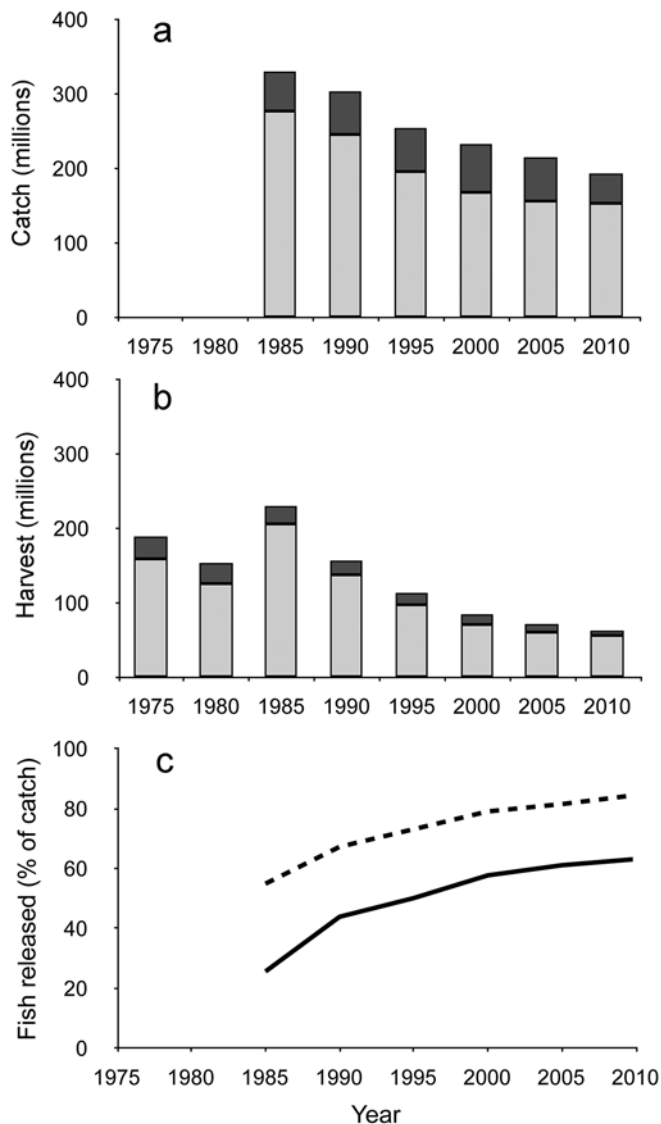
Direct expenditures averaged \$786/angler for all angler types from 1990 to 2010 (Figure 5c). Direct expenditures/angler remained stable for Canadian residents over this time period but increased over time for both Canadian nonresidents and non-Canadians. However, Canadian nonresidents spent the least per angler in 2010 at \$399/angler, down 62% from 2005. Non-Canadians generally spent the most per angler, with an increase from \$643/angler in 1990 to \$1,115/angler in 2010. Resident anglers exhibited a modest decrease in spending over the same time period, from \$762/angler in 1990 to \$696/angler in 2010.

## DISCUSSION

Recreational angling is a socially and economically important activity in Canada and a dominant use of its fish stocks in inland waters. A longitudinal study of social, biological, and economic trends highlights important interactions between



**Figure 1.** (a) Number of active Canadian resident (light grey) and nonresident (dark grey) anglers (millions) from 1975 to 2010. (b) Mean age of resident (light grey bars) and nonresident (dark grey bars) anglers; gender (% male) of resident (black line) and nonresident (hatched line) anglers from 1975 to 2010. (c) Total days fished by resident (light grey) and nonresident (dark grey) anglers from 1975 to 2010. (d) Catch per unit effort (number of fish per day) by Canadian resident (black line), Canadian nonresident (black hatched line), and non-Canadian (light grey hatched line) anglers in Canada from 1990 to 2010.



**Figure 2.** (a) Total catch of all fish species by Canadian residents (light grey) and nonresidents (dark grey), (b) total harvest of all fish species, and (c) fish released (% of catch) by Canadian residents (black line) and nonresidents (hatch line) from 1975 to 2010. No data available for (a) and (c) from 1975 to 1980.

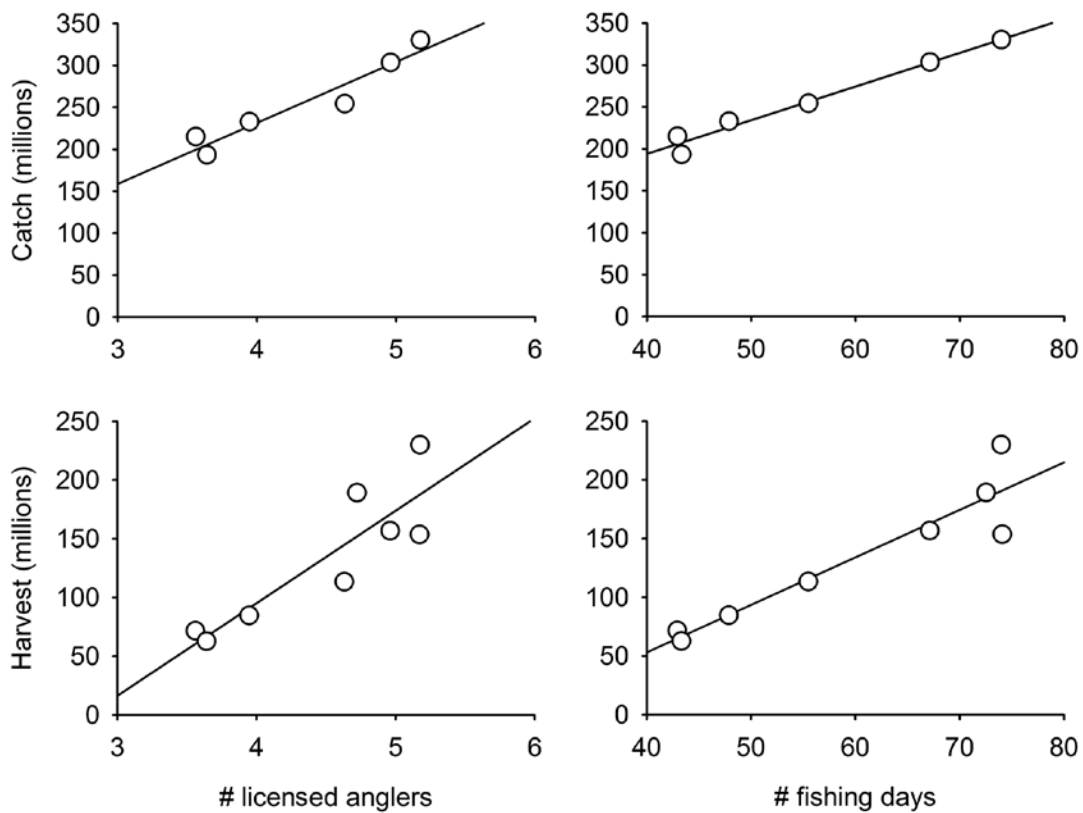
these dynamics that may inform related environmental and socioeconomic policy. Recreational angling in Canada has certainly become less popular since 1985 (number of licensed anglers declined 31%), though Canada's population has grown 30% during this time period (Statistics Canada 2013). Further, the mean age of licensed anglers has increased by nearly 10 years, indicating that decreased popularity is primarily due to poor recruitment of young anglers. Recreational anglers are also predominantly male in Canada, which is consistent with the majority of documented recreational fisheries worldwide (Aas 1996; Fedler and Ditton 2001; Freire et al. 2012). A lack of female participation has been attributed to commitments to children and family, perceptions of traditional gender roles, or a general lack of experience (Anderson et al. 2004). Previous studies have found that the most common reasons people cite for not fishing are their health, a lack of time, cost, or regulations (Aas 1996; Fedler and Ditton 2001). A "lack of time"



**Photo 2.** Dolly Varden (*Salvelinus malma*) angled in British Columbia. Photo Credit: Andrew Lotto.

may reflect that fishing is becoming less of a priority, especially for young people. With the increasing popularity of technology and social media, young people in particular are spending more of their time interacting through virtual means, which has resulted in a general lack of participation in outdoor activities and an overall lack of connectivity to nature, a phenomenon termed "nature deficit disorder" (Louv 2006, 2012; Pergrams and Zaradic 2008). Additionally, though regulations are essential for the sustainable management and conservation of fish populations, their relative degree of complexity may be deterring people from participating (Lester et al. 2003; Arlinghaus et al. 2008).

Along with participation, catch and harvest rates by recreational anglers have also declined while CPUE has remained static, suggesting that overall angling quality has remained relatively consistent. This is surprising considering that fishing quality has apparently declined in many inland waters (Post et al. 2002; Cooke and Cowx 2004, 2006). Furthermore, many fish populations have undergone recent declines due to habitat loss and overexploitation by both commercial and recreational fisheries in Canada (Christie 1974; Post et al. 2002; Lewin et al. 2006). This was not reflected in our nationwide angler CPUE; however, the measure of effort here, number of days fished, does not preclude the possibility that anglers are fishing longer days to catch the same number of fish. Catch of target species is also not considered, and abundance-related declines in fishing success for some species or regions may be mediated by others. Indeed, observed increases in catch and release rates since 1985 could reflect the fact that fewer target species or fish of harvestable size are being caught. However, catch-and-release angling has been increasing in popularity in many developed countries, which has been attributed to a combination of stricter harvest regulations and voluntary release due to shifting conservation ethics of anglers (Cowx 2002; Arlinghaus et al. 2007). Catch-and-release angling is a conservation strategy that relies on the assumption that released fish survive and have limited fitness consequences (Wydoski 1977; Arlinghaus et al. 2007). The large increase in catch-and-release activity in Canada highlights the importance of exercising best angling practices to minimize the impacts of this activity (see Cooke and Schramm 2007).



**Figure 3.** Relationships between the number of licensed anglers and total fish catch (catch =  $-59.22 + 72.69 \times$  number of anglers) and harvest (harvest =  $-220.0 + 78.9 \times$  number of anglers), as well as the total number of days fished and total fish catch (catch =  $33.4 + 4.0 \times$  days fished) and harvest (harvest =  $-108.8 + 4.0 \times$  days fished) including resident and nonresident anglers in Canada from 1975 or 1985 to 2010.



**Photo 3.** Muskellunge (*Esox masquinongy*) angled in eastern Ontario. Photo credit: Sean Landsman.

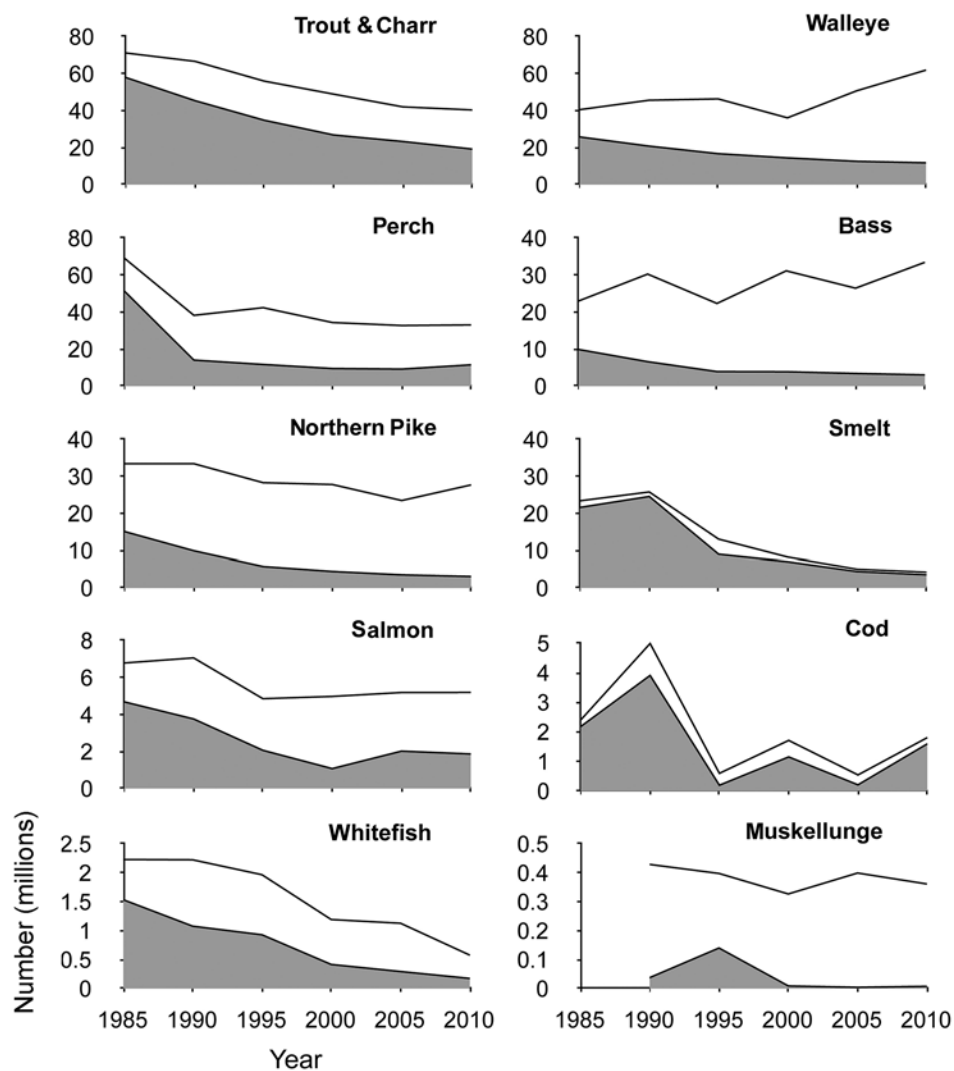


Figure 4. Catch (white) and harvest (grey) of selected species, including Trout and Charr, Walleye, Perch, Bass, Northern Pike, Smelt, Salmon, Cod, Whitefish, and Muskellunge in Canada from 1985 to 2010. For species groupings, see Table 1. No data available for Muskellunge in 1985.



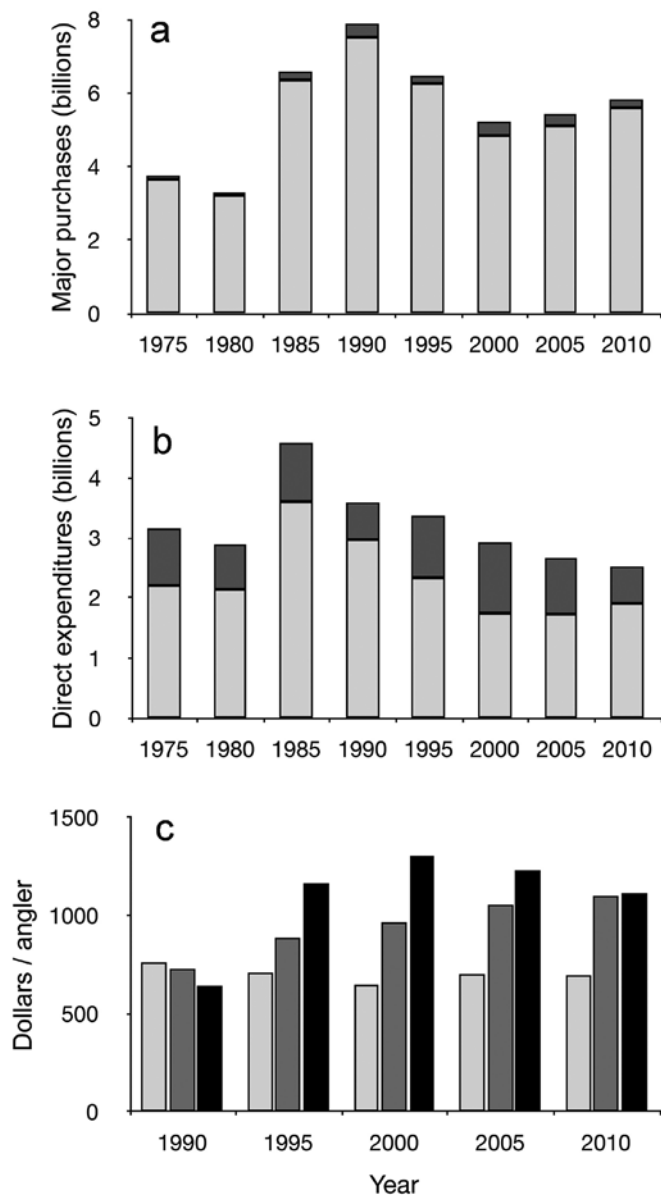
Photo 4. Largemouth Bass (*Micropterus salmoides*) angled in eastern Ontario. Photo credit: Karen Murchie.



An examination of angler catch and harvest also provides useful information for managing fisheries. It is a notable trend that every species/group examined herein that has been subjected to relatively high levels of harvest has exhibited some decline in catch by recreational anglers since 1985, particularly those fisheries with very high levels of harvest (i.e., Trout and Charr, Smelt, Cod, Whitefish). In contrast, an increase in Bass and Walleye catch over time corresponded with decreased harvest. It is uncertain whether increased release rates are due to harvest regulations or conservation ethics of anglers, but catch-and-release angling can be an effective conservation strategy (Cooke and Schramm 2007), and healthy stocks are best maintained through well-regulated and closely monitored fisheries (Pauly and Palomares 2005; Welcomme et al. 2010). However, angler CPUE must be interpreted with caution when making inferences about fish population dynamics, especially on a national scale. Anglers have a tendency to become more effective over time and therefore catch rates may not reflect declines in fish abundance (Post et al. 2002).

Recreational angling is also an economically important activity in Canada and, over time, anglers have increased fishing-related spending on an individual basis, likely due in part to technological advancements in fishing gear and relative increases in commodity prices, such as gasoline. However, because participation rates have declined since 1985, so have total angler expenditures. This is particularly true for direct expenditures, whereas related major purchases have remained relatively static. The decline in direct expenditures has been primarily due to resident anglers, whereas non-Canadians contribute an increasingly higher proportion of angling-related revenue to Canada's economy. In addition, nonresident anglers actually harvest a lower proportion of their catch and therefore may exert less pressure on fish populations. Angling-related tourism is clearly beneficial for Canada's economy and may benefit from further promotion.

In examining these long-term social, biological, and economic dynamics in Canadian recreational fisheries concurrently, the utility is clear. They reveal patterns in important metrics such as species-specific catch, fishing participation, and angler expenditures, which could contribute to management of natural resources and economies. For example, knowledge of socially and economically important fish species may inform habitat protection, stocking programs, and fishing regulations, and drastic declines in catch of a popular species may indicate a cause for concern. Similarly, knowledge of angling activity and expenditures by specific demographics may inform promotional strategies for increasing tourism-related economic growth. Despite the high social and economic importance of recreational angling in many countries worldwide (Cowx 2002; McPhee et al. 2002; Radford et al. 2007), few countries have an understanding of the complex biological, demographic, and economic dynamics of their fisheries. The collection of such data will not only benefit individual nations; it can support development of a global framework for management of recreational fisheries (see Cooke and Cowx 2004).



**Figure 5.** (a) Major purchases wholly or partly related to angling by Canadian resident (light grey) and nonresident (dark grey) anglers from 1975 to 2010, (b) expenditures directly related to angling by Canadian resident (light grey) and nonresident (dark grey) anglers from 1975 to 2010, and (c) Canadian dollars spent per angler by Canadian resident (light grey), Canadian nonresident (dark grey), and non-Canadian (black) anglers from 1990 to 2010. All data in 2010 Canadian currency values.

Canada is a pioneer in its use of nationwide voluntary mail-based angler surveys for collecting nationwide information on the complex dynamics of its recreational fisheries, and much has been learned along the way. Generally, important considerations for angler surveys include survey frequency, numbers, delivery, and design (questions), because every region has its own diverse culture of recreational anglers that may have variable response rates, reliability, and biases (Ditton and Hunt 2001; Fedler and Ditton 2001). In Canadian recreational angler survey data, the largest bias observed was a lack of data from nonresident anglers in Québec in 2005 and 2010 due to privacy laws enacted in this jurisdiction. In attempting to collect data over large spatial and temporal scales, such issues may be common. Fortunately, nonresident anglers in Québec only represented 1.3% of anglers

in Canada in the year 2000, so the dearth of this data likely resulted in only a slight underestimation of participation, catch, harvest, and economic contributions in those years.

Future applications of nationwide mail surveys should ensure that sample size is large enough to avoid nonresponse bias (Armstrong and Overton 1977), and survey delivery methods are an important consideration. For example, the demographics of respondents may be very different between mail and electronic surveys because younger demographics tend to use new technologies much more readily than older demographics (Morris and Venkatesh 2006). By using solely mail surveys in Canada, responses from younger demographics may have been underrepresented. Another potential bias in angler surveys is that anglers often overestimate their catch (Pitcher and Hollingworth 2002) and therefore the number of fish caught in Canada may have been overestimated using the above methods. For future applications, the level of angler overestimation can be quantified and a correction factor applied to the survey data (see Connelly and Brown 1995; Connelly et al. 2000). An examination of Canadian angler survey data also identified some potential metrics of interest. For example, future surveys could aim to quantify finer scale angler effort and catch of actual target species to better assess angling quality. There is also great potential for further analysis of the Canadian angler survey data set, particularly on finer spatial scales. Hogg et al. (2010) examined these data to characterize Ontario's recreational fisheries in 2005, revealing regional patterns in angler effort, catch, and harvest, which are helping guide fisheries management in that province.

Nationwide angler surveys provided a high-level overview of the biological and socioeconomic dynamics of Canadian recreational fisheries over a large temporal scale. These include exploitation rates of specific fish species or groups, the demographics and number of anglers, and their contributions to the Canadian economy. By synthesizing data from typically disparate disciplines, an important connection is formed between natural resources and their social and economic value. Recreational angling is a highly popular activity worldwide; it is of high social and economic importance and has the potential to impact exploited fish populations. However, the biological and socioeconomic dynamics of fisheries worldwide are poorly understood (Food and Agriculture Organization of the United Nations, Fisheries and Aquaculture Department 2012). Canadian recreational angler surveys should serve as a model for building a fisheries assessment framework that can be used to guide national recreational fisheries management in the future.

## ACKNOWLEDGMENTS


We thank the Recreational Fisheries group at DFO and the provinces and territories, which provided us access to the data set. We acknowledge the tireless efforts of many DFO staff that have contributed to the data collection as well as to the many hundreds of thousands of anglers that have responded to the survey over the past 35 years. In particular, we thank Kieth Brickley for his assistance in the preparation of this article.

## FUNDING

S. J. Cooke is supported by the Canada Research Chairs Program and NSERC. J. Brownscombe is also funded by NSERC. We thank the Recreational Fisheries group at DFO and the provinces and territories, which financed the surveys.

## REFERENCES

- Aas, Ø. 1996. Recreational fishing in Norway from 1970 to 1993: trends and geographical variation. *Fisheries Management and Ecology* 3:107–118.
- Anderson, L. E., D. K. Loomis, and R. J. Salz. 2005. Constraints to recreational fishing: Concepts and questions to understand underrepresented angling groups. Pages 316–320 in K. Bricker and S. J. Millington, editors. *Proceedings of the 2004 Northeastern Recreational Research Symposium*. USDA Forest Service, Northeastern Research Station, Newtown Square, PA.
- Arlinghaus, R., M. Bork, and E. Fladung. 2008. Understanding the heterogeneity of recreational anglers across an urban–rural gradient in a metropolitan area (Berlin, Germany), with implications for fisheries management. *Fisheries Research* 92:53–62.
- Arlinghaus, R., and S. J. Cooke. 2009. Recreational fisheries: socioeconomic importance, conservation issues and management challenges. Pages 39–58 in B. Dickson, J. Iutton, and B. Adams, editors. *Recreational hunting, conservation and rural livelihoods*. Science and practice. Blackwell Publishing, Oxford, UK.
- Arlinghaus, R., S. J. Cooke, J. Lyman, D. Policansky, A. Schwab, C. Suski, S. G. Sutton, and E. B. Thorstad. 2007. Understanding the complexity of catch-and-release in recreational fishing: an integrative synthesis of global knowledge from historical, ethical, social and biological perspectives. *Reviews in Fisheries Science* 15:75–167.
- Arlinghaus, R., T. Mehner, and I. G. Cowx. 2002. Reconciling traditional inland fisheries management and sustainability in industrialized countries, with emphasis on Europe. *Fish and Fisheries* 3:261–316.
- Armstrong, J. S., and T. S. Overton. 1977. Estimating nonresponse bias in mail surveys. *Journal of Marketing Research* 14:396–402.
- Christie, W. J. 1974. Changes in fish species composition of the Great Lakes. *Journal of Fisheries Research Board of Canada* 31:827–854.
- Coleman, F. C., W. F. Figueira, J. S. Ueland, and L. B. Crowder. 2004. The impact of United States recreational fisheries on marine fish populations. *Science* 305:1958–1960.
- Connelly, N. A., T. L. Brown, and B. A. Knuth. 2000. Assessing the relative importance of recall bias and nonresponse bias and adjusting for those biases in statewide angler surveys. *Human Dimensions of Wildlife* 5:19–29.
- Connelly, N. A., and T. L. Brown. 1995. Use of angler diaries to examine biases associated with 12-month recall on mail questionnaires. *Transactions of the American Fisheries Society* 124:413–422.
- Cooke, S. J., and I. Cowx. 2004. The role of recreational fishing in global fishing crises. *Bioscience* 54:857–859.
- Cooke, S. J., and I. Cowx. 2006. Contrasting recreational and commercial fishing: searching for common issues to promote unified conservation of fisheries resources and aquatic environments. *Biological Conservation* 128:93–108.
- Cooke, S. J., and H. L. Schramm. 2007. Catch-and-release science and its application to conservation and management of recreational fisheries. *Fisheries Management and Ecology* 14:73–79.
- Cowx, I. G. 2002. Recreational fisheries. Pages 367–390 in P. B. J. Hart and J. D. Reynolds, editors. *Handbook of fish biology and fisheries*, volume 2. Blackwell Science, Oxford, UK.
- DFO (Fisheries and Oceans Canada). 2012. Survey of recreational fishing in Canada, 1975, 1980, 1985, 1990, 1995, 2000, 2005, 2010. Department of Fisheries and Oceans Canada, Ottawa, Ontario.
- Ditton, R. B., and K. M. Hunt. 2001. Combining creel intercept and mail survey methods to understand the human dimension of local freshwater fisheries. *Fisheries Management and Ecology* 8:295–301.
- Ditton, R. B., S. M. Holland, and D. K. Anderson. 2002. Recreational fishing as tourism. *Fisheries* 27:17–24.
- Fedler, A. J., and R. B. Ditton. 2001. Dropping out and dropping in: A study of factors for changing recreational fishing participation. *North American Journal of Fisheries Management* 21:283–292.
- Food and Agriculture Organization of the United Nations, Fisheries and Aquaculture Department. 2012. Technical guidelines for responsible recreational fisheries. Food and Agriculture Organization, Rome.
- Freire, K. M., M. L. Machado, and D. Crepaldi. 2012. Overview of inland recreational fisheries in Brazil. *Fisheries* 37:484–494.
- Haapasaaari, H., S. Kulmala, and S. Kuikka. 2012. Growing into interdisciplinarity: how to converge biology, economics, and social science in fisheries research? *Ecology and Society* 17:139–146.
- Hendricks, W. A., and K. W. Robey. 1936. The sampling distribution of the coefficient of variation. *Annals of Mathematical Statistics* 7:129–132.
- Hogg, S. E., N. P. Lester, and H. Ball. 2010. 2005 Survey of recreational fishing in Canada: results for fisheries management zones of Ontario. Ontario Ministry of Natural Resources, Queen's Printer for Ontario, Peterborough, Ontario.
- Lester, N. P., T. R. Marshall, K. Armstrong, W. I. Dunlop, and B. Ritchie. 2003. A broad-scale approach to management of Ontario's recreational fisheries. *North American Journal of Fisheries Management* 23:1312–1328.

- Lewin, W. C., R. Arlinghaus, T. Mehner. 2006. Documented and potential biological impacts of recreational angling: insights for conservation and management. *Reviews in Fisheries Science* 14:305–367.
- Louv, R. 2006. Last child in the woods: saving our children from nature-deficit disorder. Algonquin Books, Chapel Hill, North Carolina.
- Louv, R. 2012. The nature principle. Algonquin Books, Chapel Hill, North Carolina.
- Maarof, F., A. Athirah Ahmad, and S. Mohammed. 2012. Symmetry of the sampling distribution of CV for exponential samples. *World Applied Sciences Journal* 17:60–65.
- McPhee, D. P., D. Leadbitter, and G. A. Skilleter. 2002. Swallowing the bait: is recreational fishing in Australia ecologically sustainable? *Pacific Conservation Biology* 8:40–51.
- Morris, M. G., and V. Vankatesh. 2006. Age differences in technology adoption decisions: implications for a changing workforce. *Personnel Psychology* 53:375–403.
- Pauly, D., and M. L. Palomares. 2005. Fishing down the food web: it is far more pervasive than we thought. *Bulletin of Marine Sciences* 76:197–211.
- Pergams, O. R. W., and P. A. Zaradic. 2008. Evidence for a fundamental and pervasive shift away from nature-based recreation. *Proceedings of the National Academy of Sciences* 105:2295–2300.
- Pitcher, T. J., and C. Hollingworth. 2002. Recreational fisheries: ecological, economic and social evaluation. Blackwell Science Ltd., London.
- Post, J. R., K. Sullivan, S. Cox, N. P. Lester, C. J. Walters, E. A. Parkinson, A. J. Paul, L. Jackson, and B. J. Shuter. 2002. Canada's recreational fisheries: the invisible collapse? *Fisheries* 27:6–17.
- Radford, A., G. Riddington, and H. Gibson. 2007. Economic evaluation of inland fisheries: the economic impact of freshwater angling in England and Wales. Environment Agency, Science Report SC050026/SR2, Bristol, UK.
- Searls, D. T. 1964. The utilization of a known coefficient of variation in the estimation procedure. *Journal of the American Statistical Association* 59:1225–1226.
- Statistics Canada. 2009. Statistics Canada Quality Guidelines. Available: <http://www.statcan.gc.ca/pub/12-539-x/12-539-x2009001-eng.pdf>. (May 2014).
- Statistics Canada. 2013. Estimated population size of Canada. Statistics Canada, Ottawa, Ontario.
- Statistics Canada, Operations and Integration Division. 1996. Your guide to the consumer price index. Statistics Canada, Ottawa, Ontario.
- Welcomme, R. L., I. G. Cowx, D. Coates, C. Béné, S. Funge-Smith, A. Halls, and K. Lorenzen. 2010. Inland capture fisheries. *Philosophical Transactions of the Royal Society B* 365:2881–2896.
- Wydoski, R. S. 1977. Relation of hooking mortality and sublethal hooking stress to quality fisheries management. Pages 43–87 in R. A. Bernhart and R. D. Roelofs, editors. *Catch-and-release fishing as a management tool*. California Cooperative Fishery Research Unit, Humboldt State University, Arcata, California. 

## Stream Count™ Drysuits and Travel Waders™



**O.S. Systems, Inc.**

[www.ossystems.com](http://www.ossystems.com)

503-543-3126

[SCD@ossystems.com](mailto:SCD@ossystems.com)

Save the Date

October 23-24, 2014  
Washington, DC  
[www.nwllc2014.org](http://www.nwllc2014.org)



National Workshop on Large Landscape Conservation

## Call for Proposals

The program committee invites you to submit a proposal. Conference organizers are especially interested in outcome-based sessions and symposia that will result in products such as white papers, summary reports, or recommendations from the session. The program will emphasize lessons learned and best practices in every aspect of large landscape conservation start-up, implementation, management, and assessment. The program committee is looking forward to seeing proposals for symposia, panels, and presentations related to the following thematic topics:

- Managing Projects for Successful Outcomes
- Measuring Outcomes and Evaluating Performance
- Water Conservation and Water Management
- Science, Decision Support, and Information
- Management for Landscape Scale Conservation
- Starting up and Sustaining Large Landscape Conservation Projects
- Climate Change and Climate Smart Conservation Strategies
- Metropolitan/Urban and Regional Conservation Initiatives
- New Media

**AFS IN ACTION!**

### LET THE PARENT SOCIETY TEACH YOU NEW MEDIA

Crazy about fish and their associated habitats?  
Want to get others excited about aquatic issues?  
Need to spread the word about a big project?  
Have a great idea to introduce to your members?



One of the best ways of communicating today is via a good website that connects with social media.

- Learn how to create a website for your unit (complimentary from your parent society!)
- Pick up the best tips and tricks of Facebook and Twitter.
- Get down to business with LinkedIn and GooglePlus.
- Get the hang of New Content.

For FREE!!!

And, yep, learn to master New Media!

Visit: [fisheries.org/learnnewmedia](http://fisheries.org/learnnewmedia)

AFS Annual Meeting — Québec City — 17 to 21 August 2014