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Evaluating the Benefits of Recreational Fisheries

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EVALUATING THE BENEFITS OF RECREATIONAL FISHING

Papers, Discussion and Issues:
a Conference held at the UBC Fisheries Center
June 1999

Edited by Tony J. Pitcher

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EVALUATING THE BENEFITS OF RECREATIONAL FISHING

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EVALUATING THE BENEFITS OF RECREATIONAL FISHING

ACKNOWLEDGEMENTS & SPONSORS

The idea that a conference on the benefits of recreational fishing should be held originates from discussions between Joelle Row, Cape Town, South Africa, John Harrison from Northern Territories, Australia and Tony Pitcher from Vancouver. Planning and the search for funding started in 1997. It is hoped that this meeting will form the first of a series, and a second meeting is planned for Darwin, Australia in 2002.

Tony Pitcher, Sean Cox, Eric Parkinson and Gunna Weingartner served on the local planning committee for this conference, which was very capably organised by the Fisheries Centre's Events Officer, Gundula Weingartner. Conference facilities were provided by the Faculty of Graduate Studies and the Zoology Department of the University of British Columbia. In addition, many of the Fisheries Centre graduate students freely gave of their time and enthusiasm to make the symposium a success. In particular we are grateful to Alistair Beattie who assembled the papers, and Amy Poon and Trevor Hutton who acted as Rapporteurs and produced their report to a tight deadline after the meeting.

The Fisheries Centre wishes to express its gratitude and thanks to the following sponsors, whose financial assistance supported the conference and the publication of this Research Report.

South African Deep Sea Angling Association

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Directors Foreword

Fishing for Fun, Food and Profit

Recreational fishing can be defined as catching fish for fun. Added to the fun, there may be auxiliary benefits such as profit, food, and exercise. But the fun part is mandatory.

Fun is what fishers will pay for. Although, as we will see, what is perceived as fun may seem a little perverse in some cases, the task of evaluating the benefits of sport fishing, the theme of this conference, is confounded by the problem of enumerating these diverse auxiliary benefits. Simply deciding on the units to be employed to measure the benefits is not trivial, as there is far more to this than economics and money. Who benefits and who pays? The accounting process raises problems of definitions and crosses disciplinary boundaries.

Fishing for fun turns out to have a history as long as human civilisation itself. Moreover, this history illustrates most of the problems with which we grapple with in this conference.

The first known image of pole, hook and line fishing dates back to the tomb of two wealthy Egyptian manicurists from around 4000BP, although such fishing may have been primarily for food. But it certainly looks fun, and, when it was painted this

Figure 1. Egyptian painted mural of rod, hook and pole fishing from the tomb of one of the Pharaoh's manicurists, Knumhotep, from Beni Hasan, Middle Kingdom, 4000 BP. Fun, food or profit?

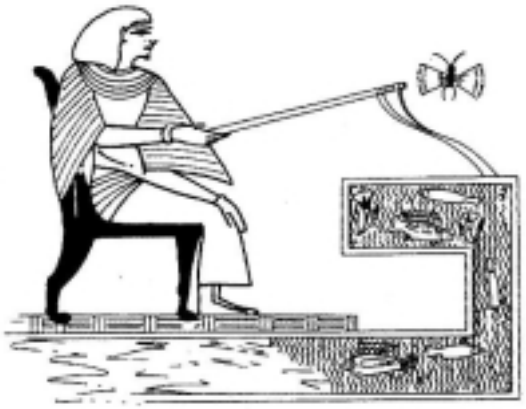

Figure 2. Egyptian noble sport fishing tilapia, from tomb of Nebwenef, a High Priest under Ramses the Great, Thebes, 3290 BP. As well as looking like a lot of fun, and reflecting the immense power of the rich in maintaining such resources, this image also has religious significance, since, long before Christians employed a fish logo, tilapia were an Egyptian symbol of rebirth.

Middle Kingdom mural reflected a fashion of recalling the gentle domestic ethic of the Old Kingdom in Egyptian history.

A thousand years later, we find a more urbane Egypt, where fishing for fun has become the preserve of a rich and powerful elite. Fish were kept in large stone tanks and nobles, seated in comfortable chairs, caught them on rod and line, possibly with insects as bait. Constructing and maintaining such arrangements would have provided quite a boost for the local economy. Fun, food, and power drove this recreational fishing.

As opposed to hunting, which was given divine sanction by Artemis (the original Greek version of the Roman goddess Diana, who is better known to us today) and a pack of lesser Greek hunting deities, the ancient Greeks regarded fishing as a lowly

Figure 3. Greek boy (and an octopus) having fun fishing with a rod and line. Ambrosios, Greece, 2480 BP.

Figure 4. Roman pole, hook and line fishers from North Africa, mosaic, Sousse, 1950 BP. What a diversity of fish! Food and profit for sure, but fun only for these boys, while Mom and Dad were likely engaged in gorier recreation.

occupation fit only for slaves and children. This means the slaves and kids likely had all the fun. For the rest it must have been just food and profit, although once you have gotten them, keeping all those kids and slaves actually doing something useful all day could be reckoned a benefit.

The Romans, who conquered the Greeks, but then adopted Greek culture as fashionable, had a similar attitude. Fishing was an important area of commerce and cuisine, but not regarded as fun, at least among the literate elite who have left us records of their culture. Many coastal cities, such as the ill-fated Pompeii, specialised in fishing and exported aromatic fish sauce, but there seem to be no records of anyone fishing for fun. Maybe for people used to divesting the entire Mediterranean basin of its large carnivore fauna in order to set them to eat criminals and Christians, mere sport fishing did not provide quite the same level of entertainment.

There are indeed many cultures that regard fishing for fun as distinctly odd, if not sacrilegious. For example, First Nation groups on the coat of BC have a hard time coming to terms with sport fisheries for salmon, since their ethics specifically exclude harming creatures other than for food, and you are certainly not supposed to have fun doing such things (e.g. Jones and Williams-Davidson 1999). This finds an echo in the more puritan wing of the European preservationist movement, who regard sport fishing as a form of fish torture. In the conference, recreational fishers were urged to take the potential power of such lobby groups very seriously.

Sometimes the 'fun' aspect of recreational fishing can be hard to recognise as such by the uninitiated. In the middle ages this point was amusingly discussed in a "Dialogue between a Hunter and a Fisher", published by Fernando Basurto in Spain in 1539.

> *Fisher*: .... fishing has great advantages over hunting for the reasons I have given you; for the pre-eminence of the soul, not to mention the health of the body.
>
> *Hunter:* Fisher, you know a lot, you tell me good things in praise of your fishing, and because I accept them as such it could be that you will convert me.

Figure 5. Recreational fishing in the middle ages of Europe could be expensive and cold. This pole, hook and line fisher having fun near Köln in Germany is well wrapped. Likely thats food too, in the pail. 450 BP.

> *Fisher:* Sir, persistence kills the stag. Do not fail to believe me .... the calm you will bring by practising my activity and leaving yours, which is warlike .... and unhealthy for the body...
>
> *Hunter:* Everything you have said is well taken, but I beg you to tell me how your health is.
>
> *Fisher*: Why do you ask?
>
> *Hunter:* Do you not know why? Because I see you very relaxed sitting in this dampness, and I think you must have a pain in the gut, or other pains which enter into human bodies when it gets cold.
>
> *Fisher:* Sir, you do not know what you say, for accustomed pain preserves the passion of the patient. When one starts to use the arms they tire and hurt, but once they have been used the fatigue lessens. ..... the start of a voyage causes sea sickness but once the first fury has passed it leaves the patient with hunger. .... after I began to enjoy this human glory, the laborious feelings were banished, and there was no pain from sitting, especially when the fish are biting, for then there is no thirst nor hunger nor heat nor cold. ...what other activity can take it place?

The hunter goes onto complain that fishing is not good for what are nowadays called relationships, to which the fisher replies that it does not matter because fishing:

> ... by immediate pleasure, makes one forget all that is absent.

Here, echoes of the martyr ethic, the individualist, and the chauvinist are found in our wet and bedraggled sport fisher defending his sport against 'military' hunting.

One recurrent theme in recreational fishing, proving the fishing is for fun axiom, is that it costs far more to catch the fish than they can possibly be worth as marketed commodities. Again we can find a Medieval example, published in a treatise on how to catch fish by Jacob Köbel in Germany in 1493, where expensive culinary ingredients are used to prepare bait to catch trout or grayling:

> Take a black chicken and yolks of three eggs and a pea sized amount of saffron. Then take the chicken and make a hole in it and press all the listed material into it and sew the hole up again. Then place the chicken in a pile of horses manure for three of four days and as many weeks as it takes the chicken to become rotten. Then you will find little yellow worms in it. Put these on the hook each time and keep the others in a little closed box. Thus you will experience marvels.

The same author promises that "great marvels" will come to fishers who smear hands, shins, front and back with a mash of camphor, wheat flour, heron grease, crushed heron bone and olive oil. Remember, this is fun!

In the middles ages freshwater fish (e.g. pike, carp) were introduced to Britain for both food and fun. Indeed, until very recently, fish introductions have been a major part of sport fishing around the world that has brought northern hemisphere salmonids to such unlikely habitats as the highlands of East Africa, Australia and South America. The benefits and costs of such introductions are a challenge to evaluate.

And so, in summary, three principal types of benefits arise from recreational fisheries: economic benefits, which are desired but generally poorly measured; ecological benefits that have only recently been recognised; and social benefits that are rarely valued.

The principal needs of recreational fisheries are, first, to obtain more accurate, detailed evaluation of direct and indirect economic impacts; secondly, to get more accurate, detailed evaluation of socio-economic impacts; and thirdly, to implement adaptive management plans using information gathered by sport fishers, thereby bridging the gap to fishery scientists. The principal requests of

recreational fisheries are to receive equitable treatment with commercial and other sectors (native, artisanal); and a recognition of the conservation benefits of catch and release, bag limit compliance and the scientific benefits from well- managed data records and tag returns.

This *Fisheries Centre Research Report* derives from a conference held at the Fisheries Centre from June 1st to 4th 1999. The three aims of the meeting were:

- To enumerate and evaluate the benefits of sport fisheries;
- To identify and focus on desirable economic social and ecological features;
- To make the case for full recognition of sport fisheries as an important sector in the world's fishing industry.

At the conference, 4 Keynote and 32 contributed papers were presented, of which 22 were submitted for editing and publication in this volume. The Keynote papers are presented first, followed by edited discussions from three sessions that focussed on different aspects of the conference theme and brief perspectives on the issues raised at the meeting by the four Keynote speakers. Contributed papers come next, accompanied by questions asked after each paper that have been recorded and edited by Rapporteurs. A few papers submitted only in abstract conclude the volume. Papers in this volume have been formatted and edited, but not peer-reviewed.

Fisheries Centre Research Reports publishes results of research work carried out, or workshops held, at the UBC Fisheries Centre. The series focusses on multidisciplinary problems in fisheries management, and aims to provide a synoptic overview of the foundations, themes and prospects of current research. *Fisheries Centre Research Reports* are distributed to appropriate workshop participants or project partners, and are recorded in *Aquatic Sciences and Fisheries Abstracts*. A full list appears on the Fisheries Centre's Web site, htpp://fisheries.com. Copies are available on request for a modest cost-recovery charge.

Tony J. Pitcher
Professor of Fisheries
Director, UBC Fisheries Centre

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Keynote Papers

Evaluating Recreational Fishing: Managing Perceptions and/or Reality

Bob Kearney
University of Canberra, Australia

In politics perception is reality. This bold statement is unreferenced but I am not claiming originality. The sentiment has been expressed in many political speeches and political commentaries. It is presented here as a 'truism', or popular perception, rather than a referenced scientific 'fact'. Truisms should not be confused with the truth. Indeed many regard the role of the latter in politics as highly questionable.

Reality dictates that fisheries management be accepted as a political issue. The final fisheries management decisions on matters of substance are normally made by politicians. I am reminded that the last time I gave an address to a conference in this part of the world (I hope Canadians will accept that to antipodeans Seattle is in this part of the world), I concluded "if you want to be fisheries managers then put your money where your mouth is: resign and run for office" (Kearney, 1989). That conference was on the management of the world's commercial fisheries, but it is my contention, not merely my perception, that politicians are also the ultimate managers of recreational fisheries. It should also be noted that the power of perception is not limited to politics, for example as acknowledged on ABC TV on 19/5/99, "In investment perception rules reality" (The 7.30 Report, 1999).

In preparing this paper on evaluating recreational fishing I have, naturally, taken guidance from the conference organisers who, in the flyer announcing the conference, stated "...the considerable social, economic and ecological benefits that recreational fisheries provide have not always been fully recognized" (The Fisheries Centre, 1998). Most anglers agree that angling, and the angling community, have for too long been deprived of justly deserved recognition. How has this truism come about?

One of the primary reasons why the benefits of recreational fishing have not been fully recognised, at least in Australia, is that assessment of recreational fisheries has in the main, not been sufficiently scientifically rigorous. Australia suffered for too long from seriously inadequate scientific discipline in the assessments of virtually all aspects of recreational fishing. When compiling the presentation I gave to a 1994 conference on recreational fishing in Australia (Recreational Fishing: what's the catch? Hancock, 1995) I could find only two Australian papers on recreational fishing that were actually published in recognised scientific journals (Kearney, 1995a). Popular magazines and even the grey literature provided an abundance of opinions and created or fuelled many perceptions, but peer-reviewed assessments were most obvious by their absence. Advocacy completely dominated quality research even within institutions that could have been expected to produce unbiased science. Most of the government researchers responsible for recreational fisheries assessments were avid anglers or had affiliations with angling groups. Government assessments of commercial fisheries were not similarly afflicted. While the situation has improved since 1994 the problem still exists.

> *"The goal of this conference will be to furnish the basis for full recognition of sport fisheries as an important sector of the world's fishing industry...by providing full recognition of social, economic and ecological benefits that recreational fishing provides" (The Fisheries Centre, 1998).*

I will argue that the values of recreational fishing are broader than simply being part of the world's fishing industry. In doing so, and in pursuing the second goal, let me start by providing my personal perceptions of the social, economic and ecological benefits of recreational fishing.

Reasons why I value recreational fishing include, not in priority order: sport (including the challenge, the contest *etc.*), camaraderie, exercise, recreation, solace, mental relaxation, appreciation of nature, understanding the environment and supreme quality food. I cannot put these in priority order because my priorities change. Sometimes I need a break and wish to be alone, sometimes I want to be with friends and sometimes I am almost desperate for some really fresh fish. My priorities have also changed with phases of my life. I admit that as I have grown older I do things a little more deliberately and more fully appreciate the moment, or the surroundings. But two things change little: I almost always go fishing for pleasure, and I (almost always) enjoy it immensely.

Activity	# of participants (x 1000)	Participation rate (%)
Swimming	1,628.8	12.3
Aerobics/fitness	1,379.2	10.4
Golf	1,116.2	8.4
Tennis	937.8	7.1
Fishing	641.5	4.8
Cycling	626.0	4.7
Tenpin bowling	438.0	3.3
Billiards/snooker/pool	373.1	2.8
Netball	339.8	2.6
Squash/racquetball	321.2	2.4

Table 1. Sports and physical activities with the most participants[(a)] (includes organised and non-organised participation). From Australian Bureau of Statistics 20/10/98. [(a)] Relates to participation by persons aged 18 years and over during 12 months prior to interview in 1997-98. Excludes non-organized running, jogging or walking. Percentage of the civilian population aged 18 years and over.

I started fishing when I was three and still value it greatly. But do I value it as much as Frank Filipic, who gave his life for the cause.[1] It is also noteworthy that Mr Filipic's last words as he stepped into the lake to try to land a giant catfish were "now I've got him". Oh, the power of perception! Unfortunately quite a few Australians lose their lives pursuing the benefits of recreational fishing; nine from rock fishing alone in the last year (1997/98) for which statistics are available (Surf Life Saving Association of Australia, 1999 pers. com.). Many of us value fishing immensely but would hope that we were never put to the test as to whether we valued it with our life.

In researching personal perceptions for this paper I canvassed the opinions of many colleagues. One, a north American, whom I knew was seriously committed to angling, replied that he found it very difficult to put a scale of value on fishing, but clearly it was of importance as it had already cost him three marriages.

When evaluating benefits on scales larger than individuals many groupings could be used. I have accepted Australian state or national perspectives as providing contrast to individual perceptions. I have selected the state of Victoria for most examples. But before considering combined opinions of recreational fishers it is first necessary to define who are recreational fishers.

[1] 'Ljubljana: A passionate angler drowned trying to reel in a giant fish, the Slovenian news agency STA reported yesterday.'

We are a diverse group. When managing us governments generally assume that we include the following categories:

- unlicensed professionals (shamateurs)
- accumulators, who use fish as food or for barter
- competitors, including those to whom the capture of more fish than others is primary
- hunters, motivated by the chase and the kill
- sportspersons, to whom the challenge, the skill, the odds, the adrenalin rush and the satisfaction of a job well done are important, but so is a feed of fish
- recreational enthusiasts, to whom the outing is most important but for whom a feed of fish is still a prize
- social fishers, to whom the camaraderie and fellowship are most important
- adventurers, who like the hunter savour the chase, but not the kill, and who release their catch
- lovers of open space, who if they do have a line in the water, do so purely to justify being outdoors (from Kearney, 1995a).

Individual views of the social benefits of fishing will clearly vary between categories, as will the broader community's view of the social acceptability, or value, of the activity.

How many anglers are there? Numerous surveys since 1984 have estimated that collectively we encompass approximately 30% of the Australian population (PA Management Consultants, 1984, VIFTA 1997). However, the most recent publication from the Australian Bureau of Statistics, the official custodian of Australian 'facts', lists participation at only 4.8%, (Table 1). This appears to be a serious underestimate but I quote it here as an example of the paucity of agreed data on recreational fisheries. Again, the lack of peer review confirms the difficulty with aligning perception with the truth.

What are the economic benefits of fishing? Clearly these will vary between individuals included in the array of categories provided above. Those nearest the top of the list may well derive more direct economic returns from the sale or barter of fish. Those nearest the bottom may argue they receive little, if any, economic benefit. My personal perception of the economic benefits include: a source of supreme quality food, an alternative to other forms of sport and recreation for which I must also pay, and an efficient way of disposing of money. Not quite as efficient as feeding dollar bills through a paper shredder, but right up there. I have several friends who regard the purchase of fishing tackle as the extension of recreational fish-

ing to recreational shopping. How many anglers do you know who have more gear than they are ever likely to use? How many of us have the same problem in tackle stores that kids have in candy stores?

It is doubtful that the average angler considers fishing as an economic means of obtaining a feed of fish. Uncles (1997) gives a pertinent reason why: "using the latest estimates of recreational fishing catches (and expenditure) in Victorian waters, this represents approximately $200 spent per kilogram of fish caught and kept". This should not come as a surprise, if the common perception that less than 10 percent of anglers are responsible for more than 90% of the total take is correct.

The regional or national economic benefits of recreational fishing are hotly debated at the present time. Again Uncles, 1997 study is pertinent; "Results from the study indicate that in the last year an estimated $1.037 billion was spent on recreational fishing activities in Victoria (including both capital and current or per-trip expenditure)" (Uncles, 1997). Senator Shane Murphy has stated that the industry is worth $5 billion a year to Australia as a whole (Murphy, 1998). Expenditure in Australia is of the order of $5 billion annually but whether or not this should be valued as an economic benefit is later discussed.

Ecological benefits are, as usual, difficult to quantify. My perception of how angling aids individual contributions to fisheries ecology includes an increased understanding by anglers of the variability and complexities of ecosystems (e.g., seasonality, lunar influence, predator-prey relationships, density dependence and the need for understanding of the impact of externalities such as pollution and El Niño). Angling often constitutes intensive or extensive fieldwork. The resulting increased understanding could be assumed to lead to heightened responsibility and concern for factors such as pollution from plastic bags and discarded fishing line, to concern over, and action against, introduced species such as carp and willow trees, and generally increased awareness of issues such as global warming and climate change.

Opinions on regional or national ecological benefits vary considerably. Most relate to the perception that recreational fishing is more benign than commercial exploitation. Examples of this assertion (perception) include "imposing lower risks of overfishing fish populations" (The Fisheries Centre, 1998), "more than 90% of the fish caught in Melbourne's bays are caught in nets which do great harm to fish stocks and marine vegetation" (VIFTA, 1997) and "...because the nets that they use catch more than they're intended to and they take up, they scoop up everything, rather than just the primary target" (Kennett, 1998). Most Australians support the truism (perception) that recreational fishing must be more environmentally friendly than ruthless use of nets by unprincipled commercial fishers. Even if nets aren't that bad environmentally anglers see them as not sporting, and only the privileged few are allowed to use them.

Let's then reconsider some of the more popular perceptions of recreational and commercial fisheries, and do so in pursuit of full recognition of the social, economic and ecological benefits. Firstly the personal social issues, I strongly support the assertion that the social benefits of responsible recreational fishing are indeed great. The obvious benefits to the individual flow over to society and contribute to a balanced and contented community. But in totalling these benefits society should not overlook the negatives, such as the loss of life by rock fishers in Australia.

The personal economic benefits of recreational fishing are largely a matter of individual decision. Does the amount of money spent in pursuit of one's sport, hobby or recreation need justification? If you believe that the purchase of a $1,000 fly rod or a $1 million game-fishing boat is a good investment then who am I to argue? If you have spare money, why not spend it on what you enjoy? If you don't spend it on fishing will you spend it more wisely? I would be surprised that if you didn't spend it on fishing you would not spend it at all. But if you do spend it on fishing is that in the national interest?

Assessment of the national economic benefits of recreational fishing is somewhat more contentious. Comparison with commercial fishing is again common. The Victorian fishing tackle association claimed that the commercial fisheries in that State's bays and inlets were worth approximately $3.4 million per year and employed approximately 100 people (VIFTA 1997). A subsequent, broader evaluation by consultant economists concluded that ' the combined output of fishers and processors is estimated to be $51.7 million. Direct employment in commercial fishing is 273 people. Taking into account all inter-related employment, there were 715 full time equivalent jobs (Kinhill 1997).

Item of Expenditure	% of recorded expenditure	Purpose of trip	Allocation to fishing
Fishing tackle, bait	0.7	Any	100 per cent
Travel, accommodation, fuel, food and drink, hire fees	2.7	Mainly fishing	100 per cent
Travel, accommodation, fuel, food and drink, hire fees	1.1	Other purposes, some fishing	50 per cent
Fishing equipment and specialised clothing	12.0	Any	100 per cent
Boats, 4-wheel drives and related expenses	83.4		Weighted by respondent's estimate of use for fishing

Table 2. Allocation of recorded expenditure items as fishing.

In his review of the relative merits of commercial fisheries output and recreational fishers expenditure of approximately $1 billion in Victoria annually, Hundloe concluded "In summary, the revenues argument suggests that the more one spends on something, notwithstanding how wasteful, the better off one is. This is fundamentally nonsense. The less one spends in resources to gain something one wants, the better off one is" (Hundloe 1997).

Hundloe then compared the assessed output of the relevant commercial fisheries with a contingent valuation estimate of the willingness of the average Victorian angler to pay for an extra fish and related this to resource allocation between recreational and commercial fishers. He concluded that "if any change of the status quo was to be adopted, it should not involve a significant shift (for any species) from one group (recreational or commercial) to another. There are not necessarily major net economic benefits from a major shift" (Hundloe 1997).It is also noteworthy that in Uncles determination of the $1 billion expenditure on recreational fisheries, he gave the breakdown as indicated in Table 2.

It is most significant that the major component (83.4%) of this expenditure is made up of boats, 4 wheel drive vehicles, and related expenses, and fishing equipment an additional 12%. As no 4 wheel drives or outboard motors are manufactured in Australia and most fishing rods, reels and lines are also imported, it is probable that somewhere near 80% of the expenditure on recreational fishing in Victoria is on imports. If one wished to provoke debate one could ask whether Australia's balance of payments can afford current recreational fishing practice.

It is accepted that countries that manufacture the majority of their own fishing gear and equipment could well value recreational fishing totally differently. They may even go so far as to take into account the importance of their own recreational fisheries for facilitating the export of products to countries like Australia.

Uncles also suggest that 'if there was no recreational fishing sector in Victoria, it is estimated that the total amount of income distributed to Victorian households would fall by approximately $830 million per annum" (Uncles 1997). Victorians have a reputation for being Australia's most avid sports fans. It seems most unlikely that Victorians would be incapable of finding other forms of sport, recreation or leisure and would revert to hiding the $830 million under their beds, or adopting the afore-mentioned option of feeding it through the paper shredder.

The ecological benefits of any form of fishing are difficult to value. As mentioned above recreational lobbyists espoused that commercial fishing in Victoria's bays and inlets was the source of much evil. Consultants employed by the Victorian Co-management Council to review the status of fisheries in the State's bays and inlets concluded:

- "The data presented...indicates that recreational catches are similar to commercial catches for the three main species."
- "The impact of recreational fishing on the mortality of juvenile fish is likely to be similar to that of commercial fishing."
- "On the basis of scientific research and observations, it is considered that haul seine nets have a minimal impact on the seagrass areas and seabed."
- "Recreational fishing activities may result in impacts to habitats of fisheries value and fish stocks (excluding fishing mortality) from processes involving:
- damage to seagrass beds from anchors and propellers;
- impacts associated with litter (especially bait wrappers) and lost fishing tackle; and,
- water quality effects relating to outboard motors" (WBM 1997).
- In my own review of the WBM reports and other available evidence I concluded that:
- 'The available evidence does not suggest that excessive commercial fishing pressure has

caused significant declines in the underlying fish populations.'

- 'Environmental degradation and introduced species have been linked with most of the reported declines in Victorian bay and inlet fish resources. There is little doubt that environmental issues pose far more serious threats to the fisheries of Victoria's bays and inlets than do current commercial or recreational fishing practices' (Kearney 1997).

In my conclusions to the 1994 Australian Conference on Recreational Fishing: What's the catch? I stressed that of the many major parties with an interest in fisheries resource management, listed below, recreational and commercial fishers arguably had most in common; the long-term sustainability of the resource and management which supports maximum yields are paramount to both. Serious conflict between the two groups seems counter-productive. My final words on this were "Much of the conflict that is currently topical results from wrong perceptions. Most of the conflict can only be resolved with appropriate information on the real issues and education of all parties involved. Consultation and education are the ways of the future, not confrontation" (Kearney 1995b).

Parties with an interest in recreational fisheries management

- The legal custodians of the resource (mostly governments)
- Traditional or aboriginal users of the resource
- Observers
- Developers
- Polluters
- Seafood wholesalers
- Seafood retailers
- Restaurateurs
- Tourism organisers
- Tourists
- Consumers of seafood
- Aquaculturists
- Individual public figures
- Politicians
- Recreational fishers
- Commercial fishers

In concluding at this Conference, how would I summarize my perceptions of 'the considerable social, economic and ecological benefits of recreational fisheries' (The Fisheries Centre, 1998). Let me summarize the benefits and problems, of these three categories in reverse order: Any activity in which 20-30% of the population participates ten times a year must have ecological impacts; particularly when the activity involves targeting living organisms. It is my perception that with full understanding of the real impacts, as could be provided by quality, unbiased research and appropriate management, the negative aspects can be contained.

On the positive side, I am reminded on my comments at a 1994 conference on Conserving Biodiversity, "The strong support for taking maximum, but sustainable yields from our oceans, estuaries, rivers and lakes, expressed by the many commercial and recreational fishers, has already led to the conservation of several of our most fragile fish nursery areas, such as mangrove swamps and seagrass beds" and furthermore, "This same group of increasingly conservation-conscious profit-takers, *i.e.* the fishing community, represent one of the greatest potential forces for the conservation of aquatic biodiversity" (Kearney 1995c). Anglers can become an even greater force for long-term resource sustainability. Particularly as environmental degradation constitutes the major threats to most of our inshore fisheries.

I believe that in Australia the major economic benefits of recreational fishing are associated with tourism and decentralization. I would be most cautious of arguing for increased involvement in management on the basis of expenditure.

The social benefits, more specifically personal satisfaction, are why I am a devotee of recreational fishing. I do not like to dwell on the negative social issues; broken marriages, neglected children, smelly clothes, sand in the double bed or the strong odour or rum on the breath. We all know that such trivia are more than compensated for by the benefits of sport, exercise, relaxation etc. listed earlier. On a more serious note, I do strongly believe it is the social benefits of recreational fishing, both individual and community, which represent the future. I also believe that accurate description of the pros and cons of recreational fishing is an essential pre-requisite for good management, including future development.

I accept that it is the right, perhaps even the responsibility, of lobbyists to argue for actions that satisfy their clients short-term objectives, and that these short-term interests may be furthered by championing some biased perceptions. However, we live, and fish, in a world where sustainability and long-term resource security are, at last, working their way up the political agendas in more and more countries. I believe that in such a world the long-term interests of recreational fishers will be best served by more openly acknowledging the difference between advocacy and science, concentrating on the latter and moving perceptions closer to reality than they traditionally have been.

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Questions and Discussion

Douglas Lipton: Why isn't commercial fishing resulting in over-fishing of fish resources? What kind of attitude exists that allows such a situation and are there any quota restrictions in place?

Bob Kearney: These are fairly small commercial fisheries with limited numbers of licenses. It is simply not economical to increase commercial fishing effort further and exploit the stocks any harder. No quotas are in place for commercial fishers and the rules for anglers do not really restrict total catches.

Ian Cowx: What are the dis-benefits of recreational fishing, especially carp fishing?

Bob Kearney: A major dis-benefit is the translocation of species. Carp are regarded nationally as a pest but they are favoured by some anglers who deliberately increase their distribution. Other aquatic fauna and flora, such as weeds have also been widely translocated, even over the Great Dividing Range. No-one is sure whether anglers are responsible.

Tony Pitcher: You mentioned the idea that spending money on fishing is not good for the economy. Can you comment?

Bob Kearney: I didn't say that; I said that in Australia, expenditure is great and it affects the economy, but I refuse to believe that Victorians will not be spending their money on something else (for example, football) if they don't spend it on fishing.

Margaret Merritt : In Alaska, we have a third set of fishers who catch fish for food (subsistence fisher); and they have their own set of regulations and allocations and priorities. Does Victoria have a classification called subsistence fishers and if so, where do they fit in the scenario of fishing conflicts?

Bob Kearney: Strictly speaking, it is illegal to catch fish as bartering items, but people do it. Also, it used to be that people who went over the limit with their catches could get away with it if they claimed that they needed the fish to feed their starving families, etc. It's changed a lot in the past 25 years, though. The accumulation of large quantities of fish is now frowned upon very seriously.

Eric Thunberg: It was illegal to use rod and reel to fish until a proposal was made to change this rule. Will this blur the line between angling and subsistence fishers?

Bob Kearney: There is a difference between the law and social "rules". Management is largely influenced by what society will accept. It is no longer acceptable for recreational fishers to take a boatload of fish. The law has not changed as much as social attitudes have.

Are recreational fisheries sustainable in multiple aquatic resource user situations?

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Abstract

Recreational fisheries involve both subsistence fishing, where the catch is consumed, and leisure fishing, where the fish are returned live to the water. Both types of recreational fishing are extremely important activities but in recent years have under gone major, often adverse, changes. These are related to numerous anthropogenic perturbations, such as pollution, eutrophication, acidification, afforestation, river engineering works and hydropower development, which have resulted in a shift in the status of the fisheries and a general decline in the yield. In these circumstances fisheries are usually not considered of sufficiently high priority or value and thus suffer in the face of economically and socially higher priorities, e.g. agriculture, hydroelectric power production or flood prevention. Perhaps the greatest, short-term problems arise from conflict with other local user groups, especially commercial fishermen, other water-based recreational activities, and those involved with the wider aspects of conservation.

If recreational fishing is to be maintained or developed in the future, it is essential that the subsector is managed on a sustainable basis, with due regard being given to other aquatic resource users. In addition the importance of recreational fisheries needs to the local and national economy needs to be evaluated in economic terms. This paper examines mechanisms by which recreational fishing can be managed on a sustainable basis, and highlights the importance economic valuation to defend the position sub-sector in aquatic resource development schemes.

Introduction

Recreational fisheries involve both subsistence fishing, where the catch is consumed, and leisure fishing, where the fish are returned live to the water. Both types of recreational fishing are extremely important leisure and subsistence activities, but are also valuable resources contributing significantly to national economies. This is highlighted by the following summary statistics.

- Amongst 22 European countries there are an estimated 21.3 million anglers, with an estimated expenditure on recreational fishing in 10 of the countries in Western Europe where data were available, in excess of $US 10 billion (Cowx 1998b).
- In the USA, 29.9 million anglers paid $US 447 million for fishing licences in 1996, down from $US 30.4 million in 1995 (Anon, 1997).
- In 1996, 18% of the population 16 years year of age and older, i.e. 35 million persons, exerted 514 million angler-days in fresh waters expending $US 38.0 billion (US Fish and Wildlife Service, 1997)
- In Canada, 4.2 million anglers exerted 55.5 million days and caught over 254 million fishes while spending $US 5.1 billion of which $US 3.4 was directly associated with the sport in 1995. Of these fishes some 113 million were retained (Department of Fisheries and Oceans, Canada, 1998).
- Retained marine recreational catch from USA sounds, estuaries and bays amounted to more than 30,000t in 1996 (Fisheries Statistics Division, 1997).
- It is estimated that total recreational catch worldwide is of the order of 2 million t, and represents an important source of animal protein in many developing countries (Coates, 1995).

Despite the importance of recreational fisheries worldwide, there is a perception that natural fisheries have under gone major, often adverse, changes. These are related to on-going restructuring in post-socialist countries, changing relationships between commercial and recreational fishermen, deficiencies and confusion in fisheries legislation, administration and access to waters.

The resources are also subject to numerous anthropogenic perturbations, such as pollution, eutrophication, acidification, afforestation, river engineering works, and hydropower development, which have resulted in a shift in the status of the fisheries and a general decline in the yield. As a consequence, fisheries that are sustained through stock enhancement strategies (Cowx, 1998a) are replacing natural fisheries. Furthermore anglers are moving towards intensively stocked fisheries because the quality of sport based on natural fisheries is considered to be inadequate. If this situation is not to deteriorate further the reasons behind the general demise of the stocks needs to be identified and mechanisms to ameliorate problems and enhance the fisheries are required. This paper examines some of the issues and problems

facing recreational fisheries, with specific reference to Western Europe, and offers a mechanism for addressing the problem. This will be examined through the use of two case studies that illustrate some of the problems facing inland fisheries.

Case studies

1. Wimbleball reservoir pump storage scheme on the River Exe, England

Increasing demand for water supply in Southwest England has resulted in the promotion and construction of Wimbleball Pumped Storage Scheme. The reservoir is a strategic reservoir that regulates flows in the River Haddeo, a tributary in the headwaters of the River Exe. The scheme was designed to pump water from the main River Exe into the reservoir during periods of high discharge and release them back to the river for subsequent abstraction further downstream during periods of low flow (Sambrook and Cowx 2000).

The original design of the scheme proposed by the consultant engineers had little consideration for the fisheries of the river, and in particular showed disregard for the main angling species, Atlantic salmon (*Salmo salar* L.). The sole objective was to ensure maximum utilization of the water resources, regardless of the impact it would have on the environment. By careful examination of the catch records and further strategic studies on the movements of salmon using acoustic tracking methods, it was possible to identify the flow characteristics essential for the maintenance of the fishery. Basically these results showed that certain river discharges were required to stimulate the upstream migration of adults and allow them to negotiate natural and man-made obstructions in the river. The original operating scheme had no regard for these requirements and would have impeded the upstream migration of fish except in the late autumn, thus reducing the number of fish available to be caught. In addition, the economic importance of the salmon fishery to the local economy was stressed, although no true valuation was available.

Armed with this information, it was possible to argue with the planners for the protection of flow characteristics at certain times of the year to ensure the upstream movements of salmon and protect the fishery from almost certain collapse. The scheme was redesigned around the flow needs for fisheries and protected the early stages of any flood which would encourage the upstream migration of the migratory salmonids.

2. River Ouse Groundwater Augmentation scheme

As a consequence of severe droughts conditions experienced in the North of England in the late 1980s and early 1990s several schemes were put forward to increase the supply of potable water. One scheme proposed by the local water company to meet demands in the West Yorkshire conurbation of Leeds and Bradford, was to increase abstraction of water from the River Ouse in Yorkshire from the current maximum of 68 tcmd (thousand cubic metres per day) to 99 tcmd. This was under the proviso that at river flows of <1000 tcmd, the water company could only abstract a maximum of 68 tcmd unless the river was augmented by groundwater at a rate of 1.4 times the abstraction in excess of 68 tcmd. It was estimated that augmentation would be required for up to 330 days, although more typically around 240 days, in drought years (e.g. 1989, 1990 and 1991).

Many concerns were expressed about the scheme, especially in relations to environmental issues, particularly with respect to poor water quality and reduced water temperature caused by pumping groundwater into the river. These were summarily dismissed by the original environmental impact assessment, which was based little scientific evidence. Indeed it was suggested the river fisheries would benefit from the increased discharge during the low flow periods. The decision led to heavy criticism from the angling fraternity, and resulted in a rapid reappraisal of the scheme and its potential impact on the fish and fisheries. New studies were carried out assess the status of the fish stocks and fisheries, to model the affect of pumping groundwater (constant temperature of 10°C) into the river on ambient water temperature, and the implications this would have on the fish population ecology (Cowx, 1992, 1999). Fortunately, there were long term data series on angler catches, cyprinid fry growth, water temperature and water quality for the river.

The salient points from the revised EIA were as follows.

- Little difference was found in the dissolved nitrogen levels in the borehole water and that of the receiving stream. The dissolved oxygen concentration of the borehole water was considerably lower than the water in the receiving stream, but this quickly equilibrated, either through dilution by existing river water or physical agitation
- Simulation of surface water temperatures under augmented flow suggested water temperature reductions would be negligible (<0.6°C)

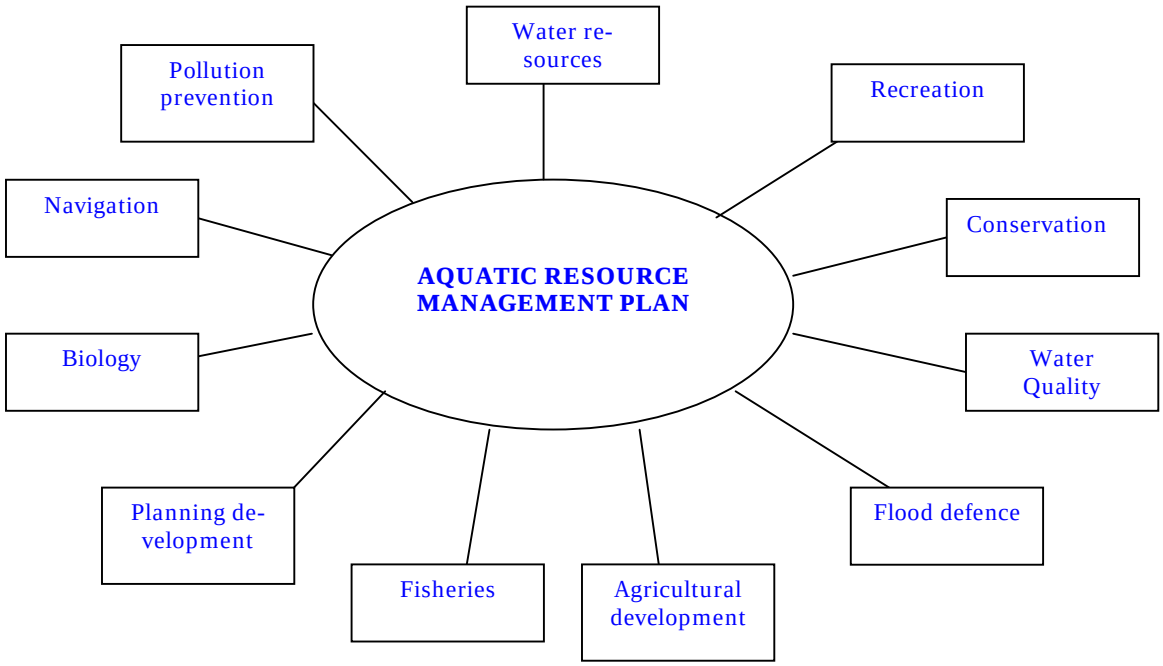

Figure 1. Summary of inputs to aquatic resource management.

in the main stream of the River Ouse. Of greater interest to the fisheries, however, was the cumulative change in degree days resulting from flow augmentation during the summer months, June, July and August. Under a typical drought regime, the scheme would operate between for 150 and 240 days per year rising to over 330 in extreme droughts. The results of the mixing model indicated that the operation of the augmentation scheme would reduce the degree day total by approximately 200 for a severe drought year.

- The River Ouse supported a top quality coarse fishery based on period strong year classes within the fish populations. These dominant year classes supported the fishery for 5-8 years or until the next strong year class developed. It was also apparent that the development of strong year classes was linked to hot summers. This link was proven by modelling fry length in September against number of degree days over 12°C in the period June-September each year. A strong positive correlation was found between the mean fry length in September and the number of degree days, and this was manifest in strong year classes of fish in hot summers typically associated with drought years.

Consequently, it was likely that groundwater pumping would reduce the ambient water temperature by up to 200 degree days per year and suppress the formation of strong year classes on which the fishery depends.

The upshot of the revised EIA was the withdrawal of the scheme by the water company. This outcome has subsequently been vindicated in a similar situation where the release of cold hypolimnial water from a reservoir in North East England has suppressed the growth of the coarse fish populations and lead to a collapse in the fishery (K. O'Hara, personnel communication).

This study demonstrates how easy it is for a major water resource scheme to override environmental issues to meet demands for potable water. If the anglers had not been persistent in their objections the fishery could have been ruined.

Issues associated with management of recreational fisheries

These examples demonstrate the low regard which recreational fisheries holds in the multiple resource user environment. Often little or no consideration is given to the fish and fisheries in development proposals. There are a number of reasons for the poor representation that are, in part, illustrated by the case studies.

Status of the fish stocks.

All too often the status of the fish stocks is poorly understood. This is because the mechanisms for assessing fish stock dynamics in fresh waters, and rivers in particular, are poorly developed (Cowx 1996b). Consequently, there is often weak scientific data on which to base a sound judgement on the conservation of the fisheries resources. The upshot is that too little is known about the role of the fisheries in the overall ecosystem dynamics and they are neglected in any evaluation.

Catch information

Recreational fishermen, despite being encouraged to do so, rarely help themselves to understand the problems associated with their sport/leisure activity. They fail to monitor their catches so they have no baseline data against which to argue for a decline or change in quality of the fishing. Consequently, there is an absence of sound catch information to elucidate the impact of major water resource development schemes. Perhaps the exception to this are statutory returns under licence as is required for migratory salmonids in the UK (e.g. Bunt, 1991; Churchward and Hickley, 1991). The benefit of these catch returns was clearly shown in the Wimbleball Reservoir Pump Storage scheme (Sambrook and Cowx, 2000).

Conservation status of the fisheries

Fisheries generally attract little attention from the conservation perspective because the fish are rarely seen. Perhaps the exception to this is the salmon that has been used successfully to promote fishery rehabilitation schemes in degraded rivers, e.g. the River Thames.

Traditional management

Recreational and commercial freshwater fisheries have been traditional managed in isolation from plan other aquatic resource users. Management initiatives have often been based on interpreting information on the fish stocks and reacting to shifts in availability or quality of exploitation (Cowx 1996a, 1998b). Thus, when subjected to a diverse range of impacts there is generally a loss of amenity because the value of the fisheries is ill-defined and not considered a high priority in any consultation process. This is born out by the paucity of information on the economic value of such fisheries (e.g. Radford 1984; Whelan and Whelan, 1986; Anon, 1989), although is now being addressed throughout the developed world. Notwithstanding, even where economic value of the resource has been determined it can be inaccurate because it is based on the wrong criteria. For example, in the recent Axford enquiry into water resource development on the River Kennet in southern England, the value of the fishery was considered to be under-estimated by an order of magnitude because it was based on transference of costs of fishing on reservoirs (K.T. O'Grady, personnel communication).

Awareness of anglers and developer / planners

Conflict between user groups will remain a problem as demand for water, disposal of effluents and provision of leisure amenities continues to increase. This is primarily because each sub-sector fails to recognise the impacts of their activities on other users.

Management of recreational fisheries in multiple resource user situations

Recreational fisheries represent an extremely important commodity that is under threat from many sources. To overcome the problems there are a number of tactics that can be employed to support fishery interests.

First there is a need to recognise the role of fisheries in a wider multiple resource user environment (Fig. 1). It is naive to believe that fisheries issues will stem development, thus fisheries must be integrated into an overall framework for the optimal use of the aquatic resource base.

Second, an evaluation of the current and future conflicts, both real and perceived, between fisheries and other user groups is needed. This can most easily be achieved using matrix analyses such as those used in environmental impact assessments (Cowx, 1998b). Two types of matrices can be developed. The first looks at direct impact between the user groups and the magnitude of the conflict can be subjectively assessed based on expert opinion. This will identify the users who are creating the greatest impact or conflict. It is these uses that will require the greatest focus in any conflict resolution.

The second matrix defines the impact of each activity on various aspects of the fishery *per se*. A subjective assessment can again be used, but if scientific data are available they should support the evaluation. This approach is akin to a scopeing study for an environmental impact assessment and identifies the key issues to be addressed. It may also show where mitigating action is required to conserve the fisheries.

Third, it is essential to provide an economic assessment of the fishery. There are various direct (financial and cost benefit analysis; e.g. Kennedy and Crozier, 1997) and indirect (travel cost method, hedonic pricing and contingency valuation analysis; e.g. Baker and Pierce 1996; Postle and Moore) methods of undertaking this appraisal which should be implemented. However, it should be recognised that the output may fall well short of the true value because the methods used are often fisheries specific and do not consider the upstream of economic value in terms of aesthetic and conservation value or the downstream value associated with the service sectors.

Once this information is available, value is a useful tool for arguing the case of fisheries. However, it must be recognised that it is not the only tool to be used because the economic benefit of a major water resource scheme will far out weigh the fisheries value.

Harmonization of the various users groups requires careful orchestration. This can be best achieved through an integrated planning and management strategy whereby all the stakeholders are involved in the decision making process. The objective of the this strategy must be to promote the sustainable use of the water body to yield the greatest benefit to the present population whilst maintaining the potential of the water body to meet the needs and aspirations of future generations, in a manner compatible with the maintenance of the natural properties of the water body and their value for wildlife. That is, it should be akin to the FAO code of Conduct for Responsible Fisheries, which targets sustainable development (FAO 1995).

The approach must be interactive, allowing wider issues than those related to a single activity, in this case recreational fisheries, to be taken into account during the decision making process. It should also evaluate the likely effect of a particular development activity upon the environment and other activities. In this process fisheries should be well represented and armed with all the appropriate information to quantify potential impact.

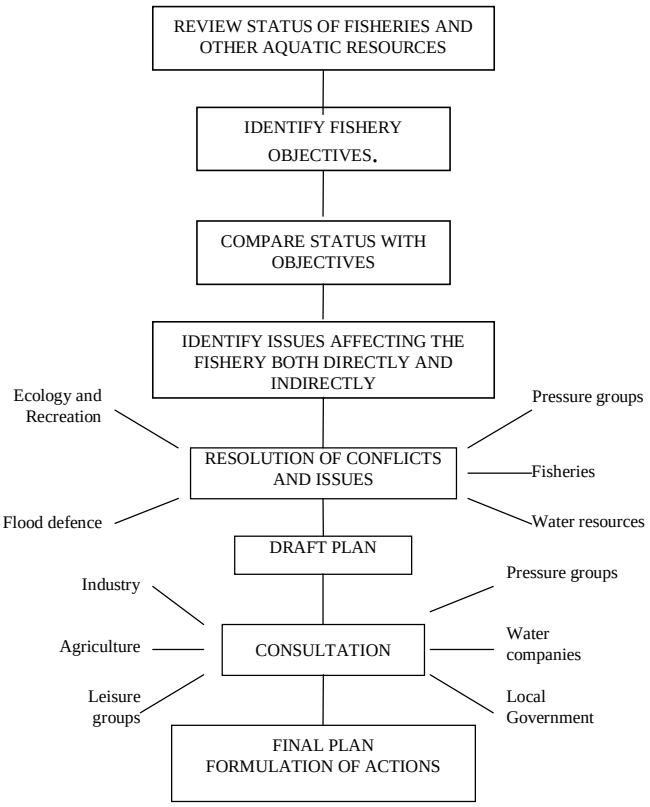

Figure 2. Process of formulating and implementing aquatic resource management plans

In view of the high degree of inter-dependence between activities, in developing the management plan it is necessary to explore the wide range of uses and issues (problems and conflicts with and between user groups) within the system itself (Fig. 1). The first step in the process from a fisheries perspective, however, is identification of the objectives of the fishery sector or recreational fishery sub-sector within the region or nationally. It is pointless trying to argue the position of fisheries if the objectives have not been clearly set. This intrinsically moves the existing approach to recreational fishing from being issue driven towards emphasis on forward planning.

Once the objectives have been established it is necessary to determine the current status of the fishery. Traditional fishery evaluation methods can be applied but equal attention should focus on the socio-economic aspects. In reviewing the aquatic system as whole the current status of the fishery should be compared to the objectives. This will make it possible to identify the issues and conflicts between user groups using the matrix methods described earlier and through local consultation. From this it will be possible to identify development options and future projects. During this phase it is essential that the boundaries of the resource area in question are well defined. Simple delimitation into catchments or zones of a river is not necessarily adequate. In many situations activities taking place up or downstream, or in adjacent catchments may have an influence on the man-

agement zone in question. Consequently, the plans should be formulated on local issues but take a wider perspective at the catchment and regional/national level. This analysis can be used to attempt to resolve the problems by aggregating the relevant aspects into a multi-functional and multi-use plan (Fig. 2).

Options to overcome the shortfalls are generated and presented in the draft management plan. It is critical that issues relating to existing and potential user groups are identified otherwise conflicts between user groups cannot be resolved in a satisfactory manner. The requirements of each user-group, in terms of demand on the aquatic resources and standards for water quality, must be addressed at this stage. To assist in the resolution of conflicts it will be necessary to identify an independent consultant or trust to chair the discussion. However, overall management of the resources should be devolved to the user groups, provided that each user is fairly represented in the management group.

Once the management plan has been formulated, and adequate consultation has been made with Government departments, institutions, user-groups, industry and the public, it will be possible to draw up action plans for the future development of the resources (Fig. 3). When considering formulation of the action plans it is critical that the goals set are achievable, the costs of the action and who pays are identified, and finally the action represents value for money or has considerable non-tangible benefit. This can only be done if clear agreement over the issues is made between the various user groups. Clear priorities for the main problems and conflicts should emerge, with a statement of the consequences of the proposed actions. At this point the conflicts between user-groups can be resolved, and a compromise be drawn up which will have the minimum impact for all concerned. Persuading those responsible for action and arriving at the proper key issues is more likely to be successful using the aquatic resource management planning methodology than a purely prescriptive one, since it focuses upon all of the relevant points and on what can be justified and implemented.

Once the potential development projects have been formulated it will be necessary to implement the proposals. This may prove to be another source of conflict because there is a clear need to establish who is willing to pay for the development, and at what cost. Often a development proposal will have some impacts, which should have been identified by this juncture. Those gaining from the development should pay mitigation and rehabilitation costs to minimise and impact. If necessary the mitigation costs can be internalised and transferred to the end user. For example, it has been proposed that the tourist industry pay for the mitigation costs of the Alqueva Reservoir in southern Portugal as it is the chief beneficiary (Cowx and Collares-Pereira 2000). This mechanism creates a way for recovering the full costs of any damage created. The difficulty is valuing the damage, but this should be overcome by sound economic analysis early in the planning phase.

The aquatic resource management planning strategy offers a harmonized approach to sustainable development, an objective that is crucial in the face of ever-increasing demands on resources. Without such an approach, which involves all the stakeholders, and where the true value of the fisheries can be integrated into the overall management of the water resources, it is likely recreational fisheries will be lost in the face in the race for development of water resources.

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Questions and Discussion

Jim Lyons: At the organisation level recreational fisheries are poorly represented.

Ian Cowx: Bigger federations are possible but these can't always stop the development. If the recreational fishers work together then they might be able to halt development, or work with development, or even make development work for them. But for optimal management, you need a planning process. In Asia and Africa they use various methods, and there is one coming up in Europe.

Gordon Gislason: I assume those individuals representing the House of Lords had property rights and they were acting as a cohesive group.

Ian Cowx: They were in a powerful position, but they could have been over-ridden if the demand for water was there. My key point is they were able to have both, both the water scheme and the fish. Through educating the engineers they were able to change the flow regimes.

Gordon Gislason: If it would have gone through as planned, would they have received compensation?

Ian Cowx: There was no compensation at all; in fact there was only one pool where they could have sought compensation, but overall the project did not obstruct the river. Rather, it was completed on a diversion so it did not impact on the river directly.

Maintaining quality in recreational fisheries: how success breeds failure in the management of open-access sport fisheries

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Abstract

Where recreational fisheries are open to public access, there is a basic pathology in which success breeds failure: development of a quality fishing situation leads to increased fishing effort until quality is reduced to be no better than other situations with comparable costs and difficulties of access. Impacts of increased fishing effort on angling quality can be greatly exaggerated by fish behaviours that limit the proportion of total stock vulnerable to capture at any moment. In open access fisheries, managers mainly react to the quality deterioration problem by trying to produce more fish and by using simple regulations such as bag and size limits; these tactics have never worked and as a result, high quality fishing is found only where fishing effort is severely restricted. There are three situations where high quality/ low fishing effort occurs : (1) high cost/time required to access the fishery (e.g., very remote lakes and ocean coastal areas far from major tourist routes); (2) control of access by private or local interests, such as guiding camps, fishing clubs, and lakeshore owners; or (3) some equitable strategy of limited access via a lottery system, as has been used routinely in big game management for decades. It is time to start facing the harsh reality of too many people wanting to catch too few fish. Hopefully, we will see a spread of lottery access systems rather than privatisation of access rights in North America; a key scientific challenge will be to recommend wise access rates.

Introduction

Most sport fisheries in North America remain open to public access, without effort or license limitation. In such situations, fishery managers need to contend with two potentially conflicting dynamics: response of fish populations to fishing and enhancement (production), and response of fishers to changes in the abundance of fish (consumption). Fisheries science has mainly concentrated on the "production-side" of this dynamic relationship, with a tacit assumption that the "consumption-side" will somehow take care of itself. Consumption-side dynamics are usually ignored because we assume that recreational fishers are not efficient (or persistent) enough to generate severe production impacts (biological over fishing), at least in part because we expect them to give up before depleting most stocks to biologically dangerous levels.

Management activities aimed at sustaining quality of recreational fishing are usually targeted on production-side measures such as habitat enhancement, stocking, and regulation of per-angler impacts via season, bag, and size limits. In management planning we rarely account for the potential impacts of these measures on the dynamics of fishing effort (i.e., consumption-side) and the subsequent impact of effort responses on angling quality and harvest. In the fisheries literature, this myopia leads to some peculiar arguments. For example, (Shaner et al., 1996) complained that it was impossible to define an optimum stocking rate for channel catfish (*Ictalurus punctatus*) because harvest increased linearly with stocking rate. Their results showed quite strongly that increasing stocking rates just led to more effort without an improvement in quality of fishing as measured by catch per effort.

The central argument of this paper is that production-side management in open access settings will almost inevitably lead to increased fishing effort but not to increased quality of fishing as perceived by the "average" angler. While angling "quality" obviously has many dimensions, we suspect that most anglers would agree that it really means "lots of big fish" (i.e., high catch per effort of the largest possible fish). Not all anglers are equally concerned about these attributes, but it is clear from sociological studies that catch-related motives are the most important determinants of angling quality (Holland and Ditton, 1992). Further, diversity of angling opportunity is also a key quality measure, as noted eloquently by a University of Wisconsin limnologist at the end of a day spent harassing 5cm. bluegills: "sometimes you need to give your wrist a rest from cranking in those lunkers". In the discussion below, it does not really matter whether quality is defined and recognized by anglers in terms of catch per effort, fish size, or diversity: we contend that provided there is freedom of movement via open access, anglers will concentrate wherever they see higher quality, until they no longer see it. We suggest that effort dynamics are particularly important considering that in most populations, relatively few fish are behaviourally reactive or accessible to

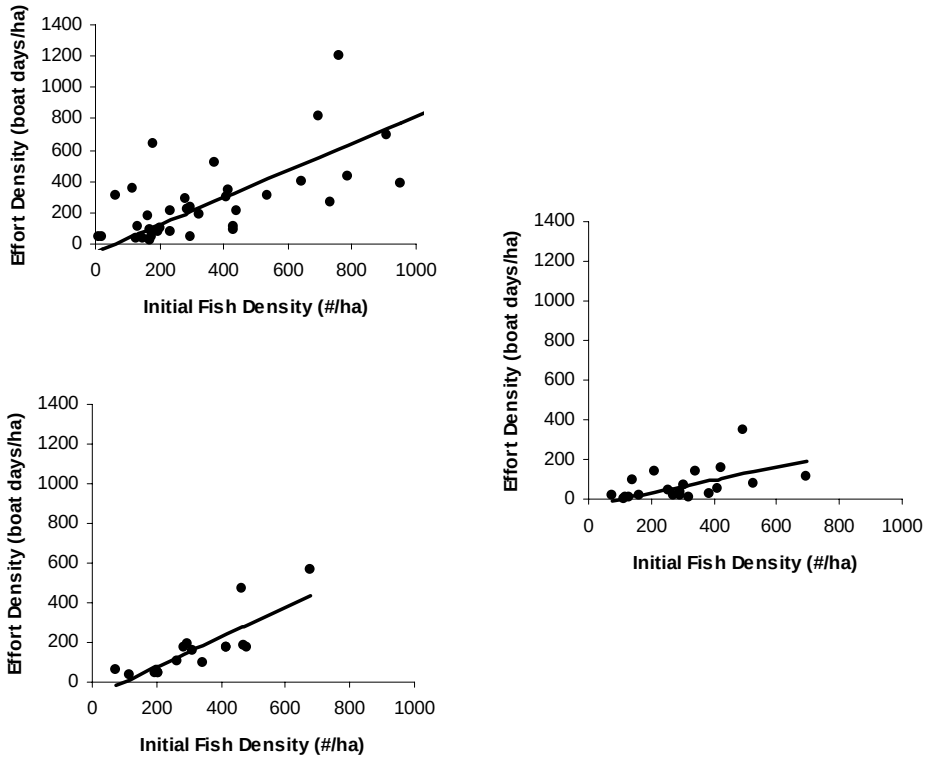

Figure 1. Predicted (solid line) and observed (solid circles) fishing effort on British Columbia rainbow trout lakes for three management regions.

fishing gear at any moment, so that anglers "see" and compete for much smaller numbers of fish than we measure in biological sampling.

If we are correct in asserting that management aimed at improving angling quality must take as careful account of consumption-side (fishing effort) dynamics as production-side dynamics, then recreational fisheries managers will have to start thinking much harder about how to directly, fairly, and effectively limit fishing effort for those places where quality of fishing is a high priority. There has been bitter opposition to effort limitation programs in North America. Should this opposition continue to dominate in management planning, what we will very likely see is continued erosion in quality of fishing combined with gradual privatisation of fishing opportunities. While myopic anglers clamour for their "rights" to fish and for more production to keep up with demand, the smart money will move to acquire exclusive fishing rights of various sorts, from control of access via riparian land purchases to development of resort opportunities in inaccessible places.

Abundance-effort relationships and depression of catch rates

Generally our empirical experience in recreational fisheries is that fishing effort is roughly proportional to abundance as measured by indices like stocking rates (Fig. 1; Moring, 1993; Fraley, 1996; Shaner et al., 1996). Generally we do not see clear relationships between abundance and catch per effort except across regional gradients of accessibility (lower effort, higher catch rates, and sometimes higher abundance in less accessible places). In this section, we argue that quality of fishing is more sensitive to effort than often supposed due to (1) competition among anglers for a limited stock of vulnerable fish; (2) production limitation mechanisms like density-dependence in growth/survival rates that limit numbers of quality fish; and (3) cumulative impacts of fishing pressure that also limit numbers of quality size fish.

At any particular time in a recreational fishery (or any other for that matter), not all fish are expected to be available to the fishing gear for various reasons. Some fish will be within the effective depth range of the gear and will react to it (a "vulnerable" state) while others are simply not behaviourally reactive or else remain in sites/habitats where angling gear cannot reach (an "invulnerable" state). Exchange between these two states likely occurs on a variety of time scales due to a variety of processes, ranging from hours-days for diurnal movements and feeding rhythms to weeks-months for recovery from previous hooking (i.e., catch and release). Fish exchanging between vulnerable and invulnerable states results in a vulnerable "stock" seen by anglers that is generally much smaller than the stock seen by biological sampling (Fig. 2).

Exchange of individuals between vulnerability states, and removals by fishing (including fish released but not immediately vulnerable) imply a strong inverse relationship between density of

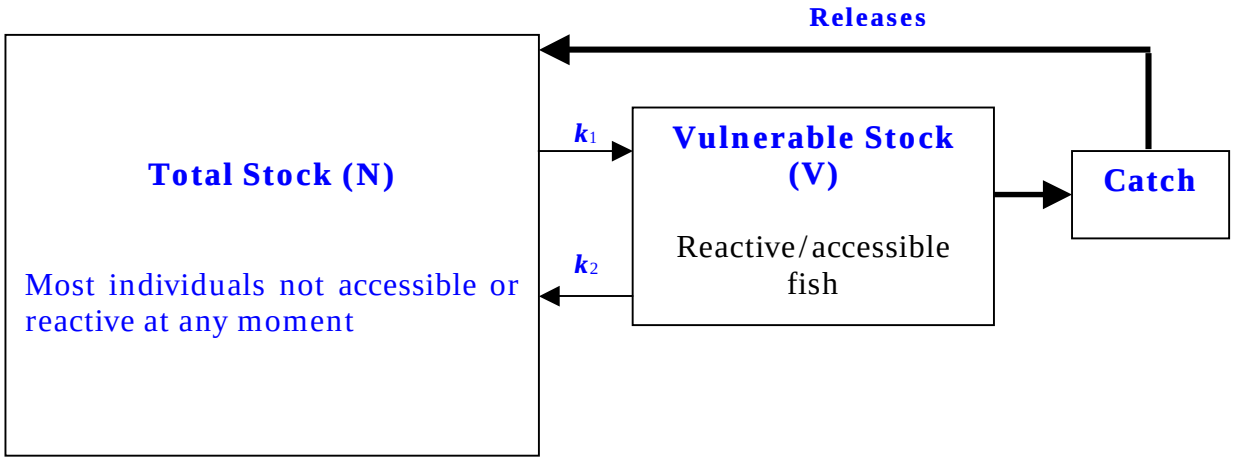

Figure 2. Schematic representation of dynamics for a typical recreational fishery. The total stock, *N*, is the abundance measured by most agency field surveys. The vulnerable stock, *V*, is the abundance detected by anglers. Exchange rates between the two stocks are given by k_1 and k_2.

vulnerable fish and fishing effort. If exchange between behavioural states is rapid compared to removal and addition of fish by population dynamics processes (recruitment, mortality, growth), a simple "variable speed splitting" (Walters and Korman 1999; Walters and Bonfil, 1999) model can be used to predict the form of the relationship between effort and abundance of available fish. Suppose the total number of fish potentially available is N, and that V of these are vulnerable (accessible and reactive to gear) at any moment. Suppose further that fish enter the vulnerable pool at rate $k_1(N-V)$, and leave this pool at rates k_2V (movement into invulnerable state) and qEV (catch, where q = catchability and E = fishing effort). If we then write a rate equation for V ($dV/dt=k_1(N-V)-k_2V-qEV$) and set the rate equal to zero to represent rapid equilibration of the "instantaneous" number of fish actually available to anglers, it is easy to see that "fast" exchange compared to depletion (high k_1, k_2 exchange coefficients compared to mortality rate for N as a whole) will result in V behaving as

$$V = k_1N/(k_1+k_2+qE) \quad (1)$$

This model implies that catch per effort (qV) will decline sharply with increasing effort E (Fig. 3) even if the fishery has no impact on N.

Equation (1) has an important implication for prediction of how fishing effort will be distributed over a collection of fishing sites (e.g. lakes, stream reaches) that have similar access characteristics (travel time from population centres, etc.). If site i has catch rate q_iV_i, we expect anglers to "detect" (by direct experience and word of mouth) differences among sites and move about so that every site ends up displaying the same average fishing quality or catch rate, c_o. That is, we expect $q_iV_i = c_o$ for every site on average (an "ideal free distribution" prediction). Substituting this expectation into equation (1) and solving for effort E_i on site i, we predict that effort will vary over sites as:

$$E_i = k_1N_i/c_o - (k_1+k_2)/q_i \quad (2)$$

That is, we expect efforts E_i to vary linearly among sites with variation in total abundance N_i, provided catchabilities (q_i) are not too variable among sites. We expect lower effort E_i in any site when the regional average catch rate c_o is high (or conversely, that high regional average catch rate will occur only when efforts E_i are low in general, due to factors like high access cost).

Equations (1) and (2) represent "instantaneous" predictions of vulnerable abundance, catch rate, and effort density. They can be integrated over time, with suitable assumptions about changes in regional "background" catch rate c_o, so as to predict annual total catches, efforts, and impact of fishing on particular sites. The equation for total catch is similar to standard fisheries "catch equations", as used for example by (Engstrom-Heg, 1986), while the equation for total effort is complex and has to be solved numerically unless c_o is constant over time (unlikely). For reasonable catchability, exchange, and c_o patterns, we usually find the predicted total effort to be roughly proportional to initial abundance (N_i at start of fishing season).

A simple test of the basic assumption that effort tends to move about so as to level catch rates among sites (at rate c_o in eq. 2) is to plot total catch and total effort against an independent index of total abundance (N) or stocking rate, for a set of sites with strongly contrasting abundance. If both catch and effort are on average proportional to abundance (straight line pattern with near zero intercept), then catch per effort must on average be independent of abundance (if catch = aN and effort = bN, catch/effort = a/b) and we can conclude that fishers have "succeeded" at detecting and eliminating any really outstanding fishing opportunities. In such plots we expect to see considerable unexplained variation, due to site factors such as access (higher catch per efforts for relatively inaccessible sites), catchability, and behaviour/site differences in morphometry leading to variation among sites in k_1 and k_2. But if proportionality is observed as an average response despite variability among sites, then the central conclusion would be that increasing abundance is not a way to insure increasing quality of fishing, at least as measured by catch per effort.

One might argue that equation (2) ignores potential limits on regional fishing effort due to the size of the angler population available to generate effort and to limits on how much time each angler can potentially spend fishing. This is certainly a valid argument for "regions" that are very inaccessible or costly to access (e.g. fly-in lakes, remote northern areas), but it is deeply incorrect for most angling situations, which are now within a few hours drive from at least one major urban centre. In these situations, if we keep producing more fish, we will keep attracting more effort. For example, hundreds of B.C. trout lakes within a few hours drive of Vancouver are mainly sustained through annual stocking of fingerling/yearling trout or natural reproduction; in these lakes we would consider a "high" effort level to be 80 angler days/ha/year. In the Sierra Nevada mountains of California where there are also many lakes, at considerably greater travel distances from urban centres like Los Angeles and San Francisco, some lakes are stocked weekly or even bi-weekly with catchable trout. During the early 1960's, when the senior author worked as a creel census clerk in California, such lakes commonly received as much effort *per day* as we currently see *per year* in B.C. lakes. These effort differences are orders of magnitude larger than we would expect on the basis of differences in angler population size or number of lakes available for fishing.

Another objection to models like equation (2) might be that individual anglers are not necessarily good at detecting and responding to variation in fishing opportunity. Certainly we do see some people who just keep going to the same places at the same times, year after year, apparently not the least concerned about quality of fishing. But in our experience, a key thing that distinguishes really good anglers (and these are the individuals with the most influence on catch rate and fish available to other anglers) is that they constantly test new methods and sites, while listening carefully to various information sources for hints about good fishing spots. Information sources for anglers are very well developed in most regions (indeed, providing fishing information is a significant business—newspapers, magazines, tackle shops), and may improve still further through channels like the Internet. In short, it is just silly to hope that anglers will fail to notice new quality fishing opportunities that managers might create.

Catch/release fishing does not prevent an inverse relationship between vulnerable fish density and fishing effort as predicted by equation (1) even where total abundance remains high. Released fish undoubtedly suffer a certain amount of "handling trauma" after being caught and released by anglers. There is also growing evidence to suggest that for some length of time after being released, they may behave differently from other fish that have either, never been caught, or have been caught and released in the distant past (Lewynsky and Bjornn, 1987). Depending upon the length of time to full recovery from capture (up to 3-4 weeks in some studies), equation (1) will still predict an inverse relationship between effort and catch per effort because released fish do not remain in the vulnerable state. These direct effects of angling pressure on catch rates are particularly evident in recreational fisheries that have closed seasons; catch rates are typically very high for a short period after opening (short enough to have little impact on N) and decline dramatically thereafter (Champeau and Denson, 1987). Further, catch/release fishing does not end all fishing-related mortality and incidental impacts of fishing activity (Barnhart and Roelofs, 1987; Fraley, 1996; Brett ,1996).

Effects of fishing effort on catch rates can be particularly strong in situations where the vulnerable fish "pool" V is defined only in terms of larger, older "quality" fish (Brett, 1996). In such cases, there are severe limits on the potential total number (N) of quality fish that can be produced by aquatic environments, for at least two reasons.

First, the rearing environment must support and grow many small fish for every quality one that is ultimately produced. In places lacking natural reproduction, low stocking rates may be necessary to insure good growth and survival to large sizes, and reduction in stocking rates causes a direct reduction in V. Second, in most sport fisheries there is considerable "incidental" and cumulative impact on small fish by anglers attempting to catch the larger ones. Even a low annual mortality rate on smaller fish can have a very large cumulative impact on the number of fish reaching quality sizes, especially if these smaller fish are subject to the annual rate for several years before reaching quality size.

The bottom line of this section is quite simple: success at producing more vulnerable fish (increasing V in equation 1, by producing higher N) is no guarantee of producing higher quality of fishing as measured by catch rate or fish size. Rather, in open access situations we expect anglers to detect unusually good fishing opportunities and to respond by adding and redistributing effort (E_i in equation 2) so as to "flatten" the quality of fishing across sites or opportunities. This flattening can only be prevented by somehow preventing the "ideal free distribution" process of fishing effort redistribution (i.e., by directly limiting fishing effort for at least some angling sites). This admonition is particularly important for situations where large fish size is considered a key element of quality, since there are severe ecological limits on the total number of large fish that can be produced.

Conflicting stakeholder interests and management paralysis

Most management jurisdictions can reasonably claim to provide a diversity of opportunities in terms of fishing quality. But in most cases, the quality opportunities are created mainly by high access costs and/or direct access limitation by private landowners, so that high quality opportunities are used mainly by fishers willing to spend more time and money. A key option for management is to create more opportunities for quality fishing at relatively low access cost (for less wealthy anglers), by directly limiting fishing effort on some sites using a lottery process that gives every angler a "fair" chance at these opportunities. But in our experience, managers have been loath to adopt this approach because of the bitter opposition they see whenever it is suggested. Here we point out that this opposition reflects real and fundamental conflicts of interest among angling stakeholders, and these conflicts almost inevitably result in management paralysis (inaction).

One of the surest ways to elicit screams of outrage from anglers at public meetings or talks to angling groups is simply to mention the idea of "limited entry" fishing (most North American anglers recognize this terminology because of its widespread use in big game harvest management). In roughly increasing order of sophistication, the arguments go something like this:

(1) Fish are not like large mammals - there are millions of fish;
(2) I have a fundamental right to go fishing wherever I want, in public waters;
(3) If there are not enough fish, it is your job to produce more;
(4) Anglers are not responsible for low catch rates, it is the [substitute your favourite from the following list: commercial fishers, habitat damage by loggers, natives, poachers, biologists with nets, loons, seals, pollutants, El Niño];
(5) The good old days are gone forever and there are just too many people now.

Probably the most pervasive and difficult for fisheries managers to deal with is argument (2); there really is no answer to an angler who either denies that there is a quality problem in the first place or else denies that public agencies have any right to deal with it even if it does exist. Argument (3) is one that biologists have obviously responded to far too often in the past. Arguments of type (4) serve mainly to waste time and deflect attention from the real quality management issues, and it is our impression that most of the people who bring them forth are very well aware of this. In our experience, "fatalistic" arguments (5) come mainly from the very best anglers, who in fact are feeling relatively little personal impact from competition and are most likely to have benefited considerably from (made the best use of) recent improvements in sport fishing technology.

Experience with limited entry hunting, and a very few tests of limited entry fishing (e.g., Atlantic salmon on the St. John River, New Brunswick), indicate that opposition by anglers dies away very quickly if quality benefits become evident. But that is little comfort to the fishery manager who must deal with the initial opposition, particularly if it is in a small community setting where the most outraged anglers are liable to be the manager's neighbours.

There are also conflicting interests and viewpoints among the economic stakeholders who depend on recreational fishing (tackle shops, lodges, guides, etc.). In particular, one type of business is best

served by policies that maximize total fishing effort (tackle shops, boat sales and service) without regard for whether anglers are satisfied by the quality of fishing (so long as they keep spending money). Still other businesses (some lodges, guides) are best served by insuring that regional fishing quality is low enough to drive enough anglers to pay for the special opportunities that these businesses provide. Still others would be very well served by local effort limitation; for example, some lodges in British Columbia are located on trout lakes with public access, and their effective operating seasons (ability to attract late summer guests) can be severely curtailed by early season impacts of non-lodge anglers on abundance.

Hence, fishery managers are typically hit from all sides when they suggest effort limitation. Support for limitation comes mainly from a relatively small community of thoughtful anglers (who have carefully considered how much time and effort they are already having to waste to access good fishing, and would prefer to have fewer but better fishing trips under a lottery system), and from a small subset of economic stakeholders (mainly lodge owners, some guides).

The easiest and most common way for managers to react to these conflicts is to adopt a "minimum whinge" approach, which basically involves taking no more action than is needed to quiet the most vocal stakeholders. This leads to a "fire-fighting" mentality (take decisive action only where/when complaints are loudest), to "shifting baselines" over time (Pauly 1996) where progressively poorer overall quality of fishing is accepted provided stakeholders do not notice it, and to emphasis on less controversial measures like production-side enhancement and stocking programs. Some fishery managers may simply be so incompetent as to not recognize potential benefits from direct effort limitation, but we suspect that most are well aware of this option and have made calculated decisions that it is just not worth the trouble.

Alternative paths to effort limitation

Access and effort limitation is in fact happening across North America, but not as a planned and deliberate management strategy. While myopic anglers and economic stakeholders compete for too few fish while bickering about their "rights" and demanding more fish production, the smart money is finding various ways to acquire access rights and prevent general public access to good fishing sites. These ways range from purchase of

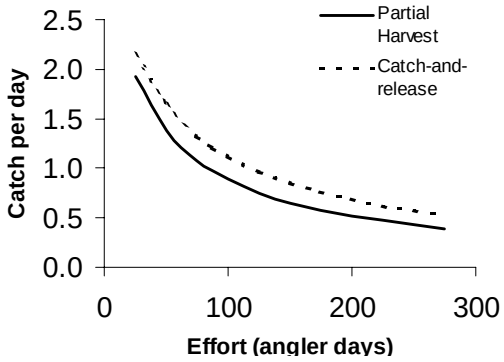

Figure 3. Predicted relationship between fishing effort and catch per effort for fixed population size. Curves are shown for a.) partial harvest fishery with a 50% retention rate and b.) catch-and–release fishery with zero retention.

stream bank properties to acquisition of fishing rights on large private properties to development of cheap and efficient schemes for accessing remote regions.

If this trend continues, it will not be long before some parts of North America look much like Austria, where most of the good fishing waters are tightly controlled (and generally very well managed) by relatively exclusive fishing clubs and private interests. The trend may be limited in western North America by the presence of large public land areas (e.g. National Forests and parks), but many of these areas are extremely inaccessible and there are considerable areas of private riparian land embedded in the public holdings as a legacy from the early days of settlement (river bottom and lakeside properties were prized by ranchers and other early settlers). Further, as in Austria we will likely see growth in angling clubs as "corporate buyers" of land, to make access acquisition and limitation more affordable for groups of anglers with moderate incomes.

So North American fishery managers have two basic choices. They can sit back and watch both the quality of fishing and access to public waters decline, or they can begin taking active steps to limit effort in enough places to make it not worthwhile for wealthier anglers to bother with the expense of excluding the competition entirely. It is not clear yet whether the active approach is really worth the trouble that it will bring to those managers who first attempt it, especially considering how easy it is to argue that myopic anglers deserve what they will get, and should be allowed to have it.

Should the idea begin to gain popularity of providing at least some fishing locations where effort is severely limited, a critical policy issue will be

how many of such locations to provide. Limiting access to all locations could severely impact businesses that depend on maintaining high total angling effort (tackle shops, boat sales and service), even if the majority of anglers come to prefer far fewer but much better fishing days each. For typical B.C. trout lakes, we estimate that effort reduction of roughly 90% would be needed to substantially improve catch per unit effort (see Fig. 3). Such a drastic reduction in fishing opportunity would not likely be acceptable (or economically wise) for more than a small percentage of lakes. A further complication in B.C. is whether to deliberately target lakes with both fishing lodges and public access as sites for effort limitation, with the dual objective of improving angling quality and protecting the economic interests of lodge owners.

Further, we do not understand the dynamics of angling effort well enough to confidently predict whether or not limiting effort for a large number of locations would cause anglers to redistribute their activity onto the remaining locations, intensifying quality impacts in those locations. That is, would anglers still spend as much time fishing if they were even more crowded into fewer open access locations? Would they redistribute their activity differentially into less accessible locations where fishing quality is presently higher, so as to differentially impact those locations?

So there is severe uncertainty about both the optimum socio-economic mix of open access versus limited entry locations, and about possible large-scale side effects of effort limitation on remaining open access areas. Considering these uncertainties, the best management approach may be to gradually increase the number of limited-access locations while monitoring regional impact on angling quality and quantity. Such an adaptive management approach could be viewed as a "titration experiment" (J. Kitchell, U. Wisconsin, pers. comm.), where limited entry locations are added over time until some desirable balance or endpoint is detected. Along the way, we would learn a great deal about the dynamics of fish vulnerability and about how anglers respond to changes in quality fishing opportunities.

Acknowledgements

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Questions and Discussion

Bill Romberg: In terms of using different regulations, why do you have such a small number of fish?

Sean Cox: Whether you have a two fish limit or a 6 fish limit, it has to do with limiting access and managing for quality. There are 2 catch-release lakes. Mainly, the management of the lakes depends on access and habits of the fishers.

Bill Romberg: When political perceptions are the reality, how do you deal with the public trust doctrine which in the United States, usually takes precedence in fishing privatization battles?

Carl Walters: The legal authority in North America exists for access limitations, it has been established in big game hunting. There is no legal problem, the critical step is the change in perceptions and demonstration projects that can show anglers the benefits of effort control. In St. John's (New Brunswick), when the salmon came in to spawn, everybody was out on the river until the DFO instituted some lottery system, stating that 15 boats can go out at a time and they all placed their names in a hat. The initial outrage was overcome. After days they loved it, as they would rather have 2 days of good fishing than 30 days of bad fishing. With high demand technology and the internet , we can

deal with large scale lottery systems, if there are no formal institutional battles.

Bill Otway: Whose definition of quality are you talking about? We need to manage for various types of definitions. Are you advocating closing all lakes?

Carl Walters: No! I'm suggesting that we set up some demonstration lakes. A good manager should try to provide diversity of opportunity, not quality. When you go to get quality fishing, you either pay in money, or you pay in hours travelled. The average angler without excessive money doesn't have a great choice in where they fish: we want to make this situation better by giving them a choice. Direct access limitation would just be one tool amongst many.

Nick Baccante: If one considers quality support and managing fish directly, in open access, space is limited and then when its privatised it becomes political. What about certain groups?

Carl Walters: This is one way where every citizen has a chance in the lottery. Everyone has the basic right to fish – we're not taking that away.

Nick Baccante: But how does one deal with "trophy" fishing as compared to those fisheries which focus on maximizing fish caught?

Carl Walters: If you set a quality objective and stocking rate, fishing effort will respond. The attempt to improve quality is thwarted by not recognising the effort side of the situation. This is not about conservation or ecology: this is about fish behaviour, and the way the fish are behaving, only a small portion of the population is accessible to the recreational angler.

Nick Baccante: When you say production, do you mean natural or hatchery quality?

Carl Walters: I'm not going to get into the hatchery versus natural production issue. Our problem is not the preferences of anglers. We must provide for opportunity; thus, if it's hatchery produced it's okay.

Chuck Hollingworth: I grew up in Quebec, where there are 20,000 lakes. What is the cost of enforcement and poaching on such large systems?

Carl Walters: We want to reduce cost and you don't need to implement the lottery system in inaccessible lakes anyway. To enforce it, you can use people with a strong interest in maintaining the integrity of the system; lodge owners, for instance. You can also use video monitoring. In addition, the guy who pays, and now has less fishing opportunities by using the lottery system, won't let someone else get away with poaching on the fish that he's waited to access.

Murray MacDonald: I presume your proposal for recreational fishing effort limitation is based on experiences with salmonid fisheries, primarily inland waters. Can you comment on the applicability of your model to marine and estuarine recreational fisheries, where angler access may be more difficult to control and where availability of target fish stocks may be less amenable to manipulation through artificial production processes?

Carl Walters: The same principles apply in both fresh and salt waters, including in Victoria (Australia). A good example is the recreational whiting fisheries in Victoria's bays and inlets where there is sea-grass. Only a portion of the total whiting population (mainly juveniles) is accessible in bays and inlets, and I believe that under these circumstances increased fishing effort depresses catch. We need to think about limiting the effort which is having an impact on other units of effort. This is not about biology or over-fishing, this is about the direct effects of fishing effort on catch rates and catches. In this respect I think Victoria has some of the world's worst sport-fishing.

An economic model of recreational and commercial fishers

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Abstract

In most cases recreational fishers compete with their commercial counterparts for a limited amount of fishery resources. In such a competitive setting, a regulator is faced with the question of how best to accommodate the preferences of the two class of users: What is the optimal allocation of the resource to the two groups that meets the stated objectives of the fishery? What are the likely outcomes in terms of economic, social and environmental concerns if regulation were to fail? This paper presents a modelling framework with the potential to address these and other relevant questions.

Introduction

It is increasingly being recognized that marine recreational fisheries are significant in many countries in terms of the number of people participating in them, the total catch they take, and their economic and social impacts (Kirkegaard and Gartside, 1998). This implies that in most cases recreational fisheries compete with commercial ones in the use of the resource, and the provision of economic and social benefits. In this paper, we present a modelling framework with the potential to help us predict possible biological, social and economic outcomes in a well-managed and regulated fishery with commercial and recreational participants. The results obtained under this scenario are then contrasted with those obtained under the assumption that management and control in the fishery are weak or non-existent.

Generally, the management goal of a fishery can be categorized into the following three groups. First, there is a biological goal of conservation of the resource. Second, there are equity and distributional concerns of who catches how much of the available resource. Third, there is the objective that seeks to optimize economic utilization of the resource. It is not difficult to see that in most situations these three goals conflict with each other. It is therefore important to have a framework that can handle the inherent trade-offs between these goals, and come out with an overall best outcome. This is what we seek to do in this paper. We therefore propose in this paper to develop a model for the determination of the desirable allocation of a given fishery resource between recreational and commercial users, taking into account the stated management objectives of the fishery. The proposed model can be used to: (i) determine the effects of exploitation by commercial and recreational users on the sustainability of the fishery resource; (ii) isolate the benefits to each participant individually and collectively; (iii) identify resource cum socio-economic outcomes that may support joint rather than separate management.

The next section presents the regulator's model. Section 3 presents a non-cooperative model to analyze the situation in which management is weak or non-existent. In section 4, a numerical example is presented. This is then followed by a brief discussion of what is needed to carry out an empirical application of the model. Finally, section 5 concludes.

The regulator's model

It is assumed that a certain body regulates the fishery, this can be a government authority, a community-based management body or sole owner of the resource. This body or regulator is assumed to be concerned with maximizing *overall* benefits from the use of the resource, without destroying the resource base. Elements of the overall benefit may include private economic benefits, social benefits, e.g., the need to preserve regional settlement, right previous wrongs, and environmental benefits not traded in the market, e.g. benefits derived from keeping the diversity of the marine habitat. The regulator faces two broad challenges. First, the optimal harvest for the two groups of users in each period must be determined to ensure that the stated objectives are met. Second, the regulator has to put in place a management plan to implement the desired harvests determined.

Let the net private benefits to the commercial and recreational users be B_c and B_r, respectively. Introduce an additional benefit function denoted by B_o to capture non-private benefits such as social and environmental benefits. The first two benefits depend, among other things, on the quantity of fish the two users harvest, H_c and H_r, respectively. Social benefits may depend in some way on the harvest taken by one of the groups, say commercial users, for social, cultural or other reasons.

And environmental benefits will depend on the amount of standing stock of fish, (N- H_c – H_r), where N is the total biomass at a given time. Alternatively, environmental benefits can be modelled to depend on the total harvest taken, that is, (H_c + H_r). Formally, we have,

$$B_c(H_c); B_r(H_r); \theta B_o(N - \theta_c H_c - \theta_r H_r)$$

or

$$\theta B_o(\theta_c H_c + \theta_r H_r) \qquad (1)$$

Where,

$$\partial B_c / \partial H_c > 0;$$
$$\partial B_r / \partial H_r > 0;$$
$$\partial B_o / \partial (N - \theta_c H_c - \theta_r H_r) > 0$$

or

$$\partial B_o / \partial (\theta_c H_c + \theta_r H_r) < 0$$

It may be argued that benefits to the users depend on variables other than just harvest, especially, with regards to recreational fisheries benefits. This may well be true, but this is probably not a bad assumption if the aim is to determine sustainable harvest levels, and the benefits that accrue to the users as a result of their harvest. In any event the model is flexible enough to accommodate other variables if deemed necessary.

Following Lopez, Shah and Altobello (1994), we define θ, θ_c and $\theta_r > 0$ to be indicator parameters to reflect the extent to which social and environmental concerns are explicitly incorporated into the decision making process. The following interpretations are given to different θ values:

$\theta = 0 \Rightarrow$ ecological and socials concern ignored

$\left.\begin{matrix}\theta > 0 \\ \theta_c = \theta_r\end{matrix}\right\} \Rightarrow$ only ecological concerns incorporated

$\left.\begin{matrix}\theta > 0 \\ \theta_c \neq \theta_r\end{matrix}\right\} \Rightarrow$ *social* and ecological concerns incorporated

In the third case above, when $\theta_c < \theta_r$ it means that society strictly prefers a unit of harvest by the commercial users than a unit of harvest by recreational fishers.

It is assumed that the regulator's problem is to maximize total net benefits B_t through the choice of $H_{c,t}$ and $H_{r,t}$ for t=1.T, where T is the last (terminal) period:

$$\max_{H_h, H_c} \sum_{t=1}^{T} [B_t] \rho_{t-1} \qquad (2)$$

subject to

$$N_{t+1} = N_t - H_{c,t} - H_{r,t}; \quad N_0 \text{ given}$$

$$B_t = B_{c,t} + B_{r,t} - \theta B_{o,t}$$

and the obvious non-negativity constraints.
where

$$\rho_{t-1} = \frac{1}{(1+r)^{t-1}}, \ \rho_0 = 1, \ t = 1, \ldots, T.$$

The parameter ρ is the discount factor, and *r* is the discount rate; N_t is the standing biomass in period *t*. Note that the above formulation assumes that the stock of fish in the previous period determines the availability of fish for current use.

The Lagrangian for this problem is:

$$L = \sum_{t=1}^{T} \rho_{t-1} \left[B_c(H_{c,t}) + B_r(H_{r,t,}) - \theta B(\theta_c H_{c,t}, \theta_r H_{r,t}) \right]$$

$$+ \sum_{t=1}^{T} \lambda_t \left[N_t - N_{t+1} - H_{c,t} - H_{r,t} \right] \qquad (3)$$

And the first order conditions for optimization are:

$$\frac{\partial L}{\partial H_{c,t}} = \rho_{t-1} \left[\partial B_{c,t} / \partial H_{c,t} - \theta \partial B_{o,t} / \partial H_{c,t} \right] - \lambda_t = 0$$

(4)

$$\frac{\partial L}{\partial H_{r,t}} = \rho_{t-1} \left[\partial B_{r,t} / \partial H_{r,t} - \theta \partial B_{o,t} / \partial H_{r,t} \right] - \lambda_t = 0$$

(5)

$$\frac{\partial L}{\partial \lambda_t} = N_t - N_{t+1} - H_{c,t} - H_{r,t} = 0$$

(6)

In the above system of equations, λ is defined as the Lagrangian multiplier or the shadow price of the resource. Equation (4) tells us that in any given period the net present value of the marginal harvest by commercial users minus the net mar-

ginal effect of their exploitation activities on environmental and social concerns must equal the shadow price of the fishery resource. A similar interpretation stems from equation (5) with respect to the harvesting activities of the recreational users. Combining the two equations, we deduce that the optimal allocation of harvest to the two groups of users must be such that the marginal net benefit to the commercial users must equal that to the recreational users. Note that equation (6) is simply a re-statement of the constraint equation in equation (2). Solving these equations for the unknown variables tells us the optimal harvest to each user and the optimal stock levels in each fishing period.

The non-cooperative game model

Once the optimal stock size and harvest are determined the remaining task of the regulator is to ensure by some means that the user's harvest precisely the optimal quantities determined by the model. Due to various reasons, it is well known that implementation is a big problem. Even if we were to succeed in specifying an accurate model for the fishery and obtain flawless data, there are still great obstacles in the way of the regulator that can block the successful implementation of the optimal harvest (see for instance, Clark 1997, Sumaila, 1998). To help us determine the consequences of implementation failure, I present a non-cooperative game model in the next section.

By a game we mean "any activity involving two or more participants, each of whom recognizes that the outcome for himself depends not only on his own actions, but also those of other participants" (Cowell, 1986, chap. 11, pp. 234). A non-cooperative game is one in which there is no "good" communication between the players in the game; no binding contracts can be entered into; and players take the actions of the others in the game as given, and then decide their own actions unilaterally. A commonly applied non-cooperative equilibrium concept in game theory is the Nash equilibrium. A formal definition of which is:

Definition: A Nash equilibrium of a strategic game $\langle I,(A_i),(\succsim_i)\rangle$ is a profile of $a^* \in A$ actions with the property that for every player $i \in Z$ we have (7)

$$(a^*_{-i}, a^*_i) \underset{\sim i}{\succsim} (a^*_{-i}, a_i)\ \forall a_i \in A_i$$

The above equation implies that for a^* to be a Nash equilibrium it must be that no player has an action yielding an outcome that he prefers to that generated when he chooses a^*_i, given that every other player chooses his equilibrium action a^*_j.

In the present context, the non-cooperative management problem facing commercial users can be stated as:

$$\max_{Hc} \sum_{t=1}^{T} \left[\rho_{c,t-1} B_{c,t}\right]$$

subject to

$$N_{t+1} = N_t - H_{c,t} - H_{h,t} \tag{8}$$

and the obvious non-negativity constraints.

Similarly, the non-cooperative management problem facing recreational users can be stated as:

$$\max_{H_r} \sum_{t=1}^{T} \left[\rho_{r,t-1} B_{r,t}\right]$$

subject to

$$N_{t+1} = N_t - H_{c,t} - H_{r,t} \tag{9}$$

and the obvious non-negativity constraints.

The key difference between the regulator's and non-cooperative models are, (i) that the users do not care about social and environmental benefits – they care only about the private benefits that accrue to them, and (ii) users race for the fish, as each one of them unilaterally decides how much to take.

The theoretic solution to each user's non-cooperative equilibrium prediction can be work out by setting up the relevant Lagrangian and solving it as in the case of the regulator's model. The outcome then looks like this - In any given period, the net present value of the marginal harvest by commercial user's is set equal to the shadow price of the fishery resource, and similarly for the recreational users. Thus, in contrast to the outcome in the regulator's model no consideration is given to social and environmental concerns in the optimal rule for harvesting the resource.

A numerical example

The aim in this section is to use a purely hypothetical numerical example to illustrate the possible outcomes under the regulator's and non-cooperative models discussed above. All functions and parameters are assumed without any basis in any fishery. To use the framework to analyze a given fishery, thorough empirical work is needed

to determine appropriate functions and parameters that best describe the fishery under consideration.

Specific functional forms

The stock dynamics of our illustrative fishery is assumed to be single cohort, for simplicity. This is captured by the following equations:

$$R_t = \frac{N_t}{1+\varphi N_t} \tag{10}$$

$$N_{t+1} = sN_t + R_t - H_{c,t} - H_{r,t} \tag{11}$$

$$g_t = \alpha / 1+\beta\lambda^t \tag{12}$$

Equation (8) is a simple Beverton Holt recruitment function, where φ is a biological parameter. The equation implies that in each year a certain number of fish, R_t, are recruited into the fishery depending on the existing number of fish (spawners, to be more precise). Equation (9) says that the number of fish in the system next period, N_{t+1}, is determined by the number in this period, N_t, the survival rate, s, the recruitment this period, R_t, and the harvest this period by the commercial and recreational users, respectively. This equation allows the accounting aspect of the stock dynamics to be monitored in numbers. Equation (10) tells us how a given number of fish grows with time, it may be taken as the weight of fish at a given age.

For illustrative purposes only, the benefits functions mentioned above are given the following specific functional forms:

$$B_c(H_c) := p_c H_c(N,e_c) - C_c(e_c) = p_c q_c N e_c - k_c e_c^2$$

$$B_r(H_r) := p_r H_r(N,e_r) - C_r(e_r) = p_r q_r N e_r - k_r e_r^2 \tag{13}$$

$$\theta B_o(H_c + H_r) = \theta(\theta_c H_c + \theta_r H_r), \qquad \theta,\theta_c,\theta_r > 0 \tag{14}$$

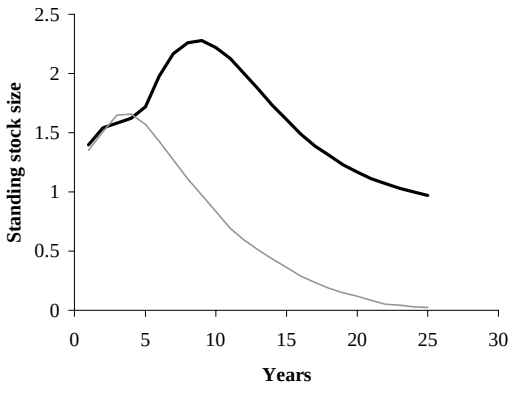
Where q is the catchability coefficient and e is the effort level. Equation (11) and (12) stipulate that the net value to the two users is given by a benefit part, which depends on the size of their catch and the unit value (p) of catch. And a cost part, which is made up of the amount of effort they employ and the unit cost (k) to them for employing this amount of effort. Clearly, the challenge in an empirical study is to determine appropriate p and k values. Depending on the values assigned to θ, θ_c, and θ_r in equation (13), both the social and ecological concerns can be incorporated into the model.

It should be noted that the model specification is deliberately designed to be simple. However, it can easily be extended to include multi-cohort age structure, a multi-species system, and the special features of the two fisheries (see Argue *et al.*, 1983).

The parameters used in the computations

Once again I stress that these are all made up data, with no capacity to capture any real fishery. They are chosen for illustrative purposes only. To start with, the two groups are assumed to be symmetric in all respects: (i) economically, in the sense that they receive the same price for the fish they catch, and it costs them the same amount to employ a unit of fishing effort: *p=10* and *k=5* for both groups; (ii) biologically, because they harvest a common stock, and (iii) technologically because they are assumed to have the same catchability coefficient (*q=0.1*). It should be noted that these are only to make the illustration simple. In a real application, asymmetry is bound to exist and this must be taken care of through an empirically based estimation of these parameters. The survival rate, *s*, is set equal to 0.95, φ=1.5, α= 84.2, λ=0.82, β= 28.76. The initial number is set equal to 1. The discount factor is given a value of 0.952 implying a discount rate of 5%. The environmental parameter, θ, is given a value of 1. This means that a unit of total harvest negatively impacts environmental benefits by 1. The social parameters, θ_c and θ_r are given values of 1 and 5, respectively, implying that harvests by the com-

Figure 1: Biomass profiles in regulator's (thick line) and non-cooperative (thin line) models.



Fishery	Regulator's			Non-cooperative		
	Benefits	Biomass	Effort	Benefits	Biomass	Effort
Commercial	4.44	1.61	1.21	1.34	0.69	0.61
Recreational	4.18	-	0.95	1.34	-	0.61
Total	8.62	1.61	2.16	2.68	0.69	1.22

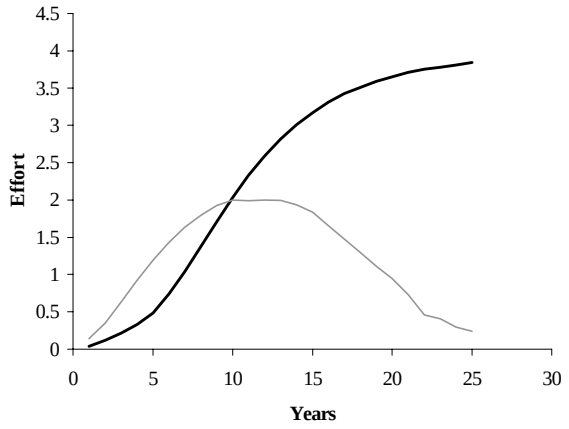
Table 1: Average annual standing biomass, effort and discounted economic benefits under the regulator's and non-cooperative models.

mercial group are valued higher to those by the recreational.

The results

Average combined annual standing biomass, effort employed and discounted economic benefits to the two groups are given in table 1. We see from this table that, the regulators model produces good outcomes relative to the non-cooperative: it generates an average annual total discounted economic rent of about 8.62 units compared to 2.68 in the case of the non-cooperative scenario. The equivalent numbers for the average annual standing biomass (effort level) are 1.61 and 2.15 (0.69 and 1.22), respectively. The regulator's model is able to deliver this win-win results (higher average biomass, higher economic benefits and more average effort employed over the 25 year time horizon of the model) because the regulator's model is much better at allowing the stock to grow to its potential size than the non-cooperative case. This becomes clear when one looks at the average level of effort employed in the two cases during the first ten periods in the time horizon of the model. For this period, the non-cooperative players use over 200% more effort than what is employed in the regulator's model, thereby undermining the potential of the biomass to grow. Socially, the preference for commercial fishing activities, expressed by giving a value of 1 to θ, 5 to θ_r and only 1 to θ_c. This implies that in the regulator's model, the commercial fishers employ more effort, in our example, about 45% more than the recreational users, and make higher profits of about 5%.

Figure 2: Effort profiles in the regulator's (thick line) and non-cooperative (thin line) models.



Figures 1 and 2 illustrate graphically the main results presented in the preceding paragraph. Figure 1 presents the stock profile, while figure 2 displays the effort profile. As mentioned earlier, the key reason for the superior outcome achieved under the regulator's model is the low effort employed during the early period of the simulation.

Concluding remarks

The first challenge facing regulators of any fishery is how to determine the appropriate total harvest (fishing effort) to take from a given system that will meet the biological, social and economic goals of fisheries management. The second challenge relates to the allocation of the total harvest to competing users in such a way and manner that the goals are met. This paper has presented a theoretical framework to help determine both the total harvest and the allocation of this to the commercial and recreational users. Having determined a reasonable estimate of the optimal harvest that meets the goals stated by management, the next challenge is implementation. The regulator needs to put in place a feasible implementation plan to make sure that the 'right' amount of harvest is taken from period to period.

It is well known that the challenges outlined above are not easy to deal with. For instance, models such us this one are not perfect in telling us the correct level of harvest or fishing effort to employ to ensure sustainable fishing. Successful implementation has also proved to be difficult. In almost all instances, exploitation by different users ends up being in a non-cooperative environment, unfortunately. To reveal the consequences of implementation failure, a non-cooperative fishery model is developed. The results from which shows, as expected, that non-cooperative behaviour is detrimental to the achievement of biological, social and economic goals of fisheries management.

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Questions

Margaret Merritt: This is a theoretical model; are there other functions you can plug into the equation, for example, trip frequency as a measure of public welfare or willingness to pay as a measure of economic value, etc.?

Ussif Rashid Sumaila: We need a group of scientists who know what they're doing and get them to decide which functions are important; it's difficult for me to just pick a function and declare it important.

Bill Romberg: Your two models logically make sense, but the basis for the non-cooperative model is the race for the resource. I can see this happening commercial fisheries but how would this occur in recreational fisheries ?

Ussif Rashid Sumaila: There are recreational fishers that are already in this race, and if fishing gets good, you might get an influx of new entrants who will also race to get the good fish while they can.

Discussion & Perspectives

This section presents the issues raised by the evaluation of the benefits and costs of recreational fisheries by reporting three general discussion sessions held at the conference, followed by perspectives delivered at the end of meeting by the four keynote speakers.

Allocation Issues: A Discussion

Material based on a discussion session at the confernce, Ttuesday, June 1st 1999.

Chair: Joelle Row

Roland Griffin: Joell Row said that recreational fishers get their own data used against them, but I see it differently.

Joelle Row: It's different in other places. We've collected data for species only to see restrictions put in place.

Roland Griffin: Does that cause people to change the data that they report?

Joelle Row: No, they would just not give it. They're not required to take a survey; it's all voluntary.

Murray MacDonald: When it comes to sharing/allocation of fish resources, all interest groups, including recreational fishing groups, want to be involved in the decision-making process. In my experience most allocation processes to date have consisted of the lodgment of claims by competing interest groups, followed by allocation decisions based primarily on which interest group has the most political influence. The outcomes of such processes are almost inevitably resisted or challenged by those groups who "didn't get what they wanted" because there is no clear economic of social rationale for the decision. We need resource allocation mechanisms which incorporate transparent decision-making processes, involve all competing interest groups, and provide clear economic or social benefit rationales for outcomes, if we wish to achieve general community acceptance of resource allocation decisions.

Bill Otway: The allocation policy in BC is to give priority access to recreational fishers for coho and chinook salmon. There has been conflict between the groups for over 25 years, but it has got worse over the last 3 or 4 years as the resources have become scarce. Ninety percent of the commercial representatives are in lockstep with recreationists: both see benefits and opportunities for getting access to other stock. I've worked in the commercial sector for over 40 years, as well as being a lobbyist and a consultant, and I've worked on a lot of issues where the commercial and recreational sectors have worked together to fend off the ecologists. But when it comes down to it, each sector wants more for itself. It takes time and education of the government, managers, and community to be informed. Studies can show the economic benefits, but we need to use caution with those. In most cases, there is room for both sectors, but it takes effort and information.

Marty Golden: Scientists are not in a position to have a say about allocation; it's a political decision. If anglers are concerned about allocation issues, they must go through the political process. Fisheries management plans are proposed by the Fisheries Management Councils and most council members are appointed by the governor of states represented by a particular council. In the past, most council members represented commercial fishing interests.

Margaret Merritt: I'm with the Alaska Department of Fish and Game, and the department is separate from the allocation process. Allocation is decided by a board with representatives from different sectors appointed by the Governor, and they take public and scientific testimonies into consideration. The public should speak up if they want a voice in allocation. Non-market estimation is quite new in Alaska. Economic information such as market estimates commonly comes up in testimony regarding allocation decisions. Non-market estimation is new in Alaska and its role in the allocation decision-making has yet to be defined. A caution to note is that traditionally, economists strive for market efficiency. However, those involved in allocation must consider trade-offs between social importance (such as the right of people to earn a living and form a community) and economic efficiencies.

Ussif Rashid Sumaila: This is a great introduction, and as an economist I would like to note that this is exactly what I'll be talking about tomorrow!

Eric Thunberg: I'm an economist. Like in all other politics, resources are allocated to whoever shouts the loudest. However, the management process responds well to information that is sensible, defensible, and peer reviewed . In the short run, the recreational fishers might lose out, but if they're willing to invest in data collection, the management might respond. It is true that sometimes they won't be heard or their data could be used against them.

Gordon Gislason: Allocation is about vested interests in property rights and its public ownership, not "common property". Limited entry is a weak form of property rights as allocation is left to political masters and bureaucrats. Users have little no control over their future. As a result, in the commercial sector many people are pushing for ITQs. Firstly, it gives the industry greater influence on policy although the government still has the most influence on policy making although participants attempt to have a greater influence on the decision-making as they pay license fees. Secondly, these systems have built in transfer mechanisms: that is,

market transactions. Thirdly, participants accept these systems as they have a greater claim to compensation if rights are eroded. I'm interested in hearing comments as to the wisest way to establish the rights for the different sectors.

Terry Gjernes: Recreational and commercial fisheries are very different in how they are run. Commercial fishing is about landing the most pounds for the least cost and recreational fishing is about the experience of fishing. For recreational fishers, you cannot use fixed numbers in the allocation process; it's anathema to what they're about. If you put a limit on the number of fish they are allowed to catch, everyone will be out there in the early summer, and there will be no fish to catch come mid-July; that's bad for the tourism industry, where the lodges will have to shut down in mid-July. It's the allocation of opportunity that's important, not pounds of fish.

Tor Hundloe: In commercial fisheries the initial allocation is critical and it's a controversial political decision. It's an exercise in political power: those who get their feet in the door first can have their say. What happens after the initial allocation is a moral and philosophical decision.

Marty Golden: With respect to allocation by purchasing shares of the fisheries, that might create some problems. If such a system is set up, then commercial fisheries could buy up the recreational fishers' shares. Additionally, since conservation groups often have more money at their disposal, they could also be at an advantage to purchase shares from both the commercial and recreational fisheries.

Karen Culham: In BC it is compounded by problems with confidence levels in the reports. You can't compare recreational and commercial fishing because they're not on the same scale, one is on the demand side and the other one is on the other side of the equation. When it comes to money and willingness to pay, the real thoughts of the fishers are different from what they write on the survey. We have to be cautious about what we are basing our information on.

Bill Otway: The feeling with the managers and the government is that recreational fishing is all fun and games. The recreational community must repeat, over and over, that there are jobs involved and that they're just as important as the jobs in the commercial industry. It's esoteric until you put a limit on fishers – that extra fish is going to cost a lot. A second chinook can cost $4000 as folk have cancelled trips because of such limits. You need to put things in context.

Joelle Row: Recreational fishing in South Africa wasn't taken seriously. To try to convince people that there are jobs at stake is difficult without papers to put on a desk, and that is extremely hard to do. Recreational fishers do this for their own enjoyment; going to conferences like these, taking time off time from our own businesses, all the costs come out of our own pockets. Information costs money.

Monde Mayekiso: I don't agree that recreational fishers are not taken seriously. You underestimate the power and authority that they have as they are often referred to as the public. You must recall what happened last year when the minister attempted to reduce the share to the recreational sector.

Joelle Row: Things have changed, not quickly enough for some, but they have changed. Maybe I should say that input from non-academic fishermen is not taken seriously, but it's just as meaningful.

Margaret Merritt: With respect to using such methods as contingent valuation to estimate "willingness to pay" and accepting this as a valid method, the real test of acceptance for valuing a non-market commodity is in a court of law with test cases. For example, in death and damage cases, the methods and values are judged in a court of law. Contingent valuation is being validated in courts of law where a price tag has to be placed on damage to award compensation. Collecting information is wonderful, but decision analyses studies show that information is coloured by the values and past experiences of the decision makers. I once had an experience where I thought I gave the facts, but somehow they were filtered by a decision-maker so that the information presented was not used in arriving at the decision.

Andy Cockcroft: When they're weighing the value of recreational and commercial fishing for comparison against subsistence fishers, what kind of units are they using?

Tor Hundloe: There's a major study going on right now in Australia to undertake such a task. To put a value on the commercial fisheries is quite easy. Indigenous and cultural fishing is a bit more involved as there are cultural differences and they don't use the same units of property rights.

Tony Pitcher: In the Canadian constitution, Aboriginal fisheries have priority on fishing allocation. I think this is the same in the USA.

Margaret Merritt: There's a distinction between US Legislation and the Alaskan Constitution regarding subsistence priority in Alaska: the former gives priority to rural residents and manages for use, while the latter maintains that all Alaskans have the right to engage in subsistence and manages for sustained yield. The two have been going head to head on some occasions, and some more state versus federal debates regarding subsistence rights in Alaska will be coming up.

Anne Coleman: There is a court case in the Northern Territories where the Aboriginal political body is taking the fisheries to court, saying that the Director of Fisheries has no right to give out licenses in the intertidal zone.

Tony Pitcher: Is there anyone from an angling association present? What are your perspectives?

John Harrison: You were looking at me, weren't you, Tony? The basic problem is the communication issue. Fisheries have people working full time for them, who know the lingo. My job is to take the message of this conference back to anglers. If you're trying to breach the gap and discuss allocation issues, please follow the KISS principle: Keep It Simple, Stupid. The anglers are laymen. If you want to convince recreational fishers of whatever, you have to keep it simple.

Marty Golden: With respect to funding studies on economics and recreational issues, keep in mind how agencies are funded. The US Congress decides how much money is allocated to an agency, and often *how the money is to be spent*. If Congress doesn't authorize an agency to do a specific study, then often they can't do it because they don't have the funds for it. If you want a particular study to be done you often have to lobby congressional representatives for it.

John Harrison: How does that then fit in with the political cycle? If you can't go to the director of the department do you then bypass him and go to your local senator and say, "Senator, I want Congress to allocate money for this research"? So you end up having a political solution to an allocation or research issue?

Marty Golden: That's a very astute observation.

John Harrison: It comes back to the political wheel. This research information is vital if we want to prevent the squeaky door. We must get your research information into the argument and attempt to stop the political decision process. If you want to argue for long-term fishing sustainability, you have to get your argument into the door, and the decision will go to the one that shouts the loudest.

Eric Parkinson: Is the line between commercial and recreational fishing more blurry rather than sharp? For example, people who gillnet 7 days a week, or commercial fishers who continue fishing after they retire, do it because they like it. Sometimes the reasons for fishing are very similar, it's just the numbers of fish caught that are different.

Gordon Gislason: I have a comment on allocation. In commercial fishing, the value is concentrated on the business side, the producer surplus; while in recreational fishing, the value is concentrated on the intangible side, the so-called consumer surplus. Producers are a lot better at advocacy that consumers. Consumer associations are generally weak while businesses are organised, so there's an asymmetry there. Because you have fragmented consumers, it's tough to get their points across.

Joelle Row: Australia has someone who takes care of recreational fishers, works full-time for the Association, but most countries don't have someone whose job is to do that, so you do get a fragmented voice from the recreational fishers.

Roland Griffin: We started with a fisheries in poor health in 1979, but that's turned around. Now, it's a commercial versus recreational fisheries issue, and people are seeing both sides. Without the commercial fisheries, tourism would be affected. Some people want to catch barramundi, sure, but more people want to *eat* barramundi. We need to get the right information to the right people in the right way. I've got a story to tell to make a point about "willingness to pay": At one point, fishing licenses were being bought back by the government for $120, 000, one was advertised for $150, 000, and the recreational anglers were guaranteed $120, 000 from the government and all they had to do was find $30, 000 but they didn't. So they were not prepared to pay $1 per head. We needed to find the balance of $25, 000. There are 25, 000 recreational fishes, but the recreational fishers were not willing to pay $1/ head.

John Harrison: I must respond to that. Yes, there are about 40, 000 anglers in the Northern Territories but getting access to them is impossible. There is no licensing system and therefore no records of addresses, etc. If we could have that information, then we would be able to do such a thing, but right now it is a major logistical problem.

Robert Hicks: An answer on how to compare recreation and commercial fisheries: You can compare by:
1. Hypothetical questions (for example, actual examples on where anglers want to fish, given a choice).
2. Using models.

Tony Pitcher: I don't think the real currency is money, it's votes. When in Canada the fisheries minister was reducing the allocation of chinook from two to one, he saw a sign that read, "One fish-no votes, two fish-one vote".

Roland Griffin: In the Northern Territories, we have a slogan: "I fish and I vote"; now it's been warped to "I fish and I fish"

Monde Mayekiso: How would allocation be made to enable fishing when dealing with the control of TAC-based fisheries? The recreational sector is open - ended and they are growing in number, there is no fixed number of permits.

Bill Romberg: In the last several years, there have been efforts by the commercial halibut fishing sector to set a TAC in Alaska for recreational halibut fishing, since they see it as an actively growing sector.

Gordon Gislason: In theory, you can measure the benefits for each sector. The challenge in practice is: how would you go about measuring these in a logical and formal way when there are differences between products, tangible business values versus intangible angler values?

Roland Griffin: The recreational sector has every right to go fishing. If the commercial fishery gets a lot of the allocation, the recreational fishers can still go fishing. They just won't catch any fish.

Calvin Blood: The allocation process doesn't end at the recreational or commercial sectors. What about sports fishing? The impacts on that sector can ripple down to every community. Each community has its own unique traits. Allocation is not a simple process; it would take years to go through.

Murray MacDonald: If there is to be any progress on the issue of fish resource allocation, we need to be much clearer about the principles and mechanisms used to make allocation decisions. If we accept the current "default" situation (no decisions are made or decisions favouring those with the most political influence are made), then I don's see the point of any further discussion.

Margaret Merritt: Allocation should be political debate conducted in a political public forum so people can talk, that's why we're having this discussion. It's a complex process - that's why we are having this discussion.

Murray MacDonald: I agree that fish resource allocation is a complex and sensitive issue, and that ultimately politicians have to make the allocation decisions. But can I ask, which criteria should be used to decide what constitutes an appropriate allocation of fish resources, and which interest/user groups have a right to participate in the allocation process?

Margaret Merritt: The burden of conservation can be shared equally among users. You also have to keep other groups in mind, like subsistence fishers.

Components of Value in Recreational Fisheries: a Discussion

Material based on a discussion session at the conference, Ttuesday, June 2nd 1999.

Chair: Ian Cowx

Ian Cowx: This is not the first conference on the benefits of recreational fishing. In fact, I have a book in front of me: "Recreational Fisheries: Social, Economic and Management Aspects". The editors are Hickley and Tomkins, and it was published by Fishing News Books and the Inland Fisheries Commission of the FAO. The conference in Dublin, Ireland held a few years ago was excellent, and was more orientated towards Europe and recreational fisheries. At the conference the components of value, that being social, economic, environmental, ecological and human were recognised. There are useful tools for evaluating, but are they compatible, and is it feasible to compare social and economic factors? The mechanisms for determining value that are becoming accepted are ones such as contingent valuation, travel cost, contingent behaviour and preference studies. However, what are they being used for, setting regulations? I used these methods in Portugal, to consider the conservation of an endangered fish, as they were constructing a dam. Some body has to pay now for the re-building of its habitat, and it may be the end users, as the dam was built for irrigation for golfers. So how do you pass the information up to the end user? You know I advocate education and the importance of it and consultation if we can get it right.

Nigel Haggen: Where is the cultural value for a particular people included, for example, the indigenous people?

Ian Cowx: We've been looking at component values. The cultural aspect is very important.

Monde Mayekiso: What is the difference between the use of concepts such as social and human dimension?

Len Hunt: Human dimension is the term for social and economic research.

Jim Lyons: There's a communication issue: the models look great, but is there any point to them? What use are they if you need to give information to managers or politicians, who don't have a great statistical background?

Bill Otway: If the model is communicated well, then we can get the community involved. There's a difference between giving them something you created, and something that you create with them.

Joelle Row: There is a need for communication. If you can't communicate what all those models mean, then you have to re-examine your models. By saying education, do you mean awareness?

Jim Lyons: Once a model has been developed, it's too late

Ian Cowx: Education means getting the message out. But how to get that message out to the anglers is a much wider issue. Werner Steffans said that in the Lower Eastern Block countries, anglers must pass an exam before they can get their angling licenses. Have you ever taken one of those exams? They're hard! But this means that the anglers are educated and they know about ecosystems and the biology of the rivers.

Leah Carlson: I have a comment about the culture and intrinsic value of angling. They've been talked about a lot, but it's hard to put a measurable economic value on some things.

Nigel Haggen: When you talk about communication and education of the value of angling, you can't just talk about, say, the value of sports fishing, or it won't go far. Unless you can get through to politicians or voters, it's just another sector conflict.

Ian Cowx: You've touched on something very dear to my heart: in the UK, the reintroduction of salmon to the River Thames is very valuable to a lot of people. It's

not that there's fish in the river to catch or to watch, but it's the perception that the Thames is not polluted anymore, that it's clean enough to support fish life again. That's very valuable! Of course, it's a struggle to keep those fish alive day to day, but that public perception is very important. The question now is how to build up public perception with regards to angling.

Marty Golden: The existence of large numbers of anglers is very important. Anglers are one of the few groups with a vested interest in quality fisheries; the general public doesn't care much. When you talk about limiting angling activity, you should also consider the potential for the reduction of your support base.

Bob Kearney: In Australia, the general public is not fully aware of the importance of fish as indicators of the health of ecosystems. While fish are not classical charismatic megafauna, they are better than some other organisms, particularly invertebrates. It has been difficult to use angler tournament results as indicators of resources because the rules of tournaments have changed too often to enable comparisons over time. We are working to find other ways of using recreational fisheries as indicators. Hopefully this will help balance some of the negative perceptions of harvesting fish by angling

Ussif Rashid Sumaila: My model deals with social and ecological issues. The trick is not just pricing the social benefit or the ecological. Ecological benefit is dependent on the number of fish in the sea. We want to see more fish in there. When choosing a harvest, sustainability is a good thing. Therefore, for ecological benefit, increased harvest is a bad thing. So, you penalise them for taking more than the ecological limits.

Ian Cowx: I still have a slight problem with it: I'm more environmentally-inclined than recreationally. You can set more dollars on the catch, but you cannot do the same for the environment, unless it's like the example of this endangered species, where the end users, the golfers, paid for the conservation effort. You can't put a monetary value on the environment.

Tony Pitcher: I'll just pick up on Bob's point about evaluating information. How do you put an economic value on information? I'm reminded of a paper on gamefish, done by a colleague in East Africa, Kenya. For the last thirty years his father kept data on every fish that he caught – size, weight, location, weather condition. You can use that data to see changes in climate or fish community or the changes in the top predators in the Indian Ocean. The value of that data is immense when looking at long term trends. What is the value of that?

Ian Cowx: Does this not fit into our understanding of resource base?

Tony Pitcher: It's more than that – it shows our impact on the fish community.

Ann Coleman: Here's something that's more difficult to put a value on the environment: a totemic animal, one with cultural significance. Of what value is that?

Ratana (Ying) Chuenpagdee: We can measure it, but we'd need a tool, one that's not monetary. What the people want, ultimately, is the bottom line, something simple. Can we use a relative unit that would take into account the cultural importance that would give people an idea of the importance?

Wolfgang Haider: It is an elusive endeavour. Managers and advocate groups often need to prove value in absolute dollars. Margaret's presentation is a good example of this point. Yet one may not necessarily require dollar values in all situations. Basically, the question is, how do I make decisions when there are contradicting opinions on a matter? Different user groups take different trade-offs, and they put different values on things. For a number of issues, you can use preference data to get values, but they are not absolute.

Tony Pitcher: Preference methods are much better for those understanding the decision-making. Politicians want votes, so decisions should be based on number of votes. If decisions are supported, then politicians will have no problem making decisions.

Wolfgang Haider: Depending on the design of our decision support systems, you may use a maximising utility for specific user groups. You may also trade off maximum economic value versus ecologically sound measures.

Tony Pitcher: I think the trade-off idea is critical. You can get people to make positive decisions. Politicians might actually be prompted to do something. The media makes us believe that people are dumb, but that's not the case. People are educated about trade-offs. If a decision is made by a community, you'll find people supporting it.

John Harrison: The angling community took the issues one step further before. If you provide the angling community with cold, hard facts – good information – they can even make the decisions for you.

Nigel Haggen: How do you get politicians to assess the value of things? Before, there was lots of influence by the commercial sector, but now recreational fishers and aboriginal people are also competing for their attention. All of them have their own take on things. How do you make politicians see all the benefits? Or the collective benefit rather than the benefit of one?

John Willow: The question of value is hard, but there are two issues involved. The first is the one of money: we need to do a better job on putting a value on the environment, and quantifying the benefits– we need to package the information, target our audience, and get our message across. The second is one of the social and human aspects. Anglers know this aspect, and it's this aspect that will get them to make contributions to help the environment. You would never come across such a high percentage of people willing to put their own

money into the benefit of a public resource. Don't try to put a monetary value on an intrinsic social and family value, just make people aware that there are two sides to this, but we haven't done a good job of doing that yet.

John Harrison: To add to that: commercial fisheries evaluate by catch value and processing value; the recreational fishers evaluate the social, environmental, and cultural package and don't place a dollar sign on it.

Chuck Hollingworth: Maybe we should think laterally about this. They say that the best defence is a strong offence. So far, we've tried to fit ourselves into the system set by the dam builders or the construction companies. What if we turn the tables and set everything on its ear? We can run surveys that ask the general public the question: "What do you think is more valuable for maintaining your father-son relationship – fishing, or building dams?" We set the values this time, not the dam builders.

Ian Cowx: I have to agree. We try to advocate a lot. Real dollars don't work in this situation and that's what consultation is for: to get all the viewpoints out on the table and to have a public debate over them. You usually can't put the human aspect of things into monetary value, and the consultation process is important to it, to hear other opinions.

Bob Otway: Ah, but you can put a value on it. If people say that they don't want a dam – that they want a river instead – then they have put a value on it; they value the river over the dam.

Ian Cowx: Well...maybe using the dam is a bad example, because the dam is important. If you were to ask the people, "What would you rather have, fishing, or water to drink, to shower, etc?" I think you'd see that there's a big social issue from the other side.

Bob Otway: If it comes down to the thrust of it: fishing or water for drinking, there's no question what they'd choose.

Tony Pitcher: Fishing!

Ratana (Ying) Chuenpagdee: But usually, the public opinion doesn't come into a decision to build a dam, the dam will be built. Once the dam is built and the fisheries do decline, then you can ask people how they would like to change things. For example, increase water flow to increase the fish population. You'll see that people will be willing to pay higher utility bills if it means that there would be fish.

Bob Kearney: Conservation, restoration, or at least cessation of mass destruction are more important, as the world has become a bit greener. In Australia, the people agreed to help the environment, rather than consuming a great deal of water, and the angler community was at the forefront of this.

Murray MacDonald: In the last few examples discussed, resource allocation negotiations were based either explicitly or *de facto* on economic measures of benefit to society. Increasingly people are perceiving that there are also non-economic benefits to consider. Therefore unless we can come up with resource allocation decision-making processes which can compare economic versus non-economic valuations of alternative uses, then either all competing uses will have to be valued in economic terms, or they will all have to be valued in non-economic terms.

Gordon Gislason: I think you need to be careful about how you assign a value. In BC, they might place a value on something, but they're not necessarily willing to demonstrate this value by putting out their money for it. The best demonstration of value is paying more. If you want more access but you're unwilling to pay for it, that doesn't go over well with policy makers.

Bob Otway: Pay more to what end, though? Does the extra money go to the politicians, or does it actually go toward improving fishing quality? In animal resource use, there's always the constant cry for more from all users, but in non-renewable resources such as coal or oil mining, it's about how to get at the resources without having to pay compensation.

Nigel Haggen: There's about 100 million dollars worth of oil under the Hecate Strait. There is a call for moratorium on Island gas exploration. The indigenous people have been living there for a thousand years, and they sure don't want to move, but there's so much money involved.

Fred Fortier: Fish can be value added, at the ocean or inland. However, once you deplete a stock, there's a tendency to move on to the next stock, and then the next, and then the next, and so on. After depleting the coho salmon stock, the fishers move to other species, fishing down the food web. So it's more of a biological diversity versus production trade-off, and there's no willingness to do that right now.

Jim Lyons: In recreational fishing, there is a non-economic and an economic value. In Europe, non-anglers hold the majority of the vote, so if it comes down to votes, the non-anglers win.

Ian Cowx: There was a paper from someone in Germany given not too long ago. They're banning angling in the Netherlands, and in 5 years there will be no angling allowed. That sort of attitude is likely to spread, first throughout Europe, then over to Australia and North America. We need to clean up the angling communities' public image, or anglers will be blamed for whatever ills befall the fish. I predict that by 2010 angling will be banned in the EU.

Jim Lyons: And the problem is, the recreational angling community has only just begun to wake up to this, and usually by the time they do, it's too late. They're being picked off one by one.

Ian Cowx: There was a TV debate on this a few years ago. Welfare people were supposed to be represented, but they were not well-represented. One of the spokes-

persons for angling happened to be in prison at that time.

Anne Coleman: We want fish to take on the role as charismatic mega-fauna so that there is conservation, but it is a double edged sword which is leading to a slippery slope, as it also increases the problem if fishing is banned.

Monde Mayekiso: Everyone has an attitude toward the decision-makers, except politicians. If anglers think angling is important and should be passed on, they shouldn't be afraid of politicians. If the cause is good, we can get society on our side, and this will force politicians to make favourable decisions.

Ian Cowx: Well, it was quite a different experience in Portugal.

Evaluating Recreational Fisheries: a Discussion

Material based on a discussion session at the confernce, Ttuesday, June 3rd 1999.

Chair: Tony Pitcher

Tony Pitcher: We will have now have a discussion session and at the end of the discussion session, our four keynote speakers will present a summary of what they thought the main points were in the conference. Well, no discussion is without a topic, and we have several topics. I wish to introduce two topics, and I will present the first of the two now. Several people during the course of the conference, and I can think of three names (Barbara Calvert, Marty Golden and Werner Steffens), mentioned a code of angler ethics. I would suggest that we consider establishing a code of ethics for anglers. I have recently completed some work at FAO in Rome and undertaken an analysis whereby we scored fisheries on compliance to the Code of Conduct for Responsible Fisheries which was published in 1995. It is suppose to guide countries in their code of conduct in all fisheries including recreational fisheries. It is a document which countries can subscribe to on a voluntary basis, but it is not binding. Now if you look inside the actual document, you only find a little about recreational fishing, but there is not very much. You find a lot about commercial fisheries, artisanal fisheries and subsistence fisheries, but the code has only brief references to recreational fisheries. What you find is that the code itself has been expanded out to several parts, actually each part dealing with different technical guidelines, one on aqua-culture, one on inland fisheries and as part of the code a section that deals with the integration of fisheries and coastal management. So you can find at least eight guidelines, but only two make reference to recreational fisheries and where they mention recreational fisheries, they mention it in terms of conflict with the commercial sector. It is not mentioned in terms of its benefits to the human side, in terms of what we have discussed at this conference.

In fact, while I was in Rome, I spoke to a number of people and I asked them how the FAO regards recreational fishing, and it seems to me that there is quite a lot of support for the development of an internationally agreed voluntary code of ethics for recreational fisheries. So I thought that it would be a good opportunity for me to say to you here that this is a suggestion, and one thing that a group like this might be able to do, in communication, post conference, is develop the text for a code of ethics for responsible recreational fisheries. There are huge differences in what we have seen from experiences in North America, Germany, and even South Africa and Australia where in some places people don't need licenses. So around the world we have a huge diversity of different kind of issues, yet that kind of diversity does not mean that we have greater problems than we already have. So I would very much like to hear from you what you think about this suggestion for the development of the text for a code of ethics for responsible recreational fishing. So, any comments on that or any suggestions?

John Harrison: As a representative of a recreational fishing body in Australia we presented a National Code of Practice in 1996 at the Second World Fisheries Congress in Brisbane. I would like to present it and we still have it on a web-site in Australia (see http://www.sunfish.org.au/recfish and http://www.dpie.gov.au/resources.energy/fisheries/recfish/pamphlet/index.html). I did also send a copy to the UN in 1996 when they were developing their code of practice, but it was probably shelved somewhere as we did not hear back from anyone.

Joelle Row: The organised sport's angling associations, whether it be a national or an international gamefish association, normally have a constitution that includes some form of code of conduct, so amongst these constitutions, codes do exist.

Tony Pitcher: Yes, we wish to support the idea that they all embody some form of code of ethics in their practices.

Carl Walters: If you are talking about recreational fisheries, I don't necessarily agree, so what exactly are we trying to do?

Tony Pitcher: Well the trouble is that, as with commercial fisheries, some form of conduct is needed, but I think I will let someone else answer that.

John Harrison: Yes, it's a tool you can use if you have young individuals coming into recreational fisheries. Its guideline so people can say this is what we expect. It will demonstrate to new fishermen what practices we accept.

Marty Golden: I have attached "A Code of Angling Ethics" (published by the NMFS) to the paper I submitted.

If anyone wants a copy of it right away, I can e-mail it to them (also see WEB site http:// www.nmfs.gov /irf/irf.html).

Tony Pitcher: Yes, I would like you to think about the fact that there is already some form of draft if we incorporate what we have learnt from everyone.

Jim Lyons: In the UK we also have a code of conduct, although it's slightly different in that it's reflected in the way we fish; we catch and release. So it's largely based on what people do.

Murray MacDonald: Are we talking about a code which specifically defines responsible recreational fishing practices, or are we talking about a code in the broader sense, such as the FAO Code for Responsible Fishing which embodies the principles for fisheries management, as well has codes of practice for fishers?

Tony Pitcher: Yes, well, in that code they have various guidelines as to how a vessel must operate in international waters. I was thinking more of general principles which appear in article 2 and 3 where management is just a sub-set of a larger set of principles, which are very conservation-minded. I think if the same set of principles is adapted for recreational fisheries that would be useful.

Carl Walters: We definitely need a code of conduct for responsibility for fisheries managers and especially middle managers which is taken on by as many agencies as possible, so they can be accountable for their mistakes, as around the world this is the principle problem. A code of conduct which focuses on managers would do a whole lot more than one that focuses on individual recreational fishers.

Tony Pitcher: Yes, that is a very good point, and for the commercial fisheries there is a section that sets out very clearly the responsibility of the member states and their management authorities for the kind of way they should operate, and so I agree.

Mike Sullivan: I wonder exactly how we are going to do this. I was on a program where one of the managers was considering eliminating a pest species, and with such a code we could not do that, under our Federal code or a code of responsible fisheries. How would this code be binding?

Tony Pitcher: It is not meant to be binding, although it's a detailed document; in fact, it's meant to be a moving goal post. The aim of such codes is to improve conservation practices to influence member states to include these principles into their national legislation, which many have already done. It's not appropriate for details for each state.

Mike Sullivan: So can I use it directly in criticizing that program and can we use such a code for our means?

Tony Pitcher: One has to consider the detailed subsections.

Mike Sullivan: In Alberta we have been frustrated by programs that have been driven by public perceptions, yet we must be accountable. Politicians are influenced by public perceptions, yet at the same time we have to be responsible and accountable to everybody else.

Michael Walker: How is a code of practice going to influence the use of live bait?

Ian Cowx: The use of live bait is not considered good practice for many reasons, including the possibility of spreading diseases. It is not just about animal welfare. It is going to become an undesirable practice.

Monde Mayekiso: My impression is that the code is not really a useful concept unless it is incorporated into national legislation. For the code to really work it has to be in local legislation so that those responsible for fisheries management and those fishing have some guidelines to adhere too.

Tony Pitcher: Yes, you are quite right, and the intention of the code of conduct was to encourage states and nations to include it, or elements thereof, within their national legislation, as many have done. In fact, we heard this week that there are about 10 nations which have incorporated such principles within national legislation. I would like someone to introduce a new topic.

John Harrison: In one of yesterday's sessions we heard about the history of fisheries management in Alberta and how in 1907 regulations were being imposed for reducing over-fishing . Within the context of this conference we should consider how far we have come and the fact that we had a conference back in 1996, and we have an opportunity to make this a regular event. It is disappointing that industries or the International Gamefish Fishing Association are not better represented. I present to the group that we meet again; that is, every three years. The next would be in 2002, and I would be delighted to be play host to the meeting in Darwin. Another thing is that it would perhaps be a good idea to set up a small group of people from different parts of the world who can email each other and send out information in their own countries to people, particularly the industry, who may be interested in attending the next meeting we have in Australia.

Tony Pitcher: I think that is a good idea and if anybody would like to be a part of that group, please give your names to either Trevor or Gunna, so we can stay in contact. We have been a small group although there are people from many different parts of the world. We promoted the inclusion of industry. The next meeting it will be a great idea to set up an international steering committee. Before we go through the final wrap up, are there any burning issues that people may wish to raise?

Roland Griffin: I have thought about the "willingness to pay for one more fish" factor and what seems to be more important than this factor and average catch rate is the fact that people compare their success against their colleagues. If he caught one fish and you caught two, you have had a great day. Average catch rate does not always capture how good a day it was.

Mike Sullivan: Another point to consider is the conclusions one can draw from angler response curves in Alberta, is that it's not total catch rate that is important but ranked catch rate, and this requires fuzzy logic methodology, in that fishing is either good or bad.

Barbara Calvert: It is a bit disappointing that there were no lodge owners at this conference or people representing tourism.

Tony Pitcher: Well, we tried. We had Velma McColl, who headed the BC Recreational Sector interests, on our planning steering committee for this conference, but unfortunately she changed jobs and we did not get the support we needed.

Eric Thunberg: When collecting data I think it is important for researchers not to ask just questions about trip success and focus on typical creel survey type questions, but to also collect information on age and gender and other social information along the way. It does not take a lot more time to obtain other social and cultural information which can be integrated into the results, and this information can be collected at the same time.

Perspectives on Evaluating Recreational Fisheries from the Keynote Speakers

At the end of the conference, the four keynote speakers were asked to state what they felt we achieved at this conference or did not achieve on the subject of evaluating the benefits of recreational fishing.

Ian Cowx

After a bit of reflection, I admit I am a bit disappointed, as I think we could have had a greater representation from the Europeans. This would have provided a more balanced perspective. There seem to be a lot of differences between recreational fishers in Europe, North America, and Australia. There are a lot of lessons to be learned both ways. Here you focus on catch whereas in Europe the focus has been on integrated resources and the links between them and the methodology required to understand these systems. There are differences, but at the same time there are similarities in the links, the biological, social and economic aspects. The methodology is the same and all of these need some fine tuning. The same topics were discussed in Dublin, and I don't think we have developed that much in three years. Are we going to make progress in the next three years? We may have the opportunity of observing the results from the study on recreational fishing in the north-east United Sates. There is a lot to learn as we biologists, sociologists, managers and economists talk amongst ourselves. I think the only equation that matters in this area of research is "$E=mc^2$", where the *E* stands for exploitation rate and *m* stands for number of anglers and the *c* stands for chaos. I believe we cannot treat fisheries as an single entity. We have to deal with other players in the system, as this is extremely important. We have to deal with factors such as education, communication and consultation. I would like to go back to one thing: the big issue of animal welfare is going to happen. I have watched it happen in Britain, Holland and other places in Europe. I think a code of practice is a good way to go, to show them that something is being done to protect the fish. On the river Trent, there are many dead fish around June 16th, as fishers engage in poor practices such as keeping fish all day in the nets and only releasing them in the afternoon. We need to teach them that this is not how it is done.

Bob Kearney

We have all learnt a lot and that there are many factors that we agree on, but the take home message for me is that there is still much that we need to debate. We have been able to quantify a few important factors relating to recreational fishing, such as expenditure, but we have not been able to quantify others, such as the social benefits.

Many of the examples that have been given at this conference relate to North America's wonderful Salmonid fisheries. I am not convinced of the universal applicability of these examples to other fisheries, particularly to those in the South Pacific.

Much of the debate was on the benefits of restricting access in order to improve the quality of fisheries. This very restriction raises serious cultural issues in many places. Access was really discussed only in terms of remoteness and the relative high quality of fisheries that are difficult to get to. We did not focus much discussion on access rights and property rights. It is clear there is still confusion over the common property nature of the resources and the role of Government as the custodian on behalf of the people. I believe we need further debate on this subject before we can progress resource allocation issues.

The conclusions from the models presented here strongly support the need for effort control in the

interests of maintaining quality fisheries. Other models also showed that maximum economic benefits, at least in terms of expenditure, are derived from fisheries that have more tourists than locals. For Australians, there is also the important issue of the high percentage of angling expenditure which is on imports. As much Australian legislation on fisheries espouses economic efficiency as the goal we need to be careful that one does not conclude from the economic model that maximum benefit would come from stopping Australians angling in Australia in order to minimise expenditure on imports and to maximise tourist dollars. Such is the folly of taking economic models to their extreme and ignoring the social importance of recreational fisheries.

The German experience where catch and release fisheries are illegal, is most enlightening. We were also informed that in Germany and Holland there is a strong move to ban angling totally. If we are not careful the animal rights movement will threaten the very existence of recreational fishing, at least in some places and at some times. The targeting and subsequent catch and release of spawning runs is one area that could be threatened. The animal rights movement will increasingly question why fish that are not being targeted for human consumption should be allowed to be tormented.

Ussif Rashid Sumaila

For me this has been a great learning opportunity, especially because recreational fisheries have not been my main area of research interest - I come from the commercial sector. I think there are two key issues that the conference participants seem to agree upon. First, we agree that there are three broad fisheries management objectives: (i) ecological, (ii) social (including cultural) and (iii) economic. Second, we also seem to agree that some form of valuation of the benefits of recreational fisheries is needed. But when it comes to how to do such valuations, there appears that there is little agreement. The main point is that we have to develop convincing ways to value these benefits not because we want to, but because we have to in order to protect our interests vis-à-vis other sectors in the economy - we do not have the luxury not to.

Carl Walters

I have learnt an enormous amount at this conference about evaluation methodology and research that focuses on recreational fisheries. It seems to me, however that there is much naïveté. Most of the discussion at this conference considered economics and the promotion and development of recreational fisheries, whether it be by reducing pollution or improving water quality and/or reducing competition with commercial sectors. This attitude implies we think that we can promote recreational fisheries assuming that we can focus on supply-side management; that is, grow more in hatcheries. I will leave you with a thought, and it is a reiteration of what I said the other day and it is, that this approach that some are advocating is doomed in the long term. I suggest that we all read Mike Sullivan's paper over and over again and see where those predictions end up. Alberta is the norm and the same roots to the problems are evident in both papers he presented.

Contributed Papers

Status and Trends in Kenyan Recreational Marine Fisheries

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Abstract

The paper provides recent figures, from 1988 onwards, on Kenya's recreational marine fisheries based on official data from the Kenya Association of Sea Angling Clubs (KASAC), estimates and private information from people involved in the business. It includes the monsoon seasons, fishing areas, fish types and the tag -and –release program, mainly of the billfish. Recreational fishing is practiced mainly by foreign tourists and chiefly as a sport, not as a means of procuring food, or for sale. The economic value of this fisheries is relatively small and mainly comes from licensing of the sport by the Fisheries Department.

Introduction

Kenya is located on the Eastern African coast astride the equator between latitudes 5^0 40' north and 4^0 4' south and between longitudes 33^0 50' and 41^0 45' east, and border the Indian Ocean to the east. The country has an area of 590,000 km^2 with Coast Province occupying 14.7 % of this. In 1996, the population was estimated at 28,267,000 and is expected to increase to over 31 million by the year 2000 (Central Bureau of Statistics, 1995). The Coast Province accounts for 8.5 % of this population and about 20 % of the national population depend on fisheries. The main fishery along the Kenya coast is artisanal and recreational fishery form less than 5 % of the total marine fishery.
Kenya has a 574-km coastline running from Kiunga in the north to Vanga in the south (see Fig. 1). The continental shelf is narrow with depths dropping below 200 meters within less than 4 km in most places, however, it widens significantly at the mouths of rivers Tana and Sabaki exceeding 15 km off the northern end of Ungwana Bay. Coral rocks characterize the coastline and sandy beaches protected from the open ocean by patch and fringing reefs. Except for the interruption of

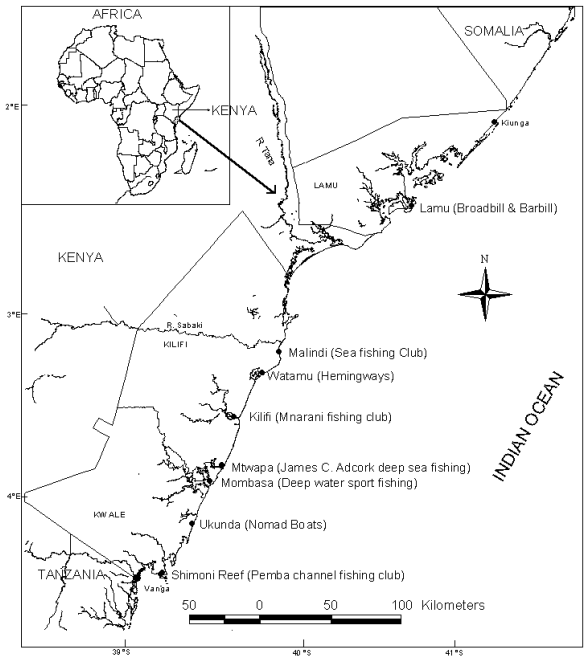

Figure 1. Map of Kenyan coast showing location of fishing areas and some fishing clubs. Inset- location in Africa.

the reefs at the creeks by outflow of fresh water from rivers, the reefs run parallel to the entire shoreline at a distance of 1-2 km (Abuodha, 1992). Between the reef and the beaches and coral cliffs lie the lagoons that are a home to seagrass and algal beds. The area of the territorial waters is approximately 9,000 km^2 (Kinyanjui, 1984).

The monsoon seasons

Climatic patterns are important factors influencing the Kenyan coastal environments and have a bearing in the physical, chemical and biological characteristics of the ocean. The changing weather patterns significantly affect the productivity, distribution and composition of marine target organisms. The Kenyan coast experiences semi-diurnal tides. The spring tides are up to 4 meters and neap tides up to about 1.8 meters. Along the coast, temperatures range from 22-34° C during the northeast monsoon season, reducing to about 19- 29° C in the rainy months of June-August, during southwest monsoon.

Kenya has two distinct monsoon seasons; northeast monsoon (December to March) and southwest monsoon (May to October). In between occurs the transition period from northeast to southwest and vice versa. During the northeast monsoons the flow is southward along the coast to about 2^0 south (off Lamu) and the velocity of the current is reduced to about 2 knots resulting

in a calm sea. At this time the Somali Current and the East African Coastal Current (EACC) converge off Kenya, enhancing the fisheries due to increased productivity associated with oceanic fronts (Wakwabi & Nguli, 1995). The high fish catches at this time are due to the arrival of the Somali Current water, which has high nutrient concentrations. The other reason is that of upwelling favorable conditions which are created by the tendency of the northeast winds to drive surface water off the shelf. As the surface water moves away from the coast, subsurface water rises to replace it. Since this water comes from below the photosynthetic zone, it is rich in nutrients. We can envisage the coastal boundary being enhanced by localized upwelling along the Kenyan coast during the northeast monsoon. However, during the southwest monsoon season, a swift northern current, the East African Coastal Current (EACC) flows along the entire Kenyan coast. The current is enhanced by momentum from local winds and reaches velocities of up to 4 knots and the sea is rough.

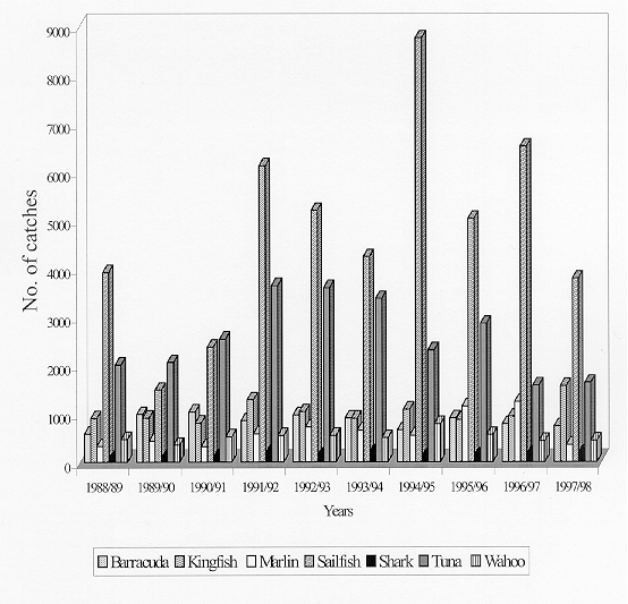

Figure 2. Annual recreational catches of fish along the Kenyan coast. Sailfish are the most numerous followed by tuna.

Status of recreational marine fisheries

Kenya offers a huge variety of different species in deep sea fishing to anglers who come to enjoy the beautiful beaches, calm sea conditions and tropical sunshine among others. These fisheries depend directly on foreign tourists and any negative effects on the tourism industry affect it. For example, the number of visitors arriving in Kenya dropped from 863,400 to 690,500 from 1994 to 1995. Correspondingly, the number of fish caught by anglers also dropped from 14,295 to 11,536 from 1994/95 to 1995/96 seasons.

This decline was blamed on negative international publicity on the local security situation, decline in tourist infrastructure like roads, water and power and competition from newly emerging destinations like South Africa. This has led to private individuals operating sport fishing laying off the sport for other leisure activities and others with more boats selling some. Various measures were taken to arrest this decline, including: formation of Kenya Tourism Board, establishment of a Tourist Police Unit and the initiation of a Beach Management Program (Odido, 1997). The sector has shown signs of recovery since 1996.

Kinds of fishing

The method used in recreational fishing is hook and line. The lines (tackle) range from light (2kg) to heavy (38 kg). Of this method, trolling accounts for 72 %; drifting 16 %; spinning 8 % and ground fishing 4 %. The accepted way of fishing for billfish is to troll a spread of lures baited with fish strips and teasers behind the boat at a speed of about 8 knots. Ground fishing (including drift fishing) outside the reef produces a large variety of edible fish. A number of game fish including marlin, sailfish, shark and kingfish are caught in this way.

Bottom fishing is done, in 150 m of water. A whole new technique for catching broadbill has been discovered in Kenya. Instead of drifting at night with natural squid baits, it has now been found that night trolling with lures can be even more effective. On dark nights, the fish seem to take best.

There is an almost infinite variety of craft available for recreational fisheries in Kenya, including canoes intended for spin casting or bottom fishing. The boats are maintained to the highest standards. *Sesse* canoes powered by outboard engines are ideal for inshore and spin fishing and also game fishing, especially with light tackle. The crafts are fast, have built in floatation and are very stable in rough seas. Most of the deep water fishing craft are twin engine and in touch with each other and the shore base by radio link. Most boats carry lifesaving and fire fighting equipment on board. Some boats though, go out fishing without radio on board and have been lucky to be rescued. There have not been reports of anglers dying while fishing.

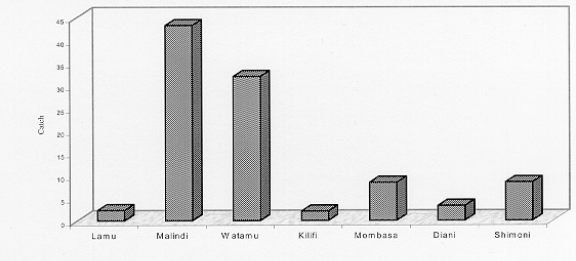

Figure 3. Percentage catches from 1988 to 1998 at seven sites along the Kenyan coast. From left, Lamu, Malindi, Kitifi, Mombasa, Diani, Shimoni.

Fishing areas

Fishing baits are trolled in areas likely to hold fish and these are the rips off Watamu, the north Kenya banks, the Sabaki river mouth at Malindi and the seamounts at Shimoni in southcoast. The rips and the banks are areas of bottom feature both well offshore which create powerful currents. A large number of striped marlin are caught in the Pemba Channel along the south coast (Rainbow Runner magazine, 1997). Malindi is probably well known in Africa for its sailfish catches and in recent years-large marlin have been landed at Watamu, Malindi and Mtwapa areas to the north of the country. The Sabaki River attracts baitfish, which the fish follow. The offshore banks over 80-km northeast of Watamu are areas rich in tunas, marlins and broadbill at night.

Fishing season and fish type

The species below (see Fig. 2) are seasonally common outside the reef. These include barracuda (*Sphyraena barracuda*), kingfish (*Scomberomorus commerson*), black marlin (*Makaira indica*), blue marlin (*Makaira nigricans*), striped marlin (*Tetrapturus audax*), sailfish (*Istiophorus platypterus*), hammerhead shark (*Sphyma spp.*), mako shark (*Isurus oxyrinchus*), tiger shark (*Galeocerdo cuvieri*), yellowfin tuna (*Thunnus albacares*) and wahoo (*Acanthocybium solandri*) among others. The composition of the catches varies throughout the year due to seasonal variation in hydrographic conditions, supply of food, life cycles, migration patterns etc.

There are two main seasons in the Kenyan sport fishing calendar and a very wide variety of top sporting game fish to be caught. Most of the fish caught are pelagic. Low season occurs from April to August with the high season starting from December to March. A mid season occurs between September and November. The fishing seasons relate directly to the weather patterns and to the tourist volume. Sailfish are by far the most numerous of the billfish caught at Malindi (see Fig. 3 & 4). August to November provides really good sport for big yellowfin tuna amongst, which are often found the marlins. Many fish are also taken at other times. The main billfish (sailfish and marlin) season runs from November to mid/late March but sailfish are often substantial in August. There is usually a run of sailfish at Watamu, north coast, between August and September, while the main season off Malindi, north coast, runs from November to February (Rainbow Runner Magazine, 1997).

Striped marlin tends to be found offshore in cleaner water and can travel in schools. It is the smallest of the three species. Large blue marlins are found usually in the deep water in mid February to mid March, whereas black marlin, the biggest of all, are often encountered in shallow waters. The sharks are often caught while fishing for tuna but they also take marlin baits. Broadbill is mostly caught at night.

Boat fishing days

In the 1997/98 season, 84 boat fishing days were reported in Lamu, 945 in Malindi, 887 in Watamu, 215 in Kilifi, 514 in Mtwapa and 607 in Shimoni. A boat day is the number of days a boat goes fishing in one fishing season. During this season, Malindi had the highest average sailfish catch per boat day of 1.1 and Watamu had 0.8. At Shimoni the sailfish average catch was 0.7. per boat day, while that of marlin was 0.2 which was the highest. Average marlin catch per boat fishing day at Watamu and Malindi was the same both had 0.1. At Watamu the average broadbill per boat night was 2.3, at Malindi, 2.2 while at Shimoni it was 0.8.

Trends in recreational marine fisheries

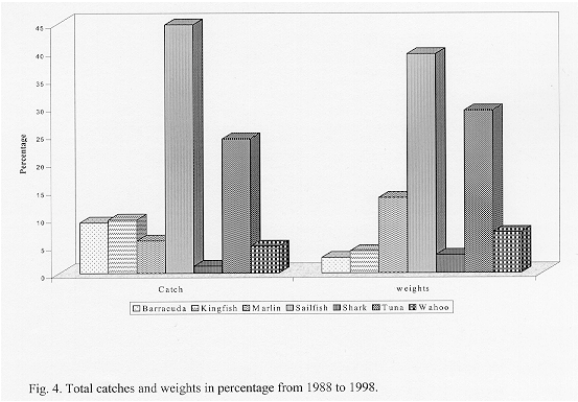

Figure 4. Percentage total catches (left) and weights (right) 1988-1998 of seven fish types. From left: barracuda, kingfish, marlin, sailfish, shark, wahoo.

In the 1994/95 season, Kenya had the best year for sailfish (see Fig. 2). Most of these were caught from Malindi (see Fig. 3). In the Shimoni area alone, some 380 marlin were caught in 1996/97 season. This season also saw a welcome return of sailfish off Mtwapa, Mombasa. There were very few fish close to the reef with the majority being caught beyond 5 km unfortunately there was a big drop off in black marlin, but this was made for by an increase in the striped marlin catch. The fishing off the northern part of the Kenyan coast was badly affected in January and the first half of February in 1996/97 by a number of cyclones in Madagascar which caused a reverse current and consequent green water for kilometres out.

Within a ten-year period from 1988 to 1998, the best catches occurred in 1991/92 (13 %) and 1994/95 (14 %) seasons (see Fig. 2), with a total catch of 104,858 fish. From 1995 onwards, there has been a general decrease in the catches. The low catches in 1997/98 were mainly due to bad weather. Heavy and torrential rains, whipped up by the strongest El Niño ever experienced in Kenya lashed the Kenya coast from mid October onwards. Bridges were destroyed, roads and houses washed away and the resulting floods swept thousands of tons of mud and sludge out to sea where the water became turbid as far as 25 kilometres out. Debris of all sorts including whole trees floated around in the sea for weeks making fishing not only difficult but hazardous too, as damage to propellers was a very real possibility. In the middle of December the current, which normally flows north along the coastline, reversed and proceeded to go south fast (Kenya fishing records, 1998). The result of all these was that catches were low (8 % of the total).

Between 1988 to 1998, Malindi accounted for 31,500 of the total catches from Kenyan waters, which was 43 % (see Fig. 3). Watamu followed with over 30 % (23,300); Mombasa and south coast together accounted for over 20 % while Lamu and Kilifi accounted for only 2 % of the catches each. Sailfish accounted for about 45 % of the catch (see Fig. 4); tuna, 25 %; barracuda and kingfish, 10 % each while marlin and wahoo, 5 % each. Sharks had the least, only one- percent. The total number of catch of these seven species was 106,152.

Tag-and-release program

Yamaha Motors are the main sponsor of the tag and release program, introduced by the African Billfish Foundation (ABF) in 1987. The program which aims at helping the stressed fish population recover requires anglers to release their catch, instead of killing it as was previously the case. A card is filled out and returned to the ABF, estimating the weight of the 'catch' as accurately as possible and its place of capture. The data thus collected is vital for estimating billfish age, growth, and migration patterns, distributions and stock structures.

The tagging procedure uses thin plastic tags approximately 4 inches long that do not in any way hinder the normal activities of the tagged fish. Ideally the tagging area is the middle shoulder, well above the lateral line and away from the head, gills, gill plates and other vital organs. The return of the tags is encouraged through financial rewards, as the information provided by those returning tags i.e. location of the catch, and its estimated length and weight, is invaluable to ABF's research program. Knowledge gained from the program is essential to the development and maintenance of international management plan for the billfish that may help ensure the worldwide future of these important fish.

The change from killing to tagging and releasing has been a self-imposed effort by visiting anglers and local captains. Both realize the value of a billfish both as a predator and a sustainable natural resource, without which many of them would be out of business and no one would have the pleasure of baffling the great fish of the Kenyan waters. The number of fish tagged and released doubled from the 1995/96 season. A number of tagged fish have been recaptured on the Kenyan coastline especially in the Malindi and Watamu areas. There has also been a distinct rise in the number of species being tagged and released. For example in 87/88 season, the number of sailfish and marlins tagged and released were 246 and 15 respectively. In the 97/98 season, however sailfish and marlins tagged and released were 1189 and 107 respectively (Rainbow Runner Magazine, 1997). This shows an increase of over 400 to 700 percent. Since 1987/88 to 1997/98 seasons, total number of billfish tagged and released were; sailfish, 13045; black marlin, 215; blue marlin, 102; striped marlin 1337 and 301 broadbill. Of these 212 recoveries have been made (Kenya fishing records, 1998).

Factors constraining fishery development

Ranges of factors that constrain the further development of recreational fisheries include decline in tourism industry, increasing costs of angling, poaching and increased diversity of leisure activities. There is still some aggravation between com-

mercial fishermen and recreational anglers, something that will always exist, whereby two different user groups target the same resource. The Spanish and Japanese commercial fleets are having a very serious effect on the tuna stocks because the nets that they use catch more than they intend to and they take up, they scoop up everything, rather than just the primary target.

Recommendations and Conclusion

Appropriate data collection system needs to be established and implemented. It is recommended to increase efforts to promote and educate young persons and adults in the field of recreational fisheries, to improve the image of recreational fisheries and participation in the activity. There are many factors (social, economic, cultural and originating from multi year tradition) characterizing recreational fisheries and to evaluate the status and prospects requires the co-ordination and collaboration of basic information of different types, catches and management activities. The tag and release program is good and more sponsors should be sought.

Acknowledgments

The author wishes to acknowledge both Mr. Wanyoike and Mr. Muriithi of Fisheries Department Mombasa for providing initial guideline. Much thanks goes to James Adcock and his captain Joseph Ngila of James Adcock sport fishing at Mtwapa who provided material forming the backbone of this paper; to Tony Cullen, Ken Adcock and Hesabu Bakari all of Hemingways Resort, Watamu for providing the same. I am grateful to my colleagues Pamela, Kamau, Samuel, Polycarp, Priscilla, Nguli and Maria for their invaluable assistance; to Shaban who proofread this manuscript; to Gunna, conference organizer, for being there for me. Much thanks also to the Carls Duisberg Gesellschaft e. V. (CDG) Germany for providing funding. All the raw data synthesized and used in this paper is courtesy of the Kenya Association of Sea Angling Clubs (KASAC). Tag and release data is courtesy of the African Billfish Foundation (ABF).

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Questions

Calvin Blood: Is there a large scale commercial sector associated with the local fisheries?

Pamela Aboudha: No, the local fishery is small-scale in nature - it is a subsistence fishery. There are no storage facilities and this is a problem as the temperatures are high.

Murray MacDonald: It seems that the local fishers and the visiting recreational sector are targeting different fish, with the recreational fishers using sophisticated equipment to target tuna and sailfish which are further offshore, whereas the locals target inshore species along the coral reefs. If this is so, what is the purpose of encouraging locals to target offshore species too?

Pamela Aboudha: Local fishers are being encouraged to target offshore species in order to take advantage of a national resource. There is a lot or pressure on the inshore fishery and thus on the coral reefs. Offshore stocks are not well documented.

Ussif Rashid Sumaila: Are the recreational fishers charged fees for their exploitation?

Pamela Aboudha: Within the Fisheries Act, the issuing of licences is covered. The licences go to clubs and operators on an annual basis. Part of the permit requires that the vessels are sea-worthy and maintained, thus an inspection takes place.

Relationships between Recreational Angling and Native Salmonids in Alberta: a Historical Perspective

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Introduction

Even before Alberta became a province in 1905, the evolution of fisheries management and recreational angling in the province had already begun. For example, concerns were being expressed by 1890 about how native stream fisheries in south-western Alberta were declining and about the ineffectiveness of the October 1st to January 1st stream closure for trout (McIllree and White-Fraser, 1983).

Similar to many other North American jurisdictions, as concerns about declining trends continued, fisheries managers and recreational anglers focused attention towards maximizing recreational angling opportunities, as opposed to conserving native fish stocks. Some of these efforts (e.g., introducing non-native species) have had serious impacts on Alberta's native fish stocks.

This paper is part of an on-going literature review to compile and summarize historical information about how anglers, fishery managers, and other stakeholders have managed, and affected, Alberta's native salmonid fishery resources. This paper discusses how recreational angling and fisheries management have evolved during the last 100 years and how this evolution has affected native salmonid fish stocks in Alberta. Bibliographies of several references (e.g., Colpitts, 1993, 1997; Brewin, 1994) describing the history of angling, angling organizations, and fisheries management in Alberta were reviewed to help locate additional reference materials. Information and photographs in archives at the National Archives of Canada, Provincial Archives (Alberta), and selected museums (e.g., Glenbow Museum, Calgary, and Whyte Museum of the Rockies, Banff) were also reviewed to further develop a database of historical reference materials.

The topics discussed in this paper include:

- The 1910-1911 Alberta and Saskatchewan Fisheries Commission;
- Early attitudes of anglers towards native fish stocks;
- Post-1980 initiatives to protect and restore Alberta's bull trout (Salvelinus *confluentus)* stocks;
- Summary of how past actions has impacted native salmonid fisheries in Alberta.
- Other chapters being developed as companion chapters to this manuscript include:
- Early fishery protection efforts by anglers and the creation of early sportsmen groups;
- Salmonid fish culture in Alberta;
- Existing policies regarding stocking fish in flowing waters within Alberta;
- Attitudes and practices affecting native salmonids (1930s - 1970s);
- Existing status of Alberta's native salmonids; and
- Distribution of non-native salmonids in Alberta.

The 1910-1911 Alberta and Saskatchewan Fisheries Commission

The Department of Marine and Fisheries's responsibility for Alberta's fisheries began with the Canadian government's purchase of Rupert's Land from the Hudson Bay Company in 1870. However, the Department never implemented a conservation policy until well after the turn of century and instead used regulations written for Manitoba to control fisheries in the Northwest Territories (Colpitts, 1993) which originally included Alberta and Saskatchewan.

Although Alberta did not become a province until 1905, complaints about rivers and streams in south-western Alberta becoming '*fished out*' had become common by the turn of the century (Colpitts, 1993, 1997; Prince *et al.* 1912; McIllree and White-Fraser, 1983). Anglers blamed new angling practices for these declines (e.g., improving access and increasing use of fisheries from non-locals). For example, from the 1890s to 1910, anglers had largely been confined to fishing near their hometowns. By the early 1910s, the use of automobiles and pack horses on fishing trips was contributing to increased fishing pressure and harvest in the foothills and mountains of southern Alberta (Colpitts, 1993). In addition to fishermen employing rod and reel, other more destructive methods of capturing fish were also utilized in Alberta's early history (i.e., netting, trapping, liming, shooting and explosives (D. Mayhood, Freshwater Research Ltd., Calgary, AB, pers. comm.).

Pollution events were also documented during Alberta's early history. Fish kills from dumping municipal sewage and industrial refuse were reported by the Northwest Mounted Police as early as 1889 (i.e., sawdust from a sawmill was found in

the gills and insides of many dead fish) (McIllree and White-Fraser, 1983). There are also several other reports of early pollution events (e.g., Prince *et al.*, 1912; Colpitts, 1993, 1997; D. Mayhood, pers. comm.), as well as concerns about habitat degradation caused by dam construction, irrigation diversions and forestry practices (e.g., Prince *et al.* 1912; Colpitts 1993, 1997).

The rush of land settlement in the early 1900's, coupled with Alberta becoming a province and petitions from anglers asking the government to correct declining fish stocks, led to the creation of the Alberta and Saskatchewan Fisheries Commission. This three person Commission travelled throughout Alberta and Saskatchewan in 1910 and 1911 to investigate fisheries resources and recommend appropriate conservation actions (Prince *et al.*, 1912). The Chairman of the Commission, E.E. Prince was a professor and the Department's fisheries specialist. The other two members, Dr. E. Sisley and T.H. McGuire, were non-scientists (i.e., a physician and judge, respectively). This structure, and the Commission's visits to selected locations to hear the views of anglers, commercial fishermen, Fishery Guardians, and other stakeholders, allowed the Commission to solicit the views of common citizens as well as fisheries specialists. This was done to help the Fisheries Branch develop a comprehensive understanding about the state of fishery resources and a list of recommended fisheries conservation efforts (Colpitts, 1993).

Among other things, the Commission's report (i.e., Prince *et al.*, 1912) discussed preferences among anglers for different species and how species like westslope cutthroat trout *(Oncorhynchus clarki lewisi)*, rainbow trout *(O. mykiss)* (only native to the Athabasca River system), and Arctic grayling *(Thymallus arcticus)* were highly regarded by anglers. It also discussed how predatory species like bull trout and northern pike were despised by some anglers. For example, the report discussed anglers requesting angling closures to protect spawning runs, particularly for preferred species; however, when both spring and fall spawning species were present, the Commission stated -

> *It is impracticable to have a close season covering both spawning periods. As a choice must be made, the best course to take is to protect the fish regarded as the most valuable, viz: the Salmo clarkii.*

After hearing that many of Alberta's fish stocks, particularly in south-western Alberta, had become depleted, the Commission listed the following causes:

> *We regretted to find that the valuable fish native to them have become sadly depleted, and we now proceed to enumerate and explain the causes:*
>
> *(a) Overfishing,*
> *(b) Illegal fishing (dynamite, nets, & c.),*
> *(c) Infraction of Irrigation Regulations,*
> *(d) Improper close seasons,*
> *(e) Lack of fisheries officers to enforce regulations,*
> *(f) Sewage and other pollutants,*
> *(g) Drought,*
> *(h) Fishing through the ice.*

The Commission's recommendations included a $2/year angling license and minimum daily catch limits of 15 fish/day for cutthroat trout, rainbow trout, grayling and mountain whitefish *(Prosopium williamsoni)* and six lake trout/day *(Salvelinus namaycush)*. Bull trout were not included in the daily limit recommendation. It was also recommended that some streams be completely closed to fishing for three consecutive years to give them a "*much needed rest*".

Other recommendations involved expanding existing Forestry Reserves along the Eastern Slopes of the Rocky Mountains into Fishery Reserves (i.e., closing headwater streams to fishing) and the creation of hatcheries to bolster fish production. It was proposed that the hatcheries be used to raise native fish for restocking depleted fish stocks (i.e., first priority spring spawning trout species and Arctic grayling, and then fall spawning lake trout and mountain whitefish if the hatchery could be winterized).

Although brook trout *(Salvelinus fontinalis)* from Lake Nipigon had already been stocked in the Bow River within BNP (Prince *et al.*, 1912; Colpitts, 1993), it was barely mentioned in the Commission's report. Several anglers also made requests to stock other non-native fish species (e.g., bass spp.); however, with respect to the stocking non-native fish the Commission stated (Prince *et al.*, 1912):

> *We are of the opinion that there should be stringent prohibition against the introduction and planting of new species of fish not native to the waters of the two provinces. Great harm has resulted in many cases from the planting of foreign species of fish, which have become a nuisance. Should there be grounds for introducing fish not indigenous to these provinces, such steps should be taken only with permission of the Honourable the Minister of Marine and Fisheries.*

Despite early recommendations made by fisheries commissions (Prince *et al.*, 1912) and experts (e.g., Prince *et al.*, 1912 and Rawson, 1939) to avoid introducing non-native species into waters containing native sportfish, non-native sportfish were stocked into many watersheds in Alberta, particularly within the national parks.

The lack of attention given to recommendations not to stock non-native species is highlighted by the number of non-native fish which were introduced[2] into the upper Bow River system in BNP (Brewin 1994). This list of sportfish includes: lake trout, brook trout, rainbow trout, golden trout (*O. aguabonita*), Yellowstone *(O.c. bouvieri)* and coastal *(O.c. clarki)* cutthroat trout, brown trout *(Salmo trutta)*, Atlantic salmon (*Salmo salar*), lake herring (*Coregonus artedii*), Quebec red trout *(Salvelinus alpinus marstoni*), splake (brook trout X lake trout hybrids); bull trout X brook trout hybrids; rainbow trout X cutthroat trout hybrids; and possibly even lake trout X bull trout hybrids. In addition to these species or hybrids, Northern Dolly Varden (*Salvelinus malma*) were introduced into Chester Lake (Nelson and Paetz, 1992) and have moved downstream in the upper Spray River system[3] [J. Stelfox, Fisheries Management Division, Alberta Environmental Protection (AEP) pers. comm.], and bass spp. were introduced into Lake Minnewanka, BNP, in 1908 (Nelson and Paetz, 1992).

Early Attitudes of Anglers Towards Native Fish Stocks

Early records reveal native cutthroat trout were highly regarded by anglers in southern Alberta. For example, Prince *et al.*, (1912) states the following:

> *- This fine game fish is the trout par excellence of the Rocky Mountain streams.*
> *- Of all the indigenous fish of the western streams, none are more worthy of preservation and of increase by artificial culture than this highly esteemed and beautiful trout.*
> *- It is a bold fighter and takes a fly with great readiness and vigour. A small Cut Throat say 7 in. and only 6 oz. in weight will give more sport that a Salvelinus of five times the size.*
> *- They are, on three grounds, worthy of the fullest protection, viz: because of their non-predatory character, their excellent food qualities, and their fine game qualities.*
> *- Some want bull trout exterminated in favour of the Cut Throat (attributed to witnesses at Calgary meeting).*

In more northern waters where cutthroat trout were absent, Athabasca rainbow trout were highly regarded. For example, Prince *et al.*, (1912) indicated:

> *Very much the same remarks as have been used in describing the Cut Throat trout could be properly used in describing this fish.*

The high regard for rainbow trout was also evident in W.F. Whitcher's 1887 report to the Department of Interior. Whitcher, a former Fisheries Commissioner, apparently ranked the Athabasca rainbow trout highest due to their form, size, colour, flavour and gaminess. His second ranked species was the eastern brook trout, then cutthroat trout, and at the bottom of the hierarchy were bull trout which were declared *"...an awkward country cousin... of insipid flesh"* (Whitcher, 1987 in Colpitts, 1997).

With respect to Arctic grayling, Prince *et al.* (1912) wrote:

> *- All alike are fine game and food fish, indeed, Dr. Henshall, the veteran fish authority in Montana declares that 'as a game fish the Grayling is fully the equal of the trout, though its way of taking the artificial fly is quite different'.*
> *- It bites at the artificial fly with eagerness, and deriving great power from its dorsal fin, affords much sport to the angler.*
> *- Where the western waters are well stocked with these fine game fish just named they afford angling sport not to be surpassed anywhere.*

Mountain whitefish were less regarded, but still valued as a game fish (Prince *et al.*, 1912):

> *- The readiness which they take the fly gives this fish an interest and importance, which confers on them a special claim to protection and increase in western streams.*

Predatory species, like bull trout and lake trout, were placed at the bottom of the hierarchy. For example, the 1910-1912 Commission recommended size limits and daily harvest limits for cutthroat trout, rainbow trout, mountain whitefish and grayling, but left bull trout out of this recommendation. Statements from Prince *et al.*, (1912) reveal the disdain of some anglers towards bull trout:

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[2] Although these species, sub-species and hybrids were introduced, information regarding whether they became established does not exist.

[3] Mouth of the Spray River into Bow River is located inside BNP immediately below Bow Falls.

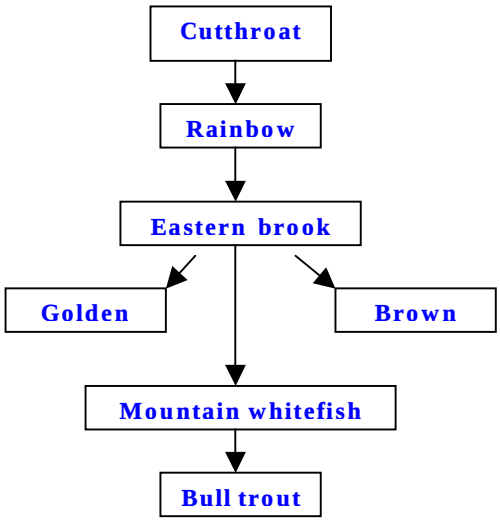

Figure 1. Rankings of sportfish attributed by Alberta anglers: 1902-1930. (Found in Colpitts 1993)

- The bull trout has not largely increased in most of the Albertan waters while the superior Cut Throat trout has been decreasing. The former has been partly regarded as the cause of the decrease for it is a predacious species and indeed a cannibal. It is a charr and though often handsomely coloured externally, it has not the fine shape, active behaviour, determined gaminess and fine table qualities of the Salmo clarkii. It is most voracious, feeding greedily on its own and other species, and usually skulks at the bottom of pools or behind a stone ready to pounce upon any passing fish. It will not rise to the fly but takes bait such as a small fish, a piece of beef or other course lure, and has no fighting qualities.
- It requires no skill to secure and on that account has some popularity amongst anglers of little ambition or experience.
- It is not an attractive fish on the table. The flesh is very pale pink as a rule. Tastes however differ, and an eminent authority has pronounced it a 'good fool fish' but he also states that it is much more voracious than the true trout and most freely takes the hook, and 'to the trout hog the Dolly Varden can be strongly recommended as it swarms in the millions'....
- In evidence at some of the Commission's sittings its voracity and ease of capture were held favourable features, 'tourists,' said one witness, 'are pleased with bull trout as nine out of ten don't know the difference between it and a good game fish.'
- Get rid of pike and bull trout (attributed to witnesses at Fort MacLeod meeting).
- I would suggest the removal of any limit to the size of bull-trout which may be caught, but would not like to suggest removal of protection as it might lead to other trout being killed out of season. (Quote from an appended letter sent to the Commission)

Similarly, lake trout, were also not highly regarded (Prince *et al.*, 1912):

> *-It is not usually regarded as a game fish but in Minnewanka Lake, near Banff, the Waterton Lakes and some other lakes near the Rockies it is fished by troll and from its sheer weight and size gives the fishermen some labour to land. The lake trout has no real game qualities although on rare occasions it has been taken by the fly, and ranges from 2 or 3 lbs. up to 60 or 70 lbs.*

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Colpitts (1993) also summarized information about preferences anglers in southern Alberta for different fish species for the period 1902 -1930 (Figure 1). It indicates cutthroat trout and bull trout were the highest and lowest ranked species, respectively.

Post-1980 initiatives to protect and restore Alberta's bull trout stocks

By the 1980's attitudes among some anglers and fisheries managers towards native species, particularly bull trout, had begun to change.
In 1983 a special resolution was passed at the Alberta Fish and Game Association's Annual Convention that called for 'no-kill regulations' for bull trout, except where harvestable surpluses exist (Roberts, 1982). Although this resolution for protective regulations was supported by several stakeholder groups [i.e., Federation of Alberta Naturalists, Trout Unlimited Canada (TUC) and the Edmonton Trout Club], all the requested changes were not implemented by Alberta Fish and Wildlife (Roberts, 1987).

By 1985 angler's harvest and possession limits for bull trout were limited to two fish/day and to two bull trout (respectively); by this time Alberta also had a draft management plan for bull trout that called for the province to "*regulate fishing in line with the production surplus*" (Carl, 1985). However, this plan was never implemented and at the end of the 1994-1995 fishing season Alberta's general regulations still allowed anglers to harvest two bull trout/day over 40 cm (total length) (NRS, 1994). Although these regulations stayed in effect until the 1995-1996 fishing season, the Bull Trout Task Force - Alberta (BTTF), which Alberta Fish and Wildlife Division was a part of, initiated a *Save the bull trout* poster campaign which encouraged anglers to release all bull trout they captured (Brewin, 1997).

Although stakeholder groups made it clear in the 1980's that they supported protection for bull trout, it is less clear whether the angling public

saw bull trout as being worthy of special protection. A survey conducted in 1991 of southern Alberta households indicates anglers had no preferences between recreational fisheries with an all native fish assemblage (bull trout, cutthroat trout and mountain whitefish) or with a mixed fish assemblage (mountain whitefish and introduced rainbow trout and brown trout) (Thompson, 1997).

These results are particularly noteworthy because Thompson (1997) targeted users of the Highwood River sub-basin. Colpitts (1993, 1997) revealed early anglers in this sub-basin were intimately involved in native trout issues (i.e., during 1900 to 1920 these anglers held cutthroat trout in high regard and resisted attempts to introduce non-native species into the Highwood River). Thompson (1997) suggested one reason why modern anglers did not display preferences between native and non-native fish assemblages could be because most anglers can not discriminate between native and non-native species. An alternative could be that by 1992 non-natives had been the dominant sportfish for so long that recreational anglers had little knowledge about, or experience with, the native fish species.

Stakeholder groups continued to champion native trout awareness efforts in the 1990's due to concerns about their plight in the province. The most high profile of these efforts were centred on bull trout. In 1992, TUC resolved to sponsor the designation of the bull trout as Alberta's official provincial fish emblem (Blake 1997).

In 1993, TUC and other groups (i.e., provincial and federal regulatory agencies, other conservation organizations, industry, and private and academic biologists) joined to form the Bull Trout Task Force - Alberta (BTTF). The BTTF was formed to facilitate the recovery of Alberta's bull trout populations. After completing all of their original objectives, the BTTF disbanded in 1997. The objectives, history and undertakings of the BTTF are described in Brewin (1997). Some of the BTTF's more significant accomplishments were:

- - hosting a major, international conference in Calgary in 1994 on the biology and management at which bull trout status reports for various regions of the province were presented (Mackay *et al.* 1997);
- - facilitating the provincial government's designation of bull trout as Alberta's official fish emblem in 1995;
- - facilitating the provincial government's implementation of a province-wide recovery program for bull trout;
- - raising support for the implementation of province-wide angling regulations (including the National Parks) which prohibit anglers from harvesting bull trout anywhere in the province;
- - developing and implementing numerous initiatives aimed at raising public awareness about the plight of the Alberta's bull trout and public support for recovery efforts; and
- - developing province-wide priorities for bull trout inventory, research and education needs (BTTF, 1995).

Prior to the implementation of many of the BTTF's awareness initiatives, TUC commissioned a survey in 1993 to document the attitudes of Alberta anglers towards bull trout and fisheries management (Boxall and LeFrancois, 1997). They reported that only 20% of TUC members and 6% the general angling public were aware of the bull trout's vulnerable status. They also found, approximately 100 years after some of the first reports regarding streams and river being '*fished out*' began to surface (Colpitts, 1993, 1997), only 10.5% and 5.6% of TUC and non-TUC members, respectively, believed that foothill and mountain streams were 'fished out'.

Although only 6% of the angling public surveyed by Boxall and LeFrancois (1997) in 1993 were aware of the bull trout vulnerable status, Baaynes and Brewin's (1998) 1996-1997 survey indicated anglers supported the need for bull trout conservation programs (average score of 9.0 of 10).

Discussion

Among the sportfish known to early anglers and fishery managers, the highest ranked were native cutthroat trout, and "*none were considered more worthy of preservation*" (Prince *et al.*, 1912). However, despite being held in the highest esteem, within their native range Alberta's pure westslope cutthroat appear to be at serious risk of extinction and should be listed as a 'threatened' *or* 'endangered' (D. Mayhood, pers. comm.). The causes of their decline include: on-going habitat degradation; angler overharvest; competition and predation from introduced salmonids; and introgressive hybridization with introduced black-spotted trout stocks (D. Mayhood, pers. comm.).
Although bull trout were Alberta's most abundant and widely distributed trout or char, they have experienced severe declines in their abundance and distribution during the last 100 years and are now considered a 'species of special concern' (Berry, 1997). Factors which have contributed to this decline include: overharvest by anglers; introduction of non-native salmonids (i.e., dis-

placement and/or replacement by introduced stocks, and hybridization with brook trout); and habitat degradation (e.g., various papers in Mackay *et al.*, 1997).

Both recreational anglers and fisheries managers throughout much of the last 100 years persecuted Bull trout. Since 1980 efforts have been taken to reverse the bull trout's decline in Alberta. Although recovery efforts are still in their infancy in Alberta, bull trout have become a high profile species (Brewin, 1997) and support for conservation efforts has grown (Baayens and Brewin, !998). It will take many years before the success of recovery efforts can be properly evaluated, but the outlook for Alberta's bull trout is improving.

Alberta's other native salmonids have also experienced severe declines in their distribution and abundance during the last 100 years (i.e., lake trout, Arctic grayling, and Athabasca rainbow trout). For example, Arctic grayling are considered 'vulnerable' by AEP and a range-wide management and recovery plan for them was implemented in 1998 (Berry, 1998). Native lake trout stocks are also at risk and a provincial management plan and recovery plan may be required for them as well (D. Radford, Fisheries Management Division, AEP, pers. comm.).

The factors that have contributed to the declines of Alberta's native lake trout, Arctic grayling, and rainbow trout are similar to those that have caused the decline of native cutthroat trout and bull trout. Although some exceptions exist which prevents the lists of factors from being completely universal (e.g., commercial fishing has been a factor in the declines of some lake trout stocks, hybridization with introduced salmonids has not led to declines of Arctic grayling), large similarities in the causes of the declines exist between species.
Another factor that has contributed to the decline of Alberta's native salmonids, but is seldom listed, is the lack of basic fisheries inventory information (e.g., population dynamics data, locations of critical habitats, and angler pressure and harvest). Basic inventory information is needed to allow fisheries managers and regulatory agencies to make informed decisions so that they can protect critical habitats and implement protective angling regulations.

In this regard, it is noteworthy that 83 years after the 1910-1911 Alberta and Saskatchewan Fisheries Commission held a series of meetings to solicit '*state-of-the-art*' information about the status and distribution of native fish stocks, fisheries managers in Alberta were still relying on similar collection methods as their principle method of collecting basic fisheries information. Walty and Smith (1997) lacked basic inventory information regarding the status and distribution of bull trout in the Peace River basin and solicited input from local anglers to supplement the knowledge of fisheries managers. Consequently, input from local anglers, rather than fisheries inventory information, was used to conclude that '*no surplus bull trout were available for harvest*' within the Fisheries Management Area.

While these fisheries managers are applauded for incorporating the knowledge and concerns of anglers into management decisions, management decisions need to be based on the best available science. Historical evidence clearly demonstrates the consequences of not basing management decisions on good science. As fisheries management in Alberta enters its second century, it is essential that fisheries management decisions be based on a solid foundation of good science, particularly if native fish stocks are going to be part of Alberta's future.

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Low Consumptive Angler Behaviour and Preferred Management Strategies: the Case of Sport Fishing in British Columbia's Tidal Waters

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Introduction

Tidal or saltwater sport fishing is a popular recreational activity for both residents and non-residents of British Columbia and is economically significant as a component of the British Columbia tourism industry. During 1997, anglers in British Columbia's tidal sport fishery spent circa $485 million. Between 1981 and 1995, non-resident anglers created most of the growth in tidal sport fishing license sales in British Columbia (GSGislason and Associates Limited, 1998). The growth in popularity of tidal sport fishing has been accompanied by overfishing of British Columbia's tidal waters. This has resulted in fish stock depletion and consequential decline in the quality of sport fishing opportunities (ARA Consulting Group Incorporated, 1991).

The growing demand for further tidal sport fishing opportunities and the concurrent decline in fish stocks have resulted in an urgent need for innovative management strategies which encourage conservation, while simultaneously accommodating angler preferences in order to enhance the sport fishing experience. Management of the British Columbia tidal sport fishery is the responsibility of the Government of Canada. That responsibility is administered by means of the Department of Fisheries and Oceans (Sport Fishing Institute of British Columbia, 1992; ARA Consulting Group Incorporated, 1996; Fisheries and Oceans Canada, 1997a). The Department of Fisheries and Oceans is challenged in its attempts to address the pressures of overfishing and increasing demand for further sport fishing opportunities. This is evident by the continual depletion of salmon stocks, and the resultant decline in the quality of sport fishing opportunities in the British Columbia tidal sport fishery.
Management strategies which promote low consumptive sport fishing are needed in the British Columbia tidal sport fishery. Low consumptive sport fishing comprises voluntary catch and release practices, and shifts the angler's focus towards the non-consumptive components of the experience. These low consumptive management strategies may help to facilitate the sustainability of the British Columbia tidal sport fishing industry, and at the same time enhance the quality of the sport fishing experience.

Purpose of study and research questions

The purpose of this study was to identify the key characteristics of low consumptive anglers, and to suggest ways of promoting increased participation in low consumptive sport fishing in the British Columbia tidal fishery. The central research questions related to this study were:

- What are the characteristics of low consumptive anglers?
- What management strategies are needed to promote greater participation in low consumptive fishing experiences in British Columbia's tidal waters?

Methods

Data used for analysis in this study were derived from the British Columbia non-resident component of a Department of Fisheries and Oceans survey of recreational fishing in Canada. The survey was conducted during 1990 (Fisheries and Oceans Canada, 1994a). This survey investigated management preferences and social, economic and behavioural characteristics of non-resident tidal anglers. More specifically, the survey explored the following traits of anglers:

- geographic origin;
- age and gender;
- personal income;
- participation patterns;
- catch and release information;
- motivations;
- satisfaction;
- management options;
- trip characteristics;
- angler expenditures.

The Department of Fisheries and Oceans supplied this angler data to the Centre for Tourism and Policy Research at Simon Fraser University for statistical analyses. During 1997, researchers at the Centre for Tourism Policy and Research performed a range of statistical analyses on the survey data by means of the Statistical Package for the Social Sciences (SPSS).

In the present study, interpretations of these data were carried out in order to determine the differences in characteristics and management preferences of low consumptive and consumptive an-

glers. Graphical representations of data, which had been previously analyzed by the Centre for Tourism Policy and Research, were prepared to detect distinctive activity patterns and response tendencies between the two groups. The average numbers of fish caught and kept per day by both groups were calculated for all species for the whole of British Columbia's tidal waters. This method was used to determine significant differences in the daily consumptive patterns between the two groups.

F-values for motivations, environmental factors and management options were used to determine where the greatest differences in mean responses between the two angler groups existed. This method was employed to identify the features of low consumptive anglers that could be used to weight management strategies suited to their preferences and behaviour.

Results

On average, the low consumptive anglers were younger than their consumptive counterparts. A greater percentage of low consumptive anglers than consumptive anglers were expert or experienced at sport fishing, and rated their tidal sport fishing experiences in British Columbia during 1990 as excellent or very good.

Compared to the consumptive group, the low consumptive group spent a higher average number of days in 1990, and a higher average number of years sport fishing in British Columbia's tidal waters. During 1990, the average number of trips for which sport fishing was the main or secondary reason for visiting British Columbia, or for which sport fishing was decided upon after arrival, was greater for the low consumptive anglers than for their consumptive counterparts. The low consumptive anglers went on a greater average number of outdoor and resort trips in conjunction with their sport fishing trips, and spent a greater average number of nights in different types of accommodation, than did the consumptive anglers. On average, the low consumptive anglers also spent more money on goods and services whilst on their tidal sport fishing holidays in British Columbia than did their consumptive counterparts. This was the case with respect to all categories of spending investigated except for the category of lodge and resort accommodation.

Surprisingly, the average numbers of fish per species caught on a daily basis were greater for the low consumptive group than for the consumptive cohort. However, the consumptive group kept greater average numbers of fish per day than did the low consumptive group. Both angler groups placed a high value on non-consumptive trip motivations. However, the low consumptive anglers valued non-consumptive motivations more highly than did the consumptive anglers. Not surprisingly, catching fish for consumption was more important to the consumptive anglers than it was for the low consumptive anglers. The greatest differences in mean responses were most pronounced with respect to the enjoyment of nature, followed by family togetherness, challenge and excitement, catch trophy fish, companionship, relaxation, opportunities to get away, improve fishing skills, and sense of achievement.

Environmental factors which played a role in the decision by anglers to fish in British Columbia's tidal waters were of greater importance to the low consumptive group than the consumptive group. The greatest differences in responses with respect to environmental factors were related to catching trophy fish. This was followed by variety of species available, lack of pollutants in fish, catch rate of all fish, absence of other recreationists, natural beauty of area, water quality, presence of favourite species, presence of wildlife in area, places to fish from shore, lack of angler crowding and size of fish. The greatest differences in responses with respect to preferred management options were in the categories of more catch and release regulations and reduced bag limits.

Conclusions

Voluntary catch and release

The literature review revealed that despite the increasing number of anglers practicing voluntary catch and release of non-restricted fish in British Columbia's tidal sport fishery, managers are currently not encouraging this practice on a wider basis. This is the case despite the growing awareness of the need to conserve fish stocks. Findings from the survey suggest that compared to consumptive anglers, low consumptive anglers contribute more significantly to the conservation of fish stocks by practicing voluntary catch and release of non-restricted fish. The low consumptive anglers kept lower average numbers of fish per day than did their consumptive counterparts. This indicates that the low consumptive group was more interested in fishing for sport than for consumption.

Objectives	Strategies	Means
Increase angler participation in voluntary catch and release of non-restricted fish.	Institute promotional campaigns to educate anglers on the need for conservation. Institute promotional campaigns to teach anglers the correct release techniques.	Public-private partnerships for education between governments, angling organisations and the sport fishing industry.
	Establish and promote a code of ethics for anglers.	Use of educational tools such as brochures, posters, leaflets, media advertisements, videos, public information meetings/presentations and sporting/outdoor magazines.
Lessen angler emphasis on preferred species.	Include catch and release of non-restricted fish in daily bag/retention limits.	Promotion and implementation of these stricter regulations through the federal government's Department of Fisheries and Oceans.
Prevent depletion of preferred species.	Reduce bag limits for all species.	Promotion of these stricter regulations by angling organisations.
Increase catch rates and sizes for all species.	Severely curtail bag limits for depleted species.	
Attract more low consumptive anglers who are primarily interested in the non-consumptive benefits of sport fishing.	Promote enjoyment of nature, family togetherness and challenge and excitement as the main components of a sport fishing experience.	Promotions by the sport fishing industry, angling organisations and the provincial government.
Accommodate the desires of low consumptive anglers.	Promote sport fishing holiday packages offering a variety of recreational activities in conjunction with fishing.	
Further angler emphasis towards the non-consumptive aspects of sport fishing.		
Attract more low consumptive anglers who are primarily interested in the sporting aspect of fishing.	Promote the British Columbia tidal sport fishery as a catch and release trophy-fishing destination.	Promotion by all sport fishing sectors.
Attract non-anglers who are interested in adventure tourism.		Use of promotional tools such as awards, trophy alternatives and tag and release fishing.

Table 1. Objectives for recreational fisheries and the means of realising them.

Promotional campaigns should be carried out to educate all anglers on the need for voluntary catch and release of non-restricted fish as a conservation measure, and to teach anglers the correct release techniques in order to ensure the maximum survival of released fish. As well, a code of ethics for anglers should be established and promoted (Table 1).

Angling organizations, the federal and provincial governments, and the sport fishing industry should cooperatively participate in this educational process. Methods to deliver information to anglers should include the use of brochures, posters, leaflets, media advertisements, videos, public information meetings and presentations, and sporting/outdoor magazines. These strategies may increase angler participation in the practice of voluntary catch and release that in turn may reduce fish consumption in the sport fishery.

Regulations

Catch restrictions that require mandatory catch and release practices currently comprise the main conservation strategy of the Department of Fisheries and Oceans. Anglers are required to release fish when bag limits have been exceeded, in areas of species depletion, and when undersized fish are caught. This approach to conservation may not be an adequate means to successfully manage the growing demand for further sport fishing opportunities and the concurrent decline in fish stocks. Results of the survey indicate that management options of significantly greater importance to low consumptive anglers than consumptive anglers were reduced bag limits and more catch and release regulations. Management strategies should require the inclusion of catch and release of non-restricted fish in bag limits. In addition, regulations should reduce bag limits for all species (Table 1). The Department of Fisheries and Oceans should be responsible for implementation and promotion of these regulations. The imposition of

these regulations may result in increased catch rates and sizes for all species. This may lessen angler emphasis on depleted species, such as Coho and Chinook salmon, and bring about an improvement in trophy fishing.

Non-Consumptive Benefits

Managers in the British Columbia tidal sport fishery are not actively taking into account the value that is placed upon the non-consumptive aspects of the sport fishing experience by low consumptive anglers. Findings indicate that the low consumptive anglers went on a greater average number of outdoors and resort trips in conjunction with their sport fishing trips than did the consumptive anglers. They were most different from their consumptive counterparts with respect to the importance they placed on such fishing experience attributes as enjoyment of nature, family togetherness and challenge and excitement.

These motivations should be promoted to anglers as the main appeal of the sport fishing experience. Managers should promote sport fishing holiday packages that offer a variety of recreational activities in conjunction with fishing (Table 1). This approach may better accommodate the desires of low consumptive anglers, and further angling efforts towards the non-consumptive aspects of the sport fishing experience. As well, cash flow benefits to the British Columbia economy may result. These promotions should be the responsibility of the sport fishing industry, angling organizations and the provincial government.Table 1. Management strategies to promote low-consumptive sport fishing in British Columbia's tidal waters.

Trophy Fishing

The British Columbia tidal sport fishery should be promoted to anglers as a catch and release trophy-fishing destination, in order to encourage fishing for sport rather than for consumption (Table 1). All sport fishing sectors should take responsibility for promotional efforts. Awards, trophy alternatives and tag and release of trophy fish are some of the ways to effect this promotion.

The current research has elucidated several strategic management directions for the British Columbia tidal sport fishery. If implemented, these management strategies will be valuable tools in effecting change towards sustainability of the tidal sport fishery.

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Questions

Bill Otway: The market is focusing on high fishing areas. You're assuming that low consumption is equal to

low impact. What is worse, if I go up to the Queen Charlotte Islands and land four chinook and keep them, or catch-and-release 40 Chinook? Which is more consumptive?

Barbara Calvert. I don't want to give the impression we were promoting that people give up everything, we wanted to encourage release. We tried to be realistic and assume that some people would still keep a few of the fish. But there is a growing demand for sports fishing and other activities such as hiking, and that's what we should target.

Bob Otway: So you're talking about expansion rather than replacement.

Barbara Calvert: Yes, exactly.

Marine Recreational Fisheries in South Africa: Status and Challenges

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Abstract

Recreational fishing is an important component of the marine inshore fisheries of South Africa. The three major recreational fisheries are those targeting spiny lobster (*Jasus lalandii*), abalone (*Haliotis midae*) and linefish (about 100 species). This paper reviews the methods used to assess the participation in these fisheries, the recreational fishing practices in these sectors and the impacts of these recreational fisheries in context of overall resource utilization. The new Marine Living Resources Act of 1998 has major implications for all fisheries sectors in South Africa. This paper highlights the challenges facing the South African recreational fisheries in light of current resource status and the changes brought about by the implementation of the new Act.

Introduction

South Africa has an extensive (± 3000 km) and productive coastline (including temperate to tropical regions) with a wide diversity of habitats and a rich marine fauna. This, coupled with a moderate climate, makes coastal recreational activities an extremely popular pastime.

The collection of intertidal invertebrates and teleosts has been an important subsistence and/or recreational activity for communities along the West and South-west coasts of South Africa since the early Holocene, some 10 000 years before present (established from the remains found in Khoi-San caves and middens)(Buchanan 1988, Voigt 1992). In recent times, recreational fishing for a wide range of invertebrate and fish species was permitted throughout most of the country without a recreational license. The exception was in the province of KwaZulu-Natal, which introduced a licensing system in 1971 under a Provincial Ordinance. Size limits, daily bag limits, closed seasons and marine protected areas were the only restrictions governing recreational angling. Permits were, however, required for the West Coast rock lobster *Jasus lalandii* and abalone *Haliotis midae*. Subsistence fishing (or the sale of daily bag limits) without a permit was also allowed in designated areas.

Following political emancipation in 1994, a new fisheries policy for South Africa, embodied in the Marine Living Resources Act of 1998, was implemented in September of 1998. The Act, which superseded all other fisheries legislation, has equity, sustainability and stability within industry as its three major pillars. Commercial, recreational and subsistence fishing were identified in the Act, and participation in all these sectors is now strictly governed by a permit requirement. The Act defines recreational fishing as: “any fishing done for leisure or sport and not for sale, barter, earnings or gain”. A subsistence fisher is defined as: “a natural person who regularly catches fish for personal consumption or for the consumption of his of her dependants, including one who engages from time to time in local sale or barter of excess catch, but does not include a person who engages on a substantial scale in the sale of fish on a commercial basis”. A new recreational permit system was introduced in January 1999, with licenses now required for harvesting of a wide range of marine species.

This paper reviews the development and management of the three most important recreational fisheries in South Africa: West Coast rock lobster, abalone and linefish. The challenges facing the South African recreational fisheries in light of resource status and the changes introduced by the Marine Living Resources Act of 1998, are highlighted.

Current Status of Resources

Rock Lobster (*Jasus lalandii*)

West Coast rock lobster are distributed generally close to shore from about 23^0S, just north of Walvis Bay in Namibia, to about 28^0S, near East London in South Africa (Fig. 1). Commercial densities are, however, only encountered along the west coast from about 25^0S in Namibia to slightly east of the Cape of Good Hope in South Africa (Pollock 1986).

Commercial exploitation of this resource started in the late nineteenth century with catches levelling off at about 10 000 tons during the 1950s to early 1960s.Catches declined during the 1960s, probably because of overfishing (Cockcroft and Payne in press) and then stabilized at 3 500 - 4 000 tons (landed mass) per annum in the 1980s.It was during this period that a permit requirement for recreational rock lobster fishing

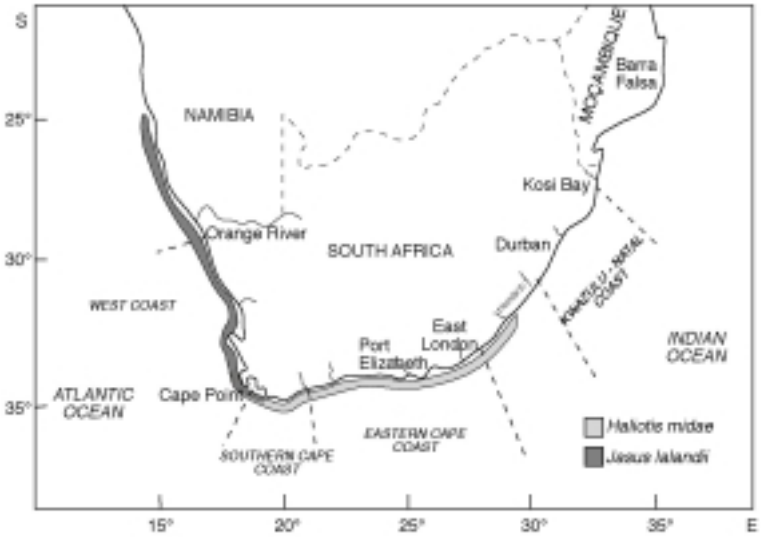

Figure 1. The major commercial and recreational fishing areas for West Coast rock lobster (*Jasus lalandii*) and the distribution of abalone (*Haliotis midae*) along the South African coast. The four regions used in the 1994 - 1996 linefish surveys are demarcated within the dotted lines.

was introduced. The stability in the commercial fishery ended after 1989 when commercial catch rates dropped dramatically. This was considered to be the direct result of reduced somatic growth rates which resulted in decreased recruitment to the component of the resource above the minimum size (Melville-Smith *et al.* 1995; Cockcroft and Goosen 1995, Cockcroft 1997). The history of the commercial fishery has been documented in Pollock (1986, 1994) and Cockcroft and Payne (in press). Extensive size based modelling assessments conducted during this period indicated that the resource was heavily depleted, with the harvestable component of the population at about 5% of its pre-exploitation level (Cockcroft and Payne *in press*).

Abalone (*Haliotis midae*)

The South African abalone is found in shallow waters around 1400km of the coast of South Africa from Transkei on the east coast to the vicinity of Cape Columbine on the west coast (Fig. 1). The majority of the population occurs in less than 10m water depth, making them readily accessible to snorkelers. Commercial exploitation of abalone began in 1949, and reached a peak harvest of 2800t in 1965. Concern over declining catches resulted in the imposition of quota controls, which first limited commercial landings in 1970 to a production quota of 227t. Since then the annual quotas have been reduced gradually in a series of steps from around 700t to the present level of 515t for the 1998/99 season. The history of the commercial fishery has been documented in Tarr (1992) and Tarr (1999).

The abalone resource is currently under severe pressure from a variety of sources. Poaching has escalated to epidemic proportions since 1994 with poachers increasingly targeting sublegal size animals. A decrease in TAC from 150t to 15t over a seven-year period in one of the commercial fishing sectors is considered largely due to poaching. In addition, the movement of lobster into the area east of Cape Hangklip, the area in which the bulk of commercial and recreational harvesting occurs, has resulted in the collapse of the sea urchin (*Parechinus angulosus*) population with a concomitant severe decrease in juvenile abalone survival (Tarr *et al.* 1996). Age structured modelling shows the South African abalone resource to be overexploited (C. Moloney, Marine and Coastal Management pers. comm.).

Linefishery

The linefishery operates over the entire some 3000km of South African coastline, exploiting more than 200 demersal and pelagic fishes, of which 95 are regarded as important. The fishery includes recreational, commercial and subsistence components. The commercial component is boat-based and operates on the continental shelf in depths of 5 m to 200 m. The recreational component consists of several sectors, including estuarine anglers, who fish from boats or the shore; rock and surf anglers; a lineboat sector which operates in a similar environment to the commercial component; and a recreational spearfishing sector

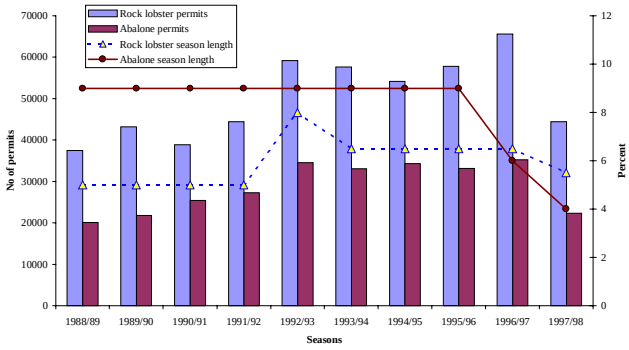

Figure 2. Number of West coast rock lobster and abalone recreational permits sold in relation to season length.

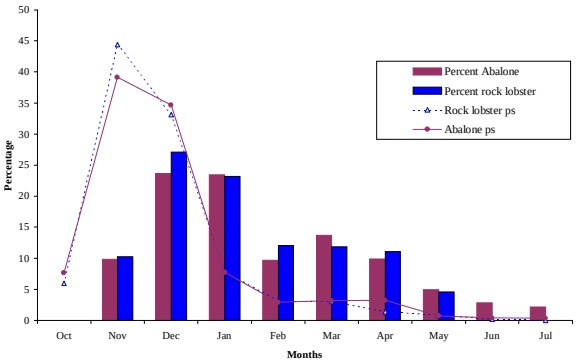

Figure 3. Monthly rock lobster and abalone permits sales (as % of total annual sales) and monthly landings (as a % of total annual landings) over the study period.

operating from boats and the shore.

Analysis of historical data and recent stock assessments indicate that many linefishes, including so-called resilient species, are severely overexploited (Griffiths 1997a&b, 1999). In addition, research surveys reveal that many of the current regulations are failing to limit recreational catch (Attwood and Bennett 1995, Griffiths 1997a). Owing to the high degree of overlap in species exploited by the various sectors, commercial fishing (including trawling) is most often blamed for perceived catch declines (Sauer *et al.* 1997, Brouwer *et al.* 1997). However, recent stock assessments reveal that South African recreational fishers have been directly responsible for the depletion of several species, including representatives of the Sparidae (Bennett 1993), Coricinidae (Bennett 1988) and Sciaenidae (Griffiths 1997a).

Methods used in assessing South African recreational fisheries

Rock lobster and abalone

An attempt at obtaining information from rock lobster and abalone recreational permits holders via voluntary catch returns was initiated in 1983. The reverse side of the permits were modified to allow for the voluntary return of catch data (including numbers caught and area fished per month). The voluntary return of data proved a total failure with only 0.8% of permits returned in the first year and even less in the following seasons.

Multi-stage telephone interview surveys conducted by a professional survey company were commissioned to conduct the surveys on rock lobster and abalone recreational permit holders during the recreational season in 1991/92. The success of this approach resulted in the continuation of these annual assessments on both abalone and rock lobster recreational permit holders to date (with the exception of rock lobster in 1995/96). A detailed description of the questions asked and methodology used to calculate the volumes removed by the recreational sector are given in Cockcroft and Mackenzie (1997)

Linefish

Given the limitations associated with the compulsory commercial catch returns (Penny 1999) and voluntary recreational data (Mann-Lang 1996) collected for the linefishery, a two-year national survey was initiated in 1994. These surveys were aimed at evaluating the catches, socio-economic aspects and attitudes of the main sectors participating in the linefishery. The survey design included the division of the coastline into five regions (Fig. 1) with the following techniques - aerial surveys, roving creel surveys, access point surveys and interviews/questionnaires – employed in each (Sauer *et al.* 1997, Brouwer *et al.* 1997). Due to logistical constraints, estuaries and the Transkei region were excluded from the initial survey.

Current status of recreational fisheries

Rock lobster and Abalone

Recreational permit sales for rock lobster and abalone were fairly consistent during the late 1980s early 1990s (Fig. 2). The 33% increase in the sale of rock lobster recreational permits in the 1992/93 season (compared to the previous season) was a direct result of the increased recreational season length (from five months in 1991/92 to 8 months in 1992/93) combined with the re-

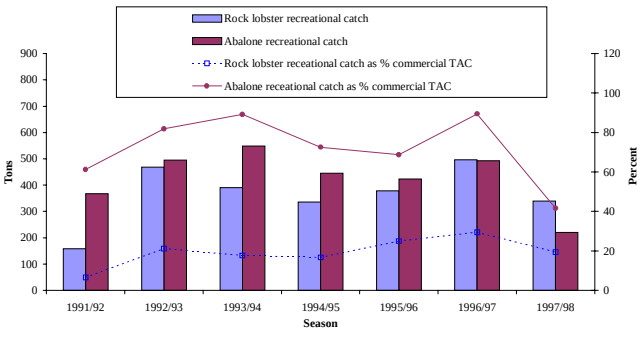

Figure 4. Rock lobster and abalone recreational catches (tons) and these expressed as a % of commercial Total Allowable Catch for the period 1991/92 – 1997/98

Figure 4. Rock lobster and abalone recreational catches (tonnes) and thses expressed as a % of commercial Total Allowable Catch for the period 1991/92 – 1997/98.

	Sector			
	Rock & Surf[1,5]	Recreational boat[2,5]	Commercial Boat[3]	Spearfishing[4]
Participants	412 000	12 054 (3444 boats)	18 583 (2581 boats)	7 000
Annual Catch	2836t	5118t	16 671t	214t

Table 1. Estimated total catch and number of participants in the four main sectors of the linefishery (1994-1996). Commercial data from National Marine Linefish System of Marine and Coastal Management. [1]Brouwer *et al.* (1997), [2]Sauer *et al.* (1997), [3] NMLS, [4]Mann *et al.* (1997), [5]McGrath *et al.* (1997)

duction of the legal minimum size for recreational caught lobsters over the same period. The dramatic decrease in the sale of recreational permits for both species in 1997/98 was a direct result of a moratorium being placed on the sale of recreational fishing permits when one third of the season had elapsed. The purchase of recreational permits for both species showed a clear within-season trend. On average, more than 80% of the annual permit sales for both abalone and rock lobster were made by the end of December and 90% were purchased by the end of January (Fig. 3). The bulk (>50%) of the annual recreational lobster and abalone catches are usually landed by the end of January which is consistent with the trend in permit sales. The favourable weather and fishing conditions coupled with the annual summer holiday period are considered the major factors influencing this early season peak in recreational landings.

The demographic information obtained directly from the permits indicates that the bulk of the recreational fishing for abalone and rock lobster is done by males (around 80%) between the ages of 25 - 49 years. Most are Afrikaans or English speaking with less than 1% of permit holders belonging to other language groups. About 90% of permit holders are resident in areas within relatively easy access to the resource which contrasts with the popular perception that people from outside the nearby areas (holiday makers etc) are responsible for a large proportion of the annual recreational catch.

The majority (about 70%) of both rock lobster and abalone permit holders fish throughout the season (as opposed to holidays only) and fishing is mainly (70%) conducted over weekends (as opposed to throughout the week). The majority of both rock lobster and abalone recreational permit holders could be regarded as experienced fishermen with 79 % (rock lobster) and 84 % (abalone) of permit holders in 1997/98 having taken out a permit the previous season. The fact that 47% of rock lobster permit holders had recreational abalone permits and 80% of recreational abalone permit holders held rock lobster licenses in 197/98, further highlights the similarities in these recreational fisheries.

Recreational abalone fisher may only dive from shore, and only with snorkelling equipment. Breath hold diving (45%) and the use of hoopnets from motor powered boats (35%) are the most popular capture methods used by recreational rock lobster fishermen with shore based methods (5%) and the use of hoopnets from rowing boats (15%) of lesser importance.

The annual recreational landings of both species increased markedly in the 1992/93 season and then remained relatively stable (around 350 -500 tons for rock lobster and 420 - 550 tons for abalone) until the 1997/98 season (Fig. 4). Recreational landings as a percentage of commercial TAC for both species followed similar trends, reaching peak levels (abalone 90% and rock lobster 30%) in 1996/97. A sizeable decrease in the commercial TACs for both species coupled to a modest increase in recreational landings was responsible for this peak in 1996/97. By comparison, the recreational rock lobster catch for *P. cygnus* in Western Australia was 5.9% of the commercial catches in 1993/94 (Chubb and Melville-Smith 1996) and recreational landings of abalone in Western Australia are 150% of that of the commercial fishery (Gardiner and Young 1995).

The dramatic decrease in the recreational landings of both species in 1997/98 was a direct result of management measures aimed at limiting the estimated recreational landings. These 'savings' were allocated to subsistence fishermen as an interim relief measure prior to the implementation of the new Marine Living Resources Act.

Linefish

Given the limited information on recreational fishing available in the Cape Province prior to the surveys described above and the biases associated with recreational competition and voluntary catch return data in KwaZulu-Natal (Mann-Lang 1996)this section is based on the surveys conducted from 1994 – 1996.

Recreational fishermen (including spearfishers) constituted some 96% of the total participants in the linefishery. Rock & surf anglers constitute by far the largest sector (92%) with the commercial boat (4%); recreational boat (3%) and spearfishing (1%) sectors constituting the remainder. The commercial boat fisher, however, land the bulk (67%) of the total linefish catch with the recreational boat sector landing some 21%, rock and surf anglers 11% and about 1% (Table 1). Owing largely to differences in operational habitat, and to some extent fishing method (e.g. spearfishers also target non-angling species) and targeting, the degree of overlap in inter-sector comparisons of catch composition is highly variable. Competition is obviously highest between commercial and recreational marine boat-based fisheries as fishing grounds and methods are most similar.

Densities of shore anglers (anglers/km) were lowest (0.4) on the west and the eastern Cape coasts, intermediate (1.3) on the Southern Cape Coast and highest (7.2) in KwaZulu-Natal (Brouwer *et al*. 1997). The number of boats used for recreational fishing as a proportion of total number of boats fishing shows a clear trend from west to east. Of the total vessels active in each region (Fig. 1), recreational vessels accounted for about 4% on the west coast, 6% in the Southern Cape, 42% in the Eastern Cape and 94% in KwaZulu-Natal (Sauer *et al*. 1997). Recreational linefishing sectors are estimated to be growing at a rate of 2% (McGrath *et al*. 1997) and the spearfishery at 6% per annum (Mann *et al*. 1997). Demand for access to the resource is therefore expected increase, accordingly.

McGrath *et al*. 1997 estimated that the linefishery (all sectors combined) made an important contribution (direct and indirect) to the coastal economies, contributing 1.3% of gross geographic product (GGP) and generating employment opportunities for about 131 500 people. Recreational shore angling was found the most significant, contributing 76.3% of the GGP attributable to the total linefishery.

The challenges

The challenges facing the commercial, recreational and newly created subsistence sectors in these fisheries are inextricably linked and directly related to the status of the resources (stock status). While redressing the imbalances of the past in terms of access to resources, the new Marine Living Resources Act also has as objectives the rebuilding of over-exploited stocks and the maintenance of fish populations at levels consistent with their roles in the ecosystem. The balancing of these objectives within the framework of a depressed economy provides enormous challenges to managers.

The permitting of subsistence fishers has been delayed until the year 2000 and a special task team has been appointed to deal with a wide range of issues arising from this new dispensation. However, prior to the implementation of the Marine Living Resources Act, 1 000 rock lobster (928 activated), 250 abalone (239 activated) and 820 linefish subsistence permits were introduced as an interim relief measure in early 1998. These permits allowed the sale of the recreational daily bag limit for rock lobster and abalone (4 per person per day – same size limit as recreational fishery) and the recreational daily bag limit for two specified linefish species (10 per species per day). All other restrictions pertaining to the recreational fishery remained in force for these permits. In order to accommodate these new participants while not exceeding the TAC allocated to the rock lobster and abalone fisheries, the recreational sector was cut by reducing season length and placing a moratorium on permit sales. This resulted in major conflict and the weekend only fishing restriction was overturned in court. Persons issued with interim relief permits in 1998 were allowed to continue subsistence harvesting in 1999.

While the challenges listed below are directed at rock lobster, abalone and linefish, many are directly applicable to other fisheries that will include both recreational and subsistence sectors in future.

Challenges facing the TAC controlled fisheries (rock lobster and abalone)

The rock lobster, linefish and especially abalone resources are currently under pressure. Abalone resources are known to be vulnerable to collapse, with poaching and recreational fishing cited as reasons for the collapse of the Mexican and Californian abalone fisheries (McShane 1992). The likelihood of a substantial increase in global TACs (lobster and abalone only) in the short term is small, with the abalone TAC more likely to decrease. The Marine Living Resources Act gives the Minister of Environmental Affairs and Tourism the sole right to apportion the global TAC between the three sectors. The introduction of the new subsistence sector (in the interim relief phase) has meant a sacrifice from existing recreational sectors. Any further increase in the subsistence sectors will therefore result in a further decrease in recreational and/or commercial allocation. This is

further compounded by transformation within the commercial sectors (as required by the Act) with more participants from previously disadvantaged backgrounds now rights holders, and the great need for employment in the country. The number of applications for subsistence permits to harvest these highly lucrative species from the year 2000 onwards is expected to be high and the pressure to expand this sector great. A study, which will address the benefits of each of the sectors using a number of clearly defined criteria, is clearly a major priority. This would greatly assist the relevant minister in making decisions regarding the allocation of TAC to the various sectors.

Apart from the above, sources of conflict between the sectors usually arise from overlap of fishing areas and differences in restrictions governing the sectors. Conflict is more likely between the subsistence and recreational sectors, as their fishing areas are exactly the same and the initial restrictions governing these sectors (interim relief phase) were similar. Recreational fishing for abalone was restricted to weekends only in 1999 but subsistence fishing is allowed throughout the week (including weekends). A separation of fishing periods (for example, subsistence fishing restricted to during the week and recreational fishing restricted weekends and public holidays only) may help to reduce conflict and assist enforcement.

A major challenge is and will be the acquisition of information from subsistence fishers. Despite specific permit conditions which required the submission of catch data on a logbook supplied with the subsistence (interim relief) permit, and clear instruction that these were to be returned to a local inspector, almost no catch data was received from this sector. This was not totally unexpected (given the failure of this method for recreational sector), as many subsistence fishers are illiterate and live in remote areas. A method or methods to obtain accurate catch data from the subsistence fishing sector is therefore a major priority. The introduction of coastal monitors who would fulfil the role of observers and data collectors for a wide range of fisheries and fishing sectors is a possible way forward (see point 1 below). The use of telephone surveys has been shown to be an effective and consistent means of assessing the recreational fishing sector and should be continued.

The transformation of the subsistence sectors involved in TAC controlled fisheries such as rock lobster and abalone into small scale commercial operations has been proposed as a way of reducing conflict while maximising the economic benefits to participants.

Challenges facing the linefishery (effort controlled fishery)

The major challenge facing the linefishery is the need for improved data gathering from all fishing sectors. The limitations associated with catch returns (voluntary or compulsory) and snapshot surveys have been clearly highlighted (Mann-Lang 1996, Penney 1999). A decision to collect future linefish catch and effort (as well as biological) data by means of observers has made by management and an observer programme covering all major boat-based access points is currently being implemented. It is intended that this will expand to include data from shore anglers (recreational and subsistence) collected during enforcement patrols and access point inspections. Lack of enforcement capacity in certain regions may, however, require supplementation of the latter via snapshot surveys. In addition telephone surveys, facilitated by the introduction of a marine angling permit in 1999, will be used to provide independent catch estimates as well as socio-economic information.

Given the depleted status of the resources a new Management Plan was recently proposed for the linefishery in which regulations are based on quantifiable reference points. (Griffiths *et al.* 1999). In an attempt to achieve these aims, considerable revision of both size and bag limits are envisaged in the near future. Any difference in the application of these regulations to the subsistence and recreational sectors is bound to result in conflict.

Conclusions

Notwithstanding the policies contained in the new Marine Living Resources Act and recent advances in the development of management procedures or the efficacy of the regulations emanating from them, the success of fisheries management depends heavily on the degree of user compliance, which is often a function of enforcement level (Hemming and Pierce 1997). Inadequate enforcement and illegal fishing are a major concern for the future of the South African nearshore fisheries. There is therefore a need for education and awareness programs, and a substantial increase in the numbers of enforcement officers (particularly in the Cape Provinces). Unless these issues are appropriately addressed, reversal of declining trends and the rebuilding of depleted stocks for the benefit of all user groups will not be possible.

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Questions

Murray MacDonald: You spoke about allocation of the Total Allowable catches for some species to competing user groups (commercial, recreational, subsistence). What mechanisms or processes are used to decide what constitutes and appropriate allocation of the TAC? Are there any indications in fisheries legislation or policy documents as to who has the right to benefit from fish resource allocation decisions?

Andy Cockcroft: There are pointers in the legislation. I guess it would be best for me to direct that question to our Chief Director, Monde Mayekiso.

Monde Mayekiso. It is political in the sense that the minister depends on votes. In making any changes to the allocation, the minister has to consider the sector such changes impact on and the minimum pain he/she will bear from such decisions.

Andy Cockcroft: The subsistence fishery is being addressed because of the poverty.

FISHCOUNT: An innovative design for the collection of recreational fishing data

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Introduction

Recreational fishing has always been a major pursuit of residents and visitors to the Northern Territory (NT), Australia. Abundant fish stocks, accessible waterways and favorable weather combine to provide a fishing experience unparalleled in Australia.

While commercial fishing activities are quantified through a reporting system attached to license requirements, data on recreational fishing effort was imprecise and anecdotal at best. The comparatively high cost of recreational fisheries research has resulted in a lack of detailed information about this sector, particularly on a 'big-picture' basis for total catch and effort by target species. This is especially the case in the NT, where logistical problems render any widespread use of conventional recreational fisheries research methods (e.g. creel surveys) cost-prohibitive.

In the NT, the Fisheries Division (Department of Primary Industry and Fisheries) has conducted certain area-specific recreational fisheries research (Griffin 1992 -1996). However, the comparatively small scale and spatially isolated nature of these studies means they have contributed only in a limited way to broader data requirements. In 1986, Touche Ross Services conducted a study of recreational fishing. This was the first attempt to assess the whole of the recreational fishery in the NT. This study has been used to describe the nature and magnitude of the recreational sector, however it provided limited sample representation and made uncertain assumptions regarding visitors. In addition, the results are becoming increasingly outdated.

The NT Government, through the Fisheries Division undertook a major survey to provide the vital 'big picture' information about recreational fishing in the Northern Territory, with a primary focus on total catch and effort assessment for the key species.

Principles underlying the survey design

The aim of the survey constrained the type of data collection methods that could be used. Creel surveys, where the information is collected from the recreational fisher while the recreational fisher is still fishing, or when the fishing party returns to the boat ramp, are generally expensive to run. It would also be impractical and cost-prohibitive to ensure coverage of the whole of the NT using this type of technique only.

Conventional recall surveys, where respondents are asked about detailed fishing activity for the previous year, are very unreliable. Recall over 2 months has been shown to be inaccurate, and annual recall data produce large over-estimates of catch and under-estimates of expenditure (Pollock *et al.* 1994). A methodology was required that collected fishing activity information soon after it had occurred, to minimise any recall bias.

To overcome the problem of recall bias, recreational fishing surveys often issue fishing logbooks to respondents and they are expected to document their own fishing activities in the book for a certain period of time. However, the data collected by logbooks are usually very general in nature – e.g. where different fishing activities occur, such as a change in target fishery, on a particular day, dissection of hours fished by target fishery cannot be usually achieved. This makes the repeatability of a study difficult and impossible to assess trends in catch and effort over time for particular species. For example, if between two such studies overall fishing effort does not increase, but the total catch of a species does, is this because there are more fish to catch or due to a shift in the proportion of the total fishing effort directed at the particular species? The final survey design had to be able to collect detailed fishing data and also be able to assign actual effort to a target fishery.

The other main problem with logbooks is that the total burden of maintaining the logbook lies with the respondent, so data may be incomplete or the respondent may 'drop out' of the survey altogether. An additional problem may arise when a respondent has to be 'reminded' to provide their fishing information, often this information was never put into diaries, so it is then being collected on a recall basis. An integral part of the design philosophy used in 'FISHCOUNT' therefore, was the minimisation of respondent burden, i.e. it should make little demand on the respondent and be easy for them to participate in the survey.

	1994			1995											1996	
Month	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F
	1	----------				6	----------				11	----------					
		2	----------			7	----------				12	----------					
			3	----------		8	----------				13	----------					
				4	----------	9	----------				14	----------					
					5	----------	10	----------			15	----------					
Wave #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		

Table 1. System of 'waves' in the diary phase of the survey.

The 'FISHCOUNT' methodology had to collect detailed current data and have a low respondent burden. A combined approach was used, where the respondents were contacted regularly through the diary period by the interviewers, who recorded details of any fishing or expenditure events that had occurred since the last contact. The respondents were issued with 'memory jogger' diaries to aid the recall of events if needed. This methodology did not require the respondent to maintain or submit any documentation and the impact on their time was limited. In addition, the interviewer could immediately clarify any misunderstandings. The use of interviewers in this way allowed for greater detail and reporting precision. This, in turn, provides greater data utility, for example, a day's fishing effort can be apportioned between all target fisheries involved. The low respondent burden naturally translates to substantial responsibilities on the part of the interviewer and this was addressed through careful interviewer recruitment, training and management. The additional field costs of this methodology are more than recouped in comparison to the follow-up and editing of self-administered logbooks and in the ultimate utility and accuracy of the data collected.

Survey design

The finalisation of the survey design involved extensive development, including three trial tests. The final design was a 'general population' survey, involving two different sampling and interviewing methods: random telephone interviews with NT residents and random face-to-face interviews with visitors and tourists at the establishment in which they were staying. In both cases, the survey was conducted in three parts.

- the initial survey, which asked about past and future fishing activity, along with socio-demographic questions about the household;
- the diary survey, which applied to all people from the initial survey that were intending to fish. The diary period continued for the 4 months directly after the initial survey, during which, information about fishing activity was recorded; and
- the attitudinal survey which was conducted at the end of the diary period. This final part of the survey allowed recreational fishers to express their views and opinions on recreational fishing issues in the NT.

The survey ran for over a year, in which the total sample was divided into a sub-sample of interviews which were conducted on a monthly basis, forming a series of 'waves' of initial interviews and their subsequent diary period (see following section).

The survey was conducted by the Fisheries Division using a team of specialist interviewers based in Darwin, and two other regional population centers.

Wave design

Diary survey period

'FISHCOUNT' ran for 17 months. To allow reliable data to be collected over the whole year, with a four-month diary period, the study was designed in a series of monthly 'waves' of interviews. The total sample was divided into equal sub-samples of interviews that were conducted on a monthly basis, forming the series of 'waves' of initial interviews and their subsequent diary period.

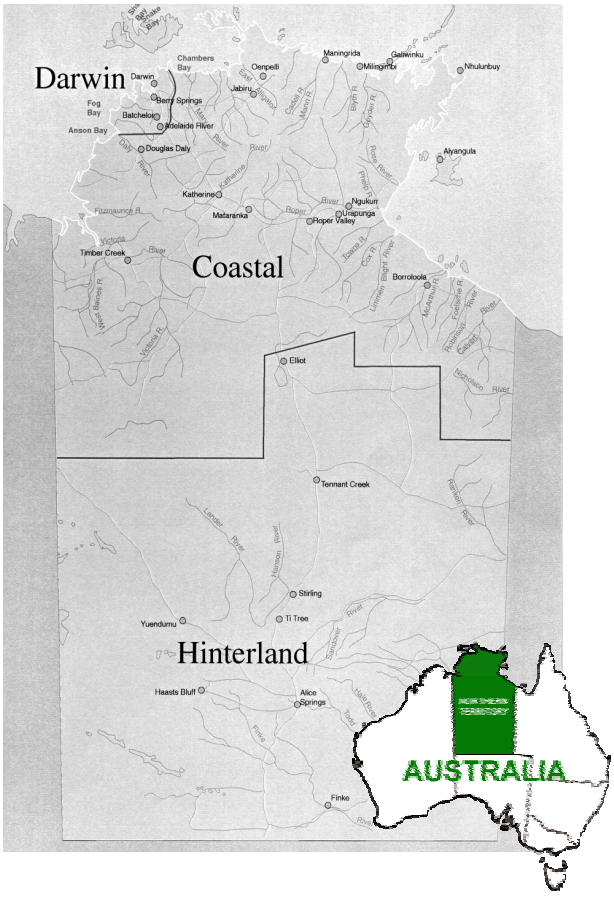

Figure 1. Map of the Northern Territory showing the sampling regions: Darwin, Coastal and Hinterland. The fourth sampling region (not indicated here) were the towns of Nhulunbuy and Katherine.

A new wave of initial interviews was conducted at the beginning of each month, with the diary period starting on the first day of the following month (Table 1). This sample design had full coverage for 12 months, from February 1995 to February 1996. At any one time, throughout this period, there were four concurrent diary 'waves', for example, in May 1995, (reading down Table 1) wave 6 is active, wave 7 has just commenced, wave 4 is about to be finalised and wave 5 is active.

As each wave was finalised, a new one commenced. The diary period for wave 12 was extended by one month, and the diary period for waves 13 to 15 were reduced to allow complete coverage and completion of the survey at the end of February 1996. This design allows for some year-to-year comparison and a gradual 'build-up' of the workload.
To ensure that no disproportionate sampling occurred within any particular area for any particular time period, the survey sample was further stratified by month, i.e. the same number of dwellings from each area were included each month.

Geographic scope

The geographic boundary for initial sampling incorporated the whole of the NT, including offshore islands. For sampling purposes however, this area has been divided into four zones (home regions) to ensure appropriate numbers were selected from each zone (see Figure 1).

These zones were for sampling procedures only. A more detailed regional system that included ocean waters along the NT coastline and adjacent islands, was used when collecting information on fishing activity. Inland areas were generally divided into basic river catchments.

Dwellings and households in scope

Two categories of dwelling were used for sampling: private dwellings (PD's) such as houses, units, apartments etc., with a home telephone number listing. The second type of dwelling was a non-private dwelling (NPD's), such as hotels, motels, guesthouses and caravan parks. Other NPD establishments such as gaols, nursing homes and staff quarters were not included. Aboriginal communities were also not included as a separate study, requiring different methodologies was proposed. The definition of a household varied within NPD's and could be a room, caravan, tent or bed, depending how the establishment was organised.
The survey questionnaire was designed so that the same interview could be conducted with a resident or visitor in either type of dwelling, for example, a permanent resident of a caravan park or a visitor in a private dwelling.

Persons in scope

For general purposes, persons included in the survey were all usual residents of either the PD or NPD selected. Usual residents who were away at the time of interview were only included if they were due to return before the end of the interview period. Respondents genuinely with 'no fixed abode' were considered as NT residents at the time of interview. All visitors were included, regardless of age, if they were staying at a PD at the time of the first contact call or were selected within a 'household' through the NPD process.

Fishing activities in scope

For the purposes of the survey, eligible fishing activity has been defined as any type of recreational fishing including

> *"prawning, crabbing, spearfishing, or even gathering oysters"*

whether anything was caught or not. This precluded commercial fishing activity, but not recreational fishing activity undertaken by a commercial fisher. Similarly, this precluded any fishing by a fishing tour operator during a tour, but not fishing activity by a respondent whilst on a tour.

Quality control and validation

A rigorous approach to quality control was applied to all phases of the survey, from design through to analysis and reporting. The need to ensure data quality was addressed in the design phase of the survey, with the wording and order of survey questions, together with the low respondent burden, designed to minimise bias and other response errors. Thorough training and supervision of the interviewers, coupled with follow-up re-interviews ensured interviewer reliability and integrity. Completed questionnaires were systematically checked and comprehensive computer editing checks were also undertaken.

The validation work associated with 'FISHCOUNT' was essential to maximise the validity and utility of the data collected. The validation depended on three sources of information: current projects within the Division, including concurrent creel surveys of localised areas, specifically designed components within the survey and secondary data sets. The major issues for validation were sample representation and data-reporting quality.

Sample coverage/representation

Validation of sample coverage and representation investigates any part of the overall sample that is known to have been missed, and assesses if it is different to that actually sampled. In this case, the sample did not include residents who did not have a listing in the Telstra 'White Pages' [*Aussie telephone book. Ed*]. The exact proportion of households without a telephone listing is unknown for commercial and privacy reasons, however, household phone ownership is known to be high. To assess whether non-phone owners have different fishing behaviour to phone owners, respondents from validation creel surveys were questioned about phone ownership. Catch rates and fishing behaviour were examined for non-phone and phone owners. There were no significant differences between resident non-phone and phone owners in the number of days previously fished (Pearson Chi-square, 6.7, df = 4, $p > 0.05$) or in the catch rates for barramundi or other fish from Darwin Harbour ($t_{0.05,(2),326}$, $p > 0.05$). It was therefore assumed that respondents contacted during the survey were representative of the total resident population.

Data reporting quality

A number of biases and other issues affecting data quality can impact on recreational fishing surveys. The following validation and design elements addressed these data quality issues:

- Recall bias, i.e. remembering or recalling information incorrectly. This bias was minimised through the survey design with frequent contact with the respondents, low respondent burden and use of the 'memory-jogger' diaries;
- Prestige bias, i.e. reporting more fish in less time. This bias was not encouraged through the whole general 'atmosphere' of the survey (i.e. passive nature of questioning, references to 'normal' activity and absence of leading questions) and was validated through associated creel surveys. No differences in catch rates were found between data collected during the survey and the concurrently run creel surveys in Darwin Harbour ($t_{0.05,(2),326}$, $p > 0.05$). No differences were found for overall catch rates or for catch rates from various types of targeted fishing. Additionally, similar numbers of 'zero' catches were reported during the survey and creel surveys for all targeted fishing in Darwin Harbour except for fishing with no specific target, where significantly more 'zero' catches were reported in the survey (Pearson chi-square 167.3, df =13, $p < 0.0001$);

- Species identification, i.e.. mis-reporting the species of fish caught. Identification was assessed during the associated creel surveys, during which, respondents identified 98% of fish correctly, either to the species or family level, or labelling as 'unknown'. Only 2% of fish were identified incorrectly.
- Intervention, i.e., being involved in the survey would make fishing activity more likely. The general 'atmosphere' of the survey discouraged respondents to go fishing more or less often than normal during the diary period. It was also stressed to respondents that the aim of the survey was to measure their 'normal' fishing activity.
- Change in fishing behaviour, a sample (10%) of households with resident respondents who were not intending to fish in the following 12 months were contacted at the end of each di-

ary period to confirm that no fishing had taken place. Less than 2% of these respondents had changed their minds and been fishing. This change in expected fishing behaviour has been incorporated into the expansion of fishing data for respondents.

Data processing, expansion and analysis

Resident data

The PD component of 'FISHCOUNT' was conducted by telephone from November 1994 to February 1996. A total of 3,776 households were contacted throughout the NT. There was some sample loss due to business listings (from recycling of phone numbers) and disconnected numbers, indicative of the transient nature of the NT's population. From the total sample take there was some non-response due to non-contacts (8%), and a small level of refusal to take part (6%). However, a high response rate of 86% was achieved, resulting in a sample take of 6144 respondents aged 5 years or older. Additionally, 836 resident respondents aged 5 years or older were included from NPD establishments.

Information on the number of residents in the NT for 1995, was based on the 1991 Population Census and estimated growth rates, which translated to an estimated 131,784 (non-aboriginal) residents within the study area. Comparisons of the sample take to the estimated resident population (by gender and age by region) revealed excellent alignment and it therefore was assumed to be representative of the total population. Expansion factors were applied to the sample data to multiply this data up to the NT resident, non-indigenous (aged 5 or older) population. These factors were applied both for households and individuals for each home region.

In total, 90% of resident recreational fishers eligible for the diary survey agreed to take part and 1735 (98%) completed the diary phase of the survey.

Using estimates of recreational fishing participation from the initial survey as a benchmark (42,483 resident recreational fishers), expansion factors were applied to the sample data to multiply the data up to the NT resident recreational fisher population. All data from the diary study, including estimates of fishing effort, catch and fishing-related expenditure, were expanded in a matrix covering month of year, fishing activity/inactivity and each home region.

Visitor data

The NPD component of 'FISHCOUNT' was conducted by face to face interviews from January 1995 to December 1995. A total of 2572 'households' were contacted in 92 different establishments in seven locations. Interviews were also conducted with visitors camping away from established camping accommodation. From the total sample take there was non-response due to non-contacts (8%), and a small level of refusal to take part (5%). However, a high response rate of 87% was achieved, resulting in a sample take of 2341 respondents aged 5 years or older. Additionally, 59 visitors aged 5 years or older were included from PD establishments.

Information on the number of visitors to the NT for 1995 was provided by the NT Tourist Commission obtained through the Tourism Monitor. An estimated total of 918,517 international and interstate tourists visited the NT in 1995, which translates to 911,457 visitors aged 5 or older. Expansion factors were applied to the sample data to multiply this data up to the number of visitors (aged 5 or older) to the NT. These factors were applied both for households and people in a matrix covering intercept location, length of stay, home origin, time of year (quarter) and accommodation type.

In total, 94% of visitor recreational fishers eligible for the diary survey agreed to take part and 418 (80%) completed the diary phase of the survey.
Using estimates of recreational fishing participation from the initial survey as a benchmark (108,343 visitor recreational fishers), expansion factors were applied to the sample data to multiply the data up to the total number of visitors to the NT who fished during their stay. All data from the diary study, including estimates of fishing effort, catch and fishing-related expenditure, were expanded in a matrix covering intercept location, length of stay, home origin, time of year (quarter) and accommodation type.

Results

While the survey database provides a large volume of 'benchmarking' information, this paper presents a only a summary of the key findings and estimates from the final report for the study (Coleman 1998), as the survey was also designed so that detailed data analysis could reveal any differences in terms of: seasons, residents/tourists, geographic regions and 'types' of fishing.

Resident Participation and Profiles

- over 42,000 non-indigenous NT residents (35% of the non-indigenous population) go fishing in the Northern Territory annually.
- higher participation rates emerge: in the Darwin (40%) and Coastal regions (52%), than the Hinterland (7%); among males (44%) than females (25%); and in the younger age groups, ranging from 39% (5-19 years) down to 15% (65 years or more).
- around one in every four resident households owns a pleasure boat (over 11,500 in total). Of these, 80% are at least partly used for recreational fishing annually, with 59% being exclusively used for fishing.

Visitor Participation and Profiles

- over 50,000 visitors (6% of all visitors to the Territory annually) fish at least once during their stay.
- higher participation rates emerge among interstate visitors (8%) than those from overseas (1%).
- close to half (48%) of all visiting fishers (or members of their party) bring fishing gear with them and a significant proportion (12%) bring a boat to the Territory.

Fishing Effort

- a total of over 430,000 days are fished annually by recreational fishers, representing 2.2 million hours of fishing effort.
- residents account for a majority of the effort (77% of days fished and 82% of hours) at an average of around 8 days annually (and over 5 hours per day). Visitors fish an average of 2 days during their stay (and over 4 hours per day).
- the 'dry season' (May-Aug) is more popular among residents and visitors (38% and 41% of hours fished, respectively) than the 'wet season' (Jan-Apr, 35% and 32%) and the 'build up' (Sep-Dec, 27% and 27%).
- barramundi is the most popular target species, accounting for over a third (38%) of all hours fished and visitors target barramundi to a greater extent (48% of visitor hours fished) than residents (35%).
- Darwin Harbour is the main fishing area, accounting for close to half (45%) of all hours fished,

followed by all other regions below the 11% level.

Catch

- the total recreational catch is over 1.8 million aquatic organisms annually (i.e. harvested or released), comprising over 1.6 million fish and 230,000 non-fish (including mud crabs and shellfish) species. Of these 53% of fish and 79% of non-fish species are harvested.
- tropical snappers represent the highest proportion (15%) of the total catch of all organisms and 19% of the total harvest, followed by barramundi (13% and 10%, respectively), then shellfish (5% and 9%), with all others at or below the 5% level of catch and harvest.
- Darwin Harbour accounts for 42% of the total catch, with all other areas at or below 16%.
- resident fishers account for a clear majority (87%) of the total catch of all species and higher average catch rates for fish species (0.89 fish per fisher hour) than visitors (0.58 fish per fisher hour). Similar catch rates for non-fish species were reported for both residents and visitors (0.9 and 0.89, respectively).

Expenditure and Investment

- over $30 million in total annual expenditure is directly attributable to recreational fishing, with residents accounting for a majority (over $23 million or 77%) and visitors close to $7 million (23%). Note: due to the exclusion of certain expenditure categories (e.g. accommodation), these estimates should be viewed as minima.
- further to this, resident investment in recreational fishing boats is estimated at nearly $70 million, of which over $51 million (74%) is directly attributable to fishing.

Awareness and Opinions

- while the majority of both resident (78%) and visiting fishers (56%) are aware of the existence/role of the Fisheries Division, consistently lower awareness levels emerge in terms of important fisheries legislation, such as size and possession limits for key species.
- however, almost universal support (98%) exists among recreational fishers for *"these kinds of regulations"*, with many respondents suggesting additional regulation, more enforcement and education when prompted.

Success

Excellent outcomes have been achieved from the study, particularly in terms of response rates and data quality. The success of the methodology is reflected in these very high response rates and the lack of respondent fatigue through the diary phase. For the first time in the Territory, or for that matter, in Australia, comprehensive, detailed catch and effort data has been produced for the recreational fishing sector on a broad scale.

The methodology has also been recognised nationally and will be used as a basis for a broad scale national survey on recreational fishing.

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Questions

Calvin Blood. How much did your study cost and where did you get the funding?

Ann Coleman: It cost $200 000, and we received the money from the Northern Territory Government. The national study is costing about $3 million. It is cheaper to undertake such studies using the diary method, but then one only gets a 50% response rate.

Bill Romberg: Are there federal fishing licenses in Australia?

Murray MacDonald: Recreational fishing is managed by each state government, not by the national government. The license requirements vary from State to State: some require licenses for freshwater only, some have licenses for specific marine fisheries such as abalone, but right now there are none that require a general licence for saltwater fishing. The Sate of Victoria plans to introduce an all-waters general recreational fishing licence in July 1999, and I think the other states are going to watch very carefully to see what happens in Victoria before deciding whether or not they should follow suit.

Evaluating catch-and-release angling practices from the fish's perspective

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Abstract

Traditional catch-and-release studies have focussed on hooking mortality associated with different handling and environmental conditions and biochemical indicators of stress response and recovery. These methodologies do not permit the collection of real-time data on the stress and recovery associated with the angling event. The advent of hard-wired and telemetered technologies capable of collecting information on heart rate, stroke volume, cardiac output, and axial electromyogram activity provides researchers with a powerful methodology for monitoring the response of individual fish to different stressors. We conducted studies on several fish species to examine the effects of different angling and handling practices on their physiology and behaviour. We present results on and discuss the effects of catch-and-release angling on energetic expenditure of male largemouth bass (*Micropterus salmoides*) during the parental care period; the cardiac response of smallmouth bass (*M. dolomieu*) to simulated angling of different duration and temperatures; and the effects of air exposure on the cardiac physiology of brown trout (*Salmo trutta*). We describe how these technologies are applicable to studies of catch-and-release angling and on their advantages and limitations over conventional methodologies. We also propose a series of desirable characteristics that we feel would be embodied in the 'ideal' measure of the response of fish to angling related stressors. These ideal criteria will assist scientists in determining an appropriate study methodology to obtain the most comprehensive data for their desired objectives.

Introduction

Recreational anglers are increasingly participating in non-consumptive fishing (catch-and-release angling or some form of selective harvest) (Quinn 1996). These practices have arisen due to the over-harvest of fisheries and the subsequent imposition of regulations (Redmond 1986) as well as a significant amount of voluntary release (Quinn 1989). An important tenet of catch-and-release angling is the assumption that the majority of fish that are released do not have substantial physical injuries, physiological disturbances, or behavioural disruptions that could lead to delayed mortality. When fish do not die, they still may, however, have to deal with homeostatic disruptions which may further increase vulnerability to predation, increase disease susceptibility, or reduce foraging or parental care efficiency (Wedemeyer 1970). To date, there have been numerous studies which have evaluated the impacts of catch-and-release angling at several different biological levels ranging from molecular and cellular to the individual and even the population (Heath 1990).

Many hooking mortality studies have documented high survival rates for fish angled and released (Muoneke and Childress 1994). Very few studies, however, have monitored the physiological disturbance associated with angling and handling and the subsequent recovery of free swimming fish following release. Although high survival rates are fundamental to the success of non-consumptive fishing, it is equally important that the angling disturbance does not have any lasting impacts or sublethal effects that may decrease fitness.

Fish respond to stress with a series of defence mechanisms that are generally energetically demanding, and thus costly in terms of metabolic resources (Barton and Iwama 1991). High intensity anaerobic exercise, which is experienced during exhaustive catch-and-release angling, results in physiological disturbances which are intimately related to metabolism, including glycogen depletion, ATP and PCr alterations, and the accumulation of anaerobic metabolic end products (e.g. lactate, protons (H+)) (Dreidzic and Hochachka 1978; Milligan and Wood 1986). These metabolite disturbances induce a suite of metabolic and respiratory blood acidoses, which further result in ionic imbalances and osmoregulatory disruptions as well as elevating cardiac output (Wood 1991). Although difficult to define, acute sublethal stressors are believed to impair various physiological processes and likely result in altered behaviour and depressed reproductive capabilities that may lead to a decline in the fitness of the population (Heath 1990).

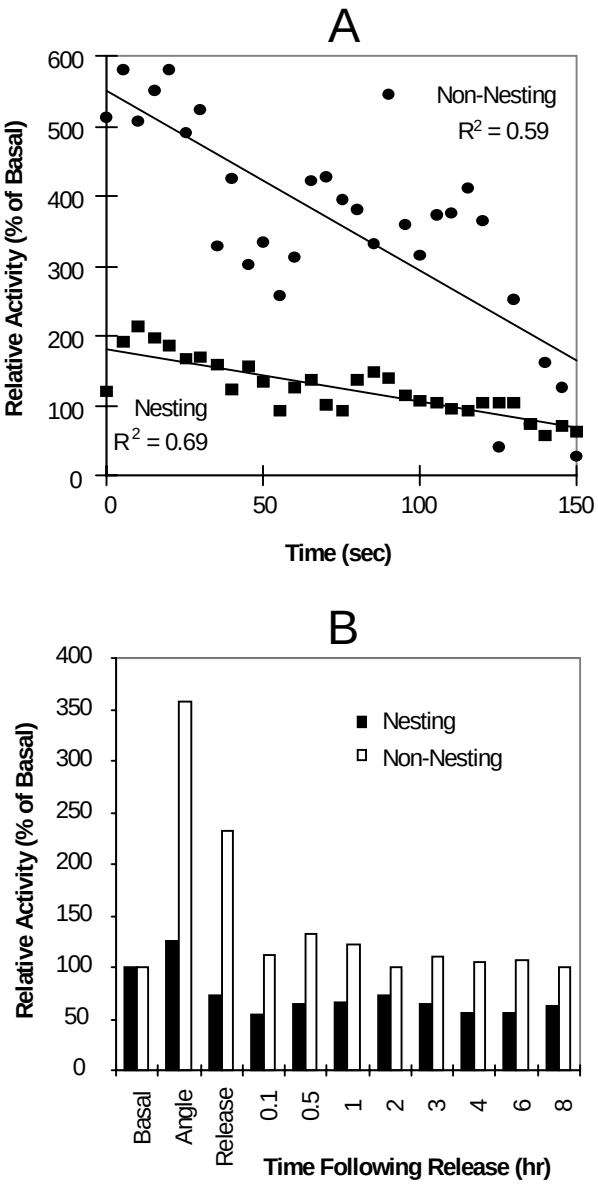

Figure 1. (A) Exhaustion patterns of 4 nesting and 2 non-nesting largemouth bass during 150 seconds of angling. Basal activity of 100% indicates the activity level of fish prior to angling. (B) Comparative recovery patterns of nesting and non-nesting fish relative to basal levels (100%). The first category column represents basal (Basal), the second represents the angling intensity (Angle), and the third represents the first minute of release (Release). The next columns are all in hours from release.

Although we are beginning to better understand why fish may die after severe exercise and handling from research conducted in laboratories (Wood et a. 1983), we still know relatively little about the behaviour and physiology of free swimming fish following release. In this paper, we highlight a series of novel approaches for monitoring the disturbances associated with angling and discuss how these tools may help us to better understand the recovery patterns and the energetic costs associated with these disturbances. In addition, we describe a set of desirable characteristics which we feel would be embodied in the ideal measure of the response of fish to angling related stressors. The approaches that we describe are beginning to be applied to free swimming fish in non-laboratory settings, allowing for a better understanding of how fish respond to these stressors from the perspective of the animal.

Traditional methodologies

As the awareness of catch-and-release angling has grown, so has the number of studies addressing the effects of these practices. Studies have ranged from being purely observational to recent studies that have undertaken an experimental approach. A brief review of the different methods for studying catch-and-release angling highlights the basic principles behind the methods and provides some key references on the subject.

Hooking injury and mortality

Studies of physical injury and hooking mortality are common (Muoneke and Childress 1994) and can be conducted by using mark-recapture techniques or by holding fish in artificial or natural environments. Physical injury usually involves some sort of description of tissue damage or some form of subjective classification (e.g. mild, extreme). Hooking mortality is simply the proportion of fish that do not survive beyond a predetermined recovery period.

One problem with assessing survival by holding fish after capture, is the potential additive stress of the holding methods which may bias mortality estimates (Wright 1970). The biases associated with tag loss and poor tag reporting are major confounding variables in mark-recapture studies involving external tagging (Candy *et al.* 1996). Nonetheless, external marking programs have been used effectively for assessing catch-and-release (Jagielo 1999). Although hooking injury and mortality studies are still common, they have given way to methodologies that are capable of detecting sublethal effects.

Blood and Muscle Biochemistry

Haematological studies of catch-and-release impacts began in the mid-1970's and have become quite common (e.g. Wydoski *et al.* 1976; Beggs *et al.* 1980; Gustaveson *et al.* 1991; Tufts *et al.* 1991). These studies can provide important information on the magnitude of physiological disturbance and the duration required for hematological parameters to recover. Common parameters assessed include plasma lactate, glucose, and chloride. These studies are limited by the finite volume of blood that may be sampled from fish without resulting in further physiological responses. In many situations, the fish are sampled terminally. This results in the sequential collection of samples from different individuals that may affect the resolution of such studies.

Studies have also assessed the physiological disturbance to white skeletal muscle. White muscle is used extensively during anaerobic burst swimming that is often encountered during angling (Ferguson *et al.* 1993; Booth *et al.* 1995; Kieffer *et al.* 1995). Similar to hematology, these tissue analyses can provide information on the magnitude of physiological disturbance and recovery duration. White muscle acid-base and metabolite status (primarily muscle lactate, muscle pH, and metabolic protons) are often used as indicators of stress. Studies involving white muscle analyses are particularly invasive, as they almost always require terminal sampling.

Some of this blood and tissue work has been further augmented by basic exercise physiology studies conducted in laboratories. These studies have had a less applied slant, but have nonetheless been useful in the understanding of catch-and-release impacts (Black 1957; Wood *et al.* 1983).

Novel approaches

Direct assessments of activity levels and other behavioural or physiological parameters displayed by free swimming fish are difficult to obtain (Beamish 1978; Scherer 1992). However, recent advances in the miniaturization of telemetry devices has permitted the development of systems capable of relaying information on fish location, behaviour, and physiology (Winter 1996) which in some cases serve as indicators of activity and metabolism (Lucas *et al.* 1993). The basic principle behind telemetry involves attaching a device to the organism and either transmitting the data to a receiver, or storing it until the device can be retrieved and the data downloaded. The primary benefit of such technology is the ability to collect data from the organism without disrupting its behaviour or physiology. This requires testing the assumption that the transmitter or the attachment procedure does not effect the fish. As technology changes we will undoubtedly be able to remotely monitor numerous physiological and behavioural parameters in free swimming fish (Stasko and Pincock 1977; Baras 1991). We are currently limited to locational telemetry, electromyogram (EMG) telemetry, heart rate telemetry, and hard-wired cardiac output. Several researchers have had limited success using other telemetry methods including ventilation rates (Rogers and Weatherley 1983) and tailbeat frequency (Johnstone *et al.* 1992) but they have not become readily available in the commercial market.

Conventional locational telemetry

Since 1957, conventional locational telemetry has been used to study the free-swimming behaviour of numerous species (Baras 1991), but only in several recent accounts has this technology been applied to studies on catch-and-release angling. Locational telemetry involves attaching a radio or ultrasonic transmitter to the organism and then locating the fish using a manual tracking system or a fixed antenna or hydrophone array.

The most common application of telemetry to catch-and-release angling has been to examine the post-release behaviour of fish displaced from where they were caught. This activity commonly occurs in competitive angling events (Ridgway and Shuter 1996; Stang *et al.* 1996). Several other telemetric studies have used the mobility of fish after release as indications that they survived the catch-and-release angling event (Jolley and Irby 1979; Bendock and Alexandersdottir 1993; Skomal and Chase 1997). In all cases, fish were captured by angling, affixed with transmitters and then released. The post-release behaviour and survivorship was assessed for a period of up to several days or until the fish could no longer be located. In some cases, temperature sensitive transmitters were used (Bettoli and Osborne 1998). When fish exhibited negligible movement, and when water temperature data indicated consistently low temperatures indicative of resting on bottom, the fish were determined to be dead (Bettoli and Osborne 1998). Other researchers have used pressure-sensitive depth tags to examine fish behaviour and survival relative to thermal and oxygen stratification following hooking (Lee and Bergersen 1996).

Perhaps the biggest limitation of any of these techniques, is that it is difficult to obtain informa-

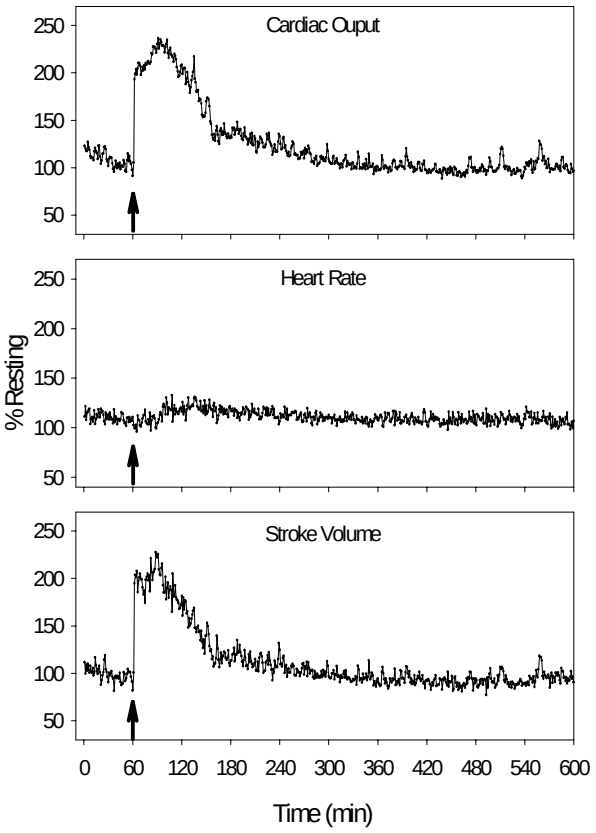

Figure 2. Example of cardiac response to simulated angling and air exposure in brown trout acclimated to 12°C, angled for 1 min, and exposed to air for 10 sec. The angling event was simulated by harassing the fish to elicit burst swimming within a 1x 0.5 m tank. Fish were exposed to air within **a** wetted sling. All values are percent resting with resting equal to 100%. The arrows denote the beginning of the angling event which always occurs at time = 60 min.

tion on control specimens. The confounding effect of tagging usually cannot be separated from being hooked and released (Bettoli and Osborne 1998). As such, these studies become more observational than experimental. These studies can also become logistically difficult when dealing with species that are highly mobile. Concentrated tracking efforts extending around the clock are required to obtain sufficient data.

EMG Telemetry

Commercially available transmitters (EMG, Lotek Engineering Inc., Newmarket, ON) capable of detecting the fine-scale activity patterns (electromyograms) of fish are becoming widely used in fisheries science. Electromyograms are records of bioelectric potentials that are strongly correlated with the strength and duration of muscle contraction. Electrodes implanted in the axial swimming musculature detect this activity, and emit signals when a predetermined threshold has been achieved. Using a respirometer, EMG transmitters can be calibrated to swimming speed and oxygen consumption, permitting *in situ* estimates of metabolic activity of free swimming fish. Further details on these transmitters and their applications are available in Kaseloo *et al.* (1992) and Beddow and McKinley (1999).

Changes in the activity levels of fish have recently been observed to be sensitive indicators of stress (Schreck 1990; Scherer 1992; Schreck *et al.* 1997). Therefore, efforts to understand the behavioural impacts of catch-and-release angling should focus on activity levels. Behavioural changes in free swimming fish have been difficult to quantify *in situ* until the recent development of the EMG transmitter (Scherer 1992). However, oxygen consumption estimates obtained from electromyogram activity that have been calibrated in respirometers have limited utility in studies of catch-and-release angling. Following release, while the oxygen debt is repaid (Gaesser and Brooks 1984; Scarabello *et al.* 1991), the fish may remain motionless. Oxygen consumption estimates based upon EMG signals would suggest that the metabolic rate is depressed, when in fact, oxygen consumption may often be higher than if a fish were resting or swimming at low speeds.

For this reason, Anderson *et al.* (1998) concluded that EMG telemetry has limited utility for studies of catch-and-release angling. This technology would, however, be useful for monitoring catch-and-release where the amount of locomotory activity displayed by fish is particularly important and relevant to the life history of a species (e.g. migrations, parental care). Electromyogram telemetry may better detect fine scale locomotory activity following release to better understand how long fish exhibit depressed or elevated activity levels. Demers *et al.* (1996) report that largemouth bass (*Micropterus salmoides*) and smallmouth bass (*M. dolomieu*) expended a significant portion of their daily activity budget undertaking localized movements which would be undetectable using conventional telemetric methods.

Case study:
Largemouth Bass Nesting Impacts

We examined the extent that the physiological disturbance associated with angling disrupted the ability of nest-guarding male largemouth bass to provide parental care activities (e.g. nest defense, fanning). Nest guarding fish expended less energy during angling compared to control males angled at the same time (Figure 1a) likely due to the already compromised state of these individuals. This time period is known to be energetically costly due to the actual spawning act, the constant parental care activity, and the limited food intake during this period (Thorp *et al.* 1989). In addition, the results suggested that following release, activity levels of nest guarding fish had not returned to pre-angling levels at 8 hours after release compared to non nesting fish which returned to basal levels within several 2 hours (Figure 1b). This locomotory impairment which was quantified using EMG telemetry would reduce the ability of the male to provide parental care activities. This study on catch-and-release angling of nesting male bass provided a link between the documented white muscle disturbance (Kieffer *et al.* 1995), the behaviour of the organisms (Philipp *et al.* 1997), and potential influence on fitness.

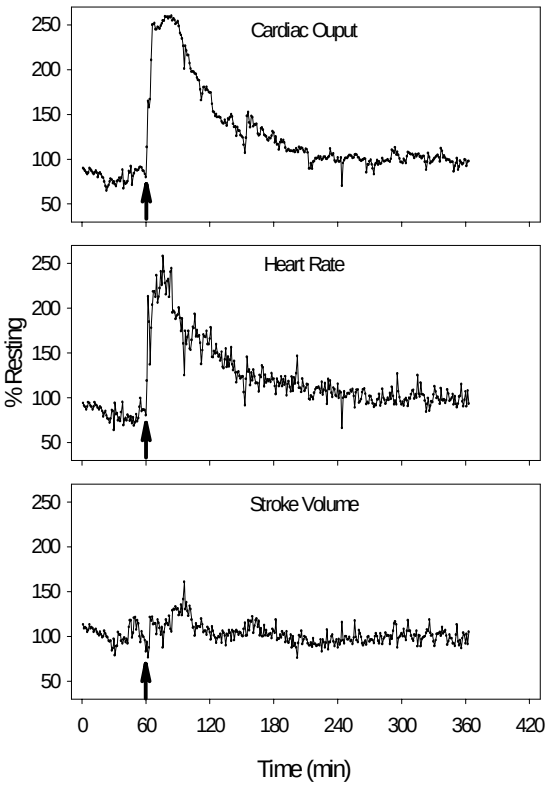

Figure 3. Example of cardiac response to simulated angling in smallmouth bass acclimated to 12°C and angled to exhaustion (~ 2 min). The angling event consisted of a series of velocity bursts up to 1.5 m s-1 within a Blazka-type respirometer. All values are percent resting always occurs at time = 60 min.

Heart Rate Telemetry

Heart rate (HR: the number of heart beats per unit time) telemetry devices have taken several forms, with the commonality being the electrodes placed in, or adjacent to the pericardial cavity to detect electrical activity indicative of heart beats. Heart rate telemetry has been used to assess the metabolic rate of free-swimming fish (Priede and Tytler 1977; Priede 1983; Lucas 1994) with varied success (Thorarensen *et al.*1996), but, at present, is the best remote monitor of physiological activity post exercise (Anderson *et al.* 1998). Although HR telemetry has been used as an indicator of metabolic rate during angling and recovery (Anderson *et al.* 1998), it may not be suitable for all species. Anderson *et al.* (1998) used HR transmitters to monitor recovery of free swimming Atlantic salmon (*Salmo salar*). Following angling at various temperatures, HR only increased 15 to 30 % above resting levels. The majority of fish species increase cardiac output (CO: the amount of blood expelled by the heart per unit time) principally through an increase in stroke volume (SV: the amount of blood expelled by the heart each heart beat) rather than HR (Farrell 1991; Farrell and Jones 1992; Thorarensen *et al.* 1996; Figure 2). Therefore, a more reliable correlate of oxygen consumption requires the measurement of CO, which is a function of both HR and SV (Thorarensen *et al.* 1996).

Cardiac Output

The measurement of CO deals with many of the shortcomings of EMG and HR telemetry. Measuring locomotor muscle activity can be useful to determine if exposure to environmental factors modify the activity level of the fish, but it will not allow detection of changes in metabolism associated with maintenance of homeostasis or recovery from oxygen dept following periods of increased activity. Heart function is influenced by variations in metabolism from all sources since oxygen consumption is a function of CO and the amount of oxygen that is extracted from the blood as it passes through tissues (EO_2). As mentioned above, HR may not always be a reliable correlate of oxygen consumption and therefore monitoring CO, which also yields HR and SV, is necessary.

Characteristic	Description
Objective and quantifiable	Central to any monitoring tool is the need to collect data that is objective and quantifiable. This type of data increases the ease of statistical analysis and removes the subjectivity that may bias results.
High resolution – real time	Data can be collected on several different time scales. Tools that facilitate the real time monitoring of stress and recovery will be more likely to detect physiological disturbances. Studies that acquire data before, during and after a perturbation will be the most useful in monitoring the physiological and behavioural status of the organism. Further, a nearly continuous data stream eliminates unknowns during times when fish were not being monitored and permits better trend through time detection. If data can be collected continuously from the same organisms over time, it increases the resolution of the data and minimized biases associated with collecting sequential samples at predetermined intervals.
Not terminal	Sampling methods which themselves do not result in the death of the organism or themselves alter the behaviour and physiology of the organism.
Free swimming fish	Studies that focus on the in situ measurement of free swimming fish to environmental perturbations will reflect the site-specific characteristics that are faced by the individual. These studies will also be able to detect how fish respond in their natural environment in the presence of additional factors that are difficult to recreate in laboratory conditions (e.g. predation, habitat heterogeneity).
Adequate controls/basal levels	Catch-and-release angling studies rarely have true controls or sham controls. Studies that compare fish that have been disturbed to those that have not been recently disturbed allows for more precise attribution of findings to the perturbation being studied. This eliminates the problems associated with nuisance variance. Also, by monitoring individuals prior to disturbance, it will be possible to have complete records of basal levels, disturbance effects, and the subsequent recovery.
Recovery/sublethal effects	Monitoring techniques that provide information on the time required for different disturbances to normalize. Studies that are able to monitor recovery and detect sublethal effects will be more useful in minimizing disturbances.
Metabolic indicators	Stressors and responses that can be quantified in an ecologically common currency (energy) will be useful in inferring the bioenergetic consequences of angling practices and will allow for more relevant comparisons between unrelated taxa.

Table 1. Desirable characteristics for an "ideal" measure of catch-and-release impacts.

Several techniques have been used to measure CO in fish including indirect (e.g. Fick equation) and direct methods (e.g. cuff-type or cannulating electromagnetic or Doppler flow probes) (Farrell and Jones 1992). In our laboratory we use cuff-type ultrasonic Doppler flow probes that are inserted around the ventral aorta and hard-wired to a flowmeter. The Doppler flow probe uses a piezoelectric transducer to emit a pulsed sonic signal and due to Doppler shift, when the signal is reflected from a moving object in the blood (e.g. a red blood cell) a shift in the signal frequency is observed. The shift in frequency represents a velocity and is measured as a change in voltage. Peaks in voltage/velocity represent a heartbeat and counting peaks per unit time yields HR. The mean voltage per unit time is an index of flow or CO (flow can also be calculated in ml time^{-1} via a post-mortem calibration). Dividing HR into CO yields SV.

Although monitoring CO of fish provides the most rigorous information regarding the metabolic response and recovery to angling, there are several limitations. First, there are currently no telemetric versions of a blood flow monitor. Therefore, all studies using CO must be conducted in laboratory or semi-constricted conditions (i.e. fish cannot be released). Several laboratories and companies are currently working on this problem and it is expected that a telemetric version will be available in the near future. Second, CO and its components, HR and SV, provide only 2 of the 3 parameters, the third being EO_2, necessary for calculating oxygen consumption. Lastly, monitoring CO will give no information on anaerobic metabolism, which is considerable in fish during exercise (especially angling).

Case Study: Brown Trout (*Salmo trutta*) Air Exposure

An important yet understudied aspect of the catch-and-release angling process is air exposure. Air exposure is known to have profound metabolic and anatomical changes associated with collapse of the gill lamellae and adhesion of the gill filaments (Ferguson and Tufts 1992; Mitton and McDonald 1994). Studies investigating the real time response to air exposure and the recovery period would be particularly useful for recommending maximal air exposure duration when handling fish. Preliminary results of a laboratory study of air exposure on the CO of brown trout suggests that recovery time increases while recovery intensity decreases with increased duration of air exposure. Further, similar to most studied fish species and unlike smallmouth bass (see below), brown trout increase CO predominantly by increasing SV rather than HR (Figure 2; Farrell 1991; Farrell and Jones 1992). This technique shows promise for future applications to studying

	Hooking Injury	Hooking mortality	Blood chemistry	Muscle biochemistry	Locational telemetry	EMG telemetry	Heart telemetry	Cardiac output	Displacement
Resolution days	NA	X							
Resolution hours	NA	X	X	X					
Resolution minutes	NA		X	X	X				X
Resolution real time	NA					X	X	X	
Sublethal effects	X		X	X	X	X	X	X	X
Continuous data						X	X	X	
Energetic implications			S	S	S	X	X	X	S
Quantifiable/objective	S	S	X	X	S	X	X	X	S
Free swimming				S1	X	X	X	S2	X
Non terminal	X	X	S3	S3	X	X	X	S4	X
Recovery			X	X	X	X	X	X	X

Table 2. Comparison of methodologies for monitoring the effects of catch-and-release angling. NA=Not Applicable; X=Almost always; S=Sometimes; S1=If cannulated; S2=Hardwired; S3=If small samples are collected; S4=Terminal calibrations required.

air exposure of different duration among species and a wider range of air and water temperatures.

Case Study: Smallmouth Bass angling disturbance

Cardiac output and its components, HR and SV, of adult smallmouth bass were measured continuously before, during, and following a simulated angling event in a Blazka-type respirometer. Fish were acclimated to 12, 16, and 20°C and exercised at speeds that elicited burst swimming either briefly (20 sec) or to exhaustion (120-180 sec). During recovery, CO typically increased 2-fold over resting values and the increase was almost entirely due to an increase in HR (Figure 3). Stroke volume either increased very little (20%), did not change, or actually decreased during recovery. This is unlike most fish species where increases in CO are primarily due to increases in SV rather than HR (e.g. brown trout – Figure 2; Farrell 1991; Farrell and Jones 1992). Recovery times increased with longer angling duration, but were not affected by temperature. From a management perspective, this research provides managers with some of the first data on the real-time recovery and metabolic consequences of catch-and-release angling. The results suggest that 1) angling duration should be kept as short as possible, 2) angling at both low and high temperatures should be avoided, and 3) even when fish are angled very quickly there is still an extended period of cardiac recovery.

Criteria for an "ideal" measure of catch-and-release effects

To better understand the effects of catch-and-release angling on all relevant biological levels, a variety of novel and creative technologies must be utilized. Recent technological advances have increased the amount of data that can be collected and its relevance to catch-and-release studies. Central to the effective use of any study methodology, is the setting of clear and concise objectives and then working towards choosing/using methodology that will provide the best and most relevant data for the situation. In order to facilitate the determination of the appropriate approach, we felt that it would be useful to propose a series of criteria that embody some of the most robust and desirable methodologies for measuring stress and recovery (Table 1). Studies which employ measures which satisfy the requirements of an ideal monitoring technique will be the most useful in accurately reflecting how organisms respond to different stressors. It is clear that very few current methodologies can satisfy many of these criteria (Table 2).

Integrated approaches using a combination of procedures will likely serve to provide the most comprehensive and robust information on the effects of catch-and-release angling. Extrapolating these findings to organism fitness, bioenergetics

models, and the population level will provide the most complete picture as to the true impacts of catch-and-release angling. Such an interdisciplinary approach is very different from the way that these studies have typically been undertaken. The ideal measures proposed here will help to shape the future of catch-and-release studies by optimizing data collection and increasing the probability of achieving the desired study objectives.

Prospectus and conclusion

The future development of remote cardiac output devices, as well as devices capable of measuring other biologically relevant parameters such as cortisol, lactate, or glucose would greatly increase our ability to undertake further studies on the response of fish to angling and handling induced stressors. Another promising technique is the use of videographic recording devices which could be affixed to the organism and provide additional insight into their free ranging activities. This technology already exists and has been applied to marine mammal studies. As always, fisheries applications will have to wait for the further miniaturization of electronic components, in particular, the restraints associated with power supply (battery size). Advances will also be required if free swimming fish are to be cannulated or have devices attached into/around other sensitive tissue for extended periods of time.

Fisheries managers must be proficient with physiological literature relevant to catch-and-release angling, and similarly, scientists must attempt to codify more direct links between their findings and management implications (Loftus 1987). It is however, ultimately up to the fisheries scientist to provide managers with scientifically justifiable data that provide direction to the management of recreational fisheries. The imposition of regulations without suitable science will lead to poor acceptance and compliance with such regulations (American Fisheries Society 1995). With increasing concern for the ethical aspects of angling, quantifiable and objective measures of animal welfare are becoming more important. The challenge is up to the scientist to develop and apply new technologies to the study of fish responses to stress and their subsequent recovery. With this information on sublethal effects, managers will be better equipped for disseminating sound scientific information and imposing regulations designed to minimize the sublethal effects on fish, not relying on mortality as the end measure of the success of a management program.

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The resource management connection to recreational fishing policies and programs

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Introduction

My presentation today will examine how the National Marine Fisheries Service (NMFS) is developing linkages between proactive recreational fisheries policies and programs and good resource management practices. The thesis of this presentation is that we can have better resource management and more fish, if we are able to garner the support of the users and the general public. A task that is easier said than done.

First I will summarize the resource management dilemma we face, so as to put things in perspective. Then I will delve into various aspects of our program and how they can be used to support good resource management. For the record, my definition of good resource management is to build and maintain robust fish stocks while providing for harvest of the surplus.

My goal today is to demonstrate to you that there are ways to enhance our resource management efforts and provide you some concepts that can be further developed and implemented for your specific needs.

The dilemma is no secret to most of us involved in resource management. However, anglers and the public in general, are less aware of the problems facing resource managers in their efforts to keep fish populations robust. Without angler/public awareness and understanding of resource management issues, effective support for good science-based resource management programs is often lacking. In fact it is common for agencies to find themselves in conflict with anglers regarding resource management decisions.

Anglers are getting better at finding and catching fish. Additionally, habitat and water quality degradation continues to adversely impact an increasing number of marine fish, both directly and indirectly. The resulting decreases in the size of many fish populations as well as fewer large fish, typically leads to demands from constituents to do something to immediately increase their catch. Unfortunately the regulatory tools, staff, and funding are often inadequate to maintain or rebuild depleted stocks in a timely manner.

The question is how do we get there from here? To answer this question, let us start by characterizing the desires of the angling public and public at large as related to angling and resource management. Anglers' greatest concerns include having an ample supply of fish to catch, a reasonable probability of catching big fish, and a good choice of places to go fishing. Overlying these desires is the opportunity to be unhindered by other users in pursuit of their catch and to have say in how the resources are managed. The public at large wants our resources to be managed in a sustainable and responsible manner. Not much to ask for, unless you are a competing user.

To address this question, the first stop, at the federal level is the Magnuson-Stevens Fishery Conservation and Management Act. This legislation is the primary guidance for federal marine fisheries management programs in the U.S. Exclusive Economic Zone (3-200 miles offshore). Fishery management councils develop and propose specific Fishery Management Plans (FMPs) in coordination with the NMFS, who then implements them. An important component of many FMPs includes how allocations are made to different user groups. It should also be noted that many marine fisheries that primarily occur within three miles of shore are managed by states and/or interstate marine fisheries commissions, and not regulated under federal FMPs.

Several amendments to the Magnuson-Stevens Fishery Conservation and Management Act, which were made in 1996, are particularly promising with respect to enhancing resource management. This Act now provides a stronger framework for defining and dealing with overfishing in a more proactive manner. Additionally, it now provides a mechanism for characterizing “essential fish habitat” and sets forth a consultation process intended to minimize adverse impacts to habitat from both fishing and non-fishing activities. Also, for the first time, the Act includes provisions that require the elimination of bycatch to the extent practicable and the reduction of fish mortality to the extent practicable in cases of unavoidable bycatch.

The new and improved Magnuson-Stevens Fishery Conservation and Management Act is certainly a valuable tool for resource managers, but it alone will not ensure enhanced recreational fishing. We need tools that focus on recreational fishing and we also need the support to use these

tools effectively - enter Presidential Executive Order 12962 - Recreational Fisheries - the tool. Anglers and the general public provide the support.

Presidential Executive Order 12962 – Recreational Fisheries

A strong mandate and tool were provided to federal agencies, as related to recreational fishing, with the signing of Presidential Executive Order 12962 - Recreational Fisheries, in 1995 (Appendix A). The Executive Order officially recognizes the social, cultural, and economic importance of recreational fishing to the nation. The reason the Executive Order is so important is that among other things, it directs federal agencies in the Departments of Commerce, Interior, Energy, Agriculture, Defense, and the Environmental Protection Agency to improve the:

- quantity,
- function,
- sustainable productivity, and
- distribution

of United States aquatic resources for increased recreational fishing opportunities.

Therefore, regardless of the mission of an agency, it must consider the effect of its actions on recreational fishing and strive to meet the above mandate in the process.

Further, the Executive Order established the National Recreational Fisheries Coordination Council consisting of Secretarial designees from the above noted agencies. The Council, in cooperation with states and tribes and after consulting with the federally chartered Sport Fishing and Boating Partnership Council published the National Recreational Fishery Resources Conservation Plan. Each federal agency was directed to develop an agency-specific implementation plan that identifies actions needed to meet the goals and objectives of the National Plan. Each agency Plan was required to include:

- measurable objectives to conserve and restore aquatic systems,
- actions to be taken by the agency,
- accountability measures, and
- evaluation criteria.

Annual accomplishments reports are prepared by the National Recreational Fisheries Coordination Council and reviewed by the Sport Fishing and Boating Partnership Council. Additionally, a Biennial Accomplishment Report is presented to the President of the United States pursuant to the Executive Order.

Responding to the Executive Order and the National Plan, the NMFS prepared an agency specific Recreational Fishery Resources Conservation Plan.

NMFS Recreational Fishery Resources Conservation Plan

The NMFS Plan has four parts, and also requires the preparation of an Agency annual accomplishment report. The next part of this presentation summarizes the four parts of the NMFS Plan and will then lead into the angler/public support connection to good resource management.

- Fish Stocks and Fisheries Habitat. - Rebuild and maintain fish stocks and protect, enhance, and restore habitat critical to marine recreational fisheries. Ensure that fisheries management decisions affecting the status of fish stocks consider recreational fishing interests and that the data for making such decisions are collected and analyzed using the best available science.
- Public Use. - Support and encourage programs and projects designed to enhance marine recreational fishing opportunities for the public.
- Public Education. - Support, develop and implement programs designed to enhance public awareness and understanding of marine conservation issues relevant to the well being of marine recreational fishing.
- Partnerships. - Establish and encourage the establishment of partnerships between governments and the private sector to advance aquatic resource stewardship and enhance recreational fishing opportunities.

Angler and Public Support

This is what the connection between resource management and recreational fishing policies and programs are all about. Among other things, the role of the NMFS Office of Intergovernmental & Recreational Fisheries is to facilitate and/or make this connection wherever possible. The two vehicles most beneficial in making this connection are communication and education. Good program support by the public is not limited to a lack of opposition, but can include active support and cooperative programs involving the states, non-government organizations, and other private resources.

Communication and education programs can be active or passive. Face to face meetings (active) will usually be more effective at getting a message across than a news release (passive), but a news release will reach more people. A program that employs a good mix of both active and passive communications is most desirable. Programs can also be reactive or proactive. Reactive programs are usually associated with damage control and have a high probability of angler/public rejection. Conversely, a good proactive program regarding a controversial issue is not likely to meet with the same amount of opposition as a reactive program, and if well designed you may be able to gain significant public support. The key to a good proactive program is that your constituents must have a good understanding of the issue before it becomes a problem. Appropriate alternatives that are readily understood and justified are also critical to developing good program support.

Communications

Communication means knowing who your constituents are, meeting with them and developing a working relationship whenever possible. In our effort to communicate with anglers, however, we must not forget the general public. Many of the issues crucial to maintaining good recreational fisheries are strongly influenced by the general public. Some of the more important issues include water pollution, habitat loss, impediments to fish passage for flood control, hydroelectric projects, and water supplies (domestic and agricultural), certain mining and forestry practices, and even wildlife management issues (i.e., sea lion protection versus salmon protection). Personal relations with open lines of communication will build trust with your constituents, and with trust better acceptance and support of resource management programs can be expected.

Build bridges between commercial and recreational fishery constituents wherever possible. There are many issues on which agreement and cooperation can be reached by these often competing user groups, habitat and water pollution being at the top of the list.

Specific communication tools our agency is using or developing includes the following:

- Staff presentations to angler organizations and civic groups;
- Staff attendance at angler organizations meetings and functions;
- Cooperative agreements with angling, conservation, and other public minded organizations (agreements focus on a variety of projects ranging from habitat improvement to pollution abatement);
- Development of web sites that address recreational fisheries issues;
- Establishment of telephone hot lines for time sensitive recreational information;
- Development of remote location kiosks to provide real time recreational fishing related information at sites frequented by anglers;
- Communicate grant opportunities to interested constituents;
- Provide news releases for press, TV, and radio on issues important to marine anglers/general public;
- Participation on local TV cable shows to address important issues related to recreational fisheries resource management; and
- Conduct an active telephone calling system to update key constituents regarding issues of interest.

Education

The question regarding education is - what kinds of information do anglers and the general public need to know? The answer, with few exceptions is - just about everything. Avid anglers know a fair amount about where to fish, and how to fish, and probably some information on a few of the most pressing angling issues related to the fisheries in which they are involved. New and/or infrequent anglers are often lucky if they can tie a proper knot and identify the fish they catch. Their information needs are significant. Anglers generally would be well served by having an increased knowledge of the ecology/biology of the fish they catch, fish identification, angling skills, applicable regulations and why they exist, angling ethics, fisheries management, related environmental issues that have the potential of adversely impacting their fishery, and the list goes on. For the general public the list is much the same, less the need for specific fishing knowledge.

The list of education needs is somewhat staggering, how are we ever going to meet all these needs? My response, we probably will never completely meet them, however, we must have a continuing education program, always looking for opportunities to educate our constituents. I also believe that if your entire staff of scientists and natural resource specialists is not actively involved in your education program, you are letting one of your most important tools go to waste. Some of our most difficult fisheries management challenges are related to incorrect public perceptions about a particular issue. We not only need to focus on what the issues are but what the solutions may be, and how the anglers and general pub-

lic can play a role in solving them. Establishing a personal connection between a particular issue or problem and the individual is almost certain to elicit action. The challenge for your education program is to elicit a desirable action.

Specific education tools the NMFS is using or developing includes the following:

- "A Code of Angling Ethics" has been developed (Appendix B), with angler and conservation group support, and published - to help focus on the big resource management picture, not just the catching of fish;
- Educational video development and publication - i.e., "Fish for Tomorrow" the most recent NMFS video is a blend of demonstrating fishing skills and conservation messages;
- Tagging/stock assessment projects get anglers involved in fisheries management, can be a tool for saving research costs, and at the same time gaining acceptance for various management initiatives;
- Tagging Registry web site provides anglers with information about ongoing tagging programs and correct tagging techniques;
- Catch-and-release cards serve as a reminder to anglers as to why they should practice proper catch-and-release and provides information on how to do it;
- Angler sea bird protection guides serve as a reminder to anglers as to why they should avoid harming seabirds and provides information on how to minimize injury to hooked birds;
- Fish identification cards and other similar identification guides are critical to getting anglers to comply with regulations, if they don't know what they have caught, compliance is difficult to achieve;
- Species profiles of important sportfish help anglers understand the biology and ecology of fish as well as related management issues and challenges;
- Fishing tackle loaner programs and youth fishing events are supported as a way to educate new anglers about marine resources, angling ethics, and garner general support for good resource management;
- 'Issue papers' and 'research summaries' written in easily understood terms are distributed to constituents; and
- Symposia and workshops are sponsored on issues of concern to anglers and the general public - such as the Billfish Symposium held in Hawaii last year, the National Symposium on Catch-and-Release, planned for December 1999, in Virginia Beach, Virginia, and the upcoming year 2000 Marine Recreational Fisheries Symposium planned for June 2000, in San Diego, California.

In summary, we have the tools to ensure sound resource management. The new amendments to the Magnuson-Stevens Fishery Conservation and Management Act, the Executive Order on Recreational Fishing, and the NMFS Recreational Fishery Resources Conservation Plan working together are designed to ensure viable resources for recreational fishing into the next century. The keys that will bring this all together are the anglers and general public. The energy to turn these keys, however, must come from us - the scientists and resource managers, through effective communication and education programs. Without the energy to turn these keys we risk the possibility that our tools will not be used to optimize the future of our fisheries. As you consider what I have said today, if you remember only one thing, remember to turn those keys.

Questions

Calvin Blood: Is there an organisation involved with the allocation process?

Marty Golden: The Fisheries Council is in charge of that. We, as scientists, can make comments on ecology and such, but we don't get a direct say in the allocation.

Using revealed and stated preferences for estimating the benefits of recreational fisheries regulations

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Abstract

Recreational anglers have many motivations for fishing, including catching fish to eat, enjoying the sporting aspect of fishing, and spending time with family and friends. These motivations affect whether anglers keep all, some or none of the fish that they catch. In this paper, we explore information about anglers' actual catch and release behaviour, and combine this with information about their stated preferences for changes in bag limits. Using data collected by the NMFS= Marine Recreational Fisheries Statistical Survey in the Northeastern United States in 1994, we estimate anglers' willingness to pay for striped bass trips under the current regulatory schemes (bag and size limits). We also exploit information collected in the survey about anglers= willingness to pay for more lenient bag limits, and use this to evaluate the benefits of proposed changes to those limits. Striped bass present interesting case study -- striped bass are thought to be good fish for eating, and are considered a good small game fish, but anglers tend to catch few, if any, of them on any given trip. The evaluation of anglers' revealed preferences for keeping these striped bass (as evidenced by actual behaviour), combined with their stated preferences for higher bag limits, can offer fisheries managers useful information about the net benefits of these regulations.

Introduction

Recreational anglers have many motivations for fishing, including catching fish to eat, enjoying the sporting aspect of fishing, and spending time with family and friends. These motivations, combined with regulations on harvest, affect whether anglers keep all, some or none of the fish that they catch. In this paper, we explore the effect that the existence of these motivations has on our ability to estimate willingness to pay (WTP) for a relaxation (or to a avoid a reduction) in a harvest restriction.

We develop and evaluate two different methodologies for eliciting information about anglers' preferences and use that information to estimate anglers' WTP under both an existing and a proposed bag limit. First, using data collected by the National Marine Fisheries Service's Marine Recreational Fisheries Statistical Survey (MRFSS) in the North-eastern United States in 1994, we estimate a random utility model (RUM) of site choice for anglers targeting striped bass and describe the assumptions needed to use the model to analyze the welfare impact of a change in bag limits. Second, we exploit information collected in the survey about anglers' WTP for more lenient bag limits for striped bass, and use this to evaluate the benefits of a proposed change to the limit as stated by anglers when asked directly. This paper explores the results obtained from estimating/calculating welfare gains from relaxing the existing striped bass bag limit by one fish using both methodologies.

Given the often contentious debate over even small changes to recreational fishing regulations, some guidance on the appropriate methodology for determining the net benefits of policy changes on anglers would be useful to fisheries managers. Hence, the two methods for analyzing the policy changes are evaluated based on their relative simplicity of analysis, reasonableness of assumptions, interpretation of results and overall findings. We then try to draw some conclusions about the implications of using either methodology for policy evaluation.

Background:

Recreational fisheries management typically relies on regulations that restrict anglers' harvest through moratoriums, by banning fishing in particular regions (area closures) or by setting limits on a particular trip (using bag and/or minimum size limits). The first two types of regulations preclude anglers from fishing at all, while the third type of regulation has the potential to affect the quality of a fishing trip but does not necessarily preclude the angler from taking the trip. The extent to which bag or size limits affect the quality of a fishing trip depends on whether an angler cares about keeping fish.

Two general methodologies exist for estimating demand for recreational activities, typically referred to as revealed and stated preference models; the distinction is based on how information is obtained from individuals. Revealed preference models infer information about individuals' preferences based on observing their behaviour; stated preference models ask individuals directly about their preferences. The analysis in this paper is based on specific examples of each methodol-

ogy, namely, the RUM (a revealed preference approach) and contingent valuation (CV, a stated preference approach).

The Random Utility Model:

In a recreational fisheries context, the RUM typically estimates the angler's WTP for a fishing trip by looking at the angler's choice of fishing location. It is assumed that an angler compares all relevant fishing sites, and chooses to go to the one that yields him the most utility. The angler's expected catch rate at each of the potential sites enters his utility function directly, and the model estimates a parameter representing the marginal utility of catching fish.

The RUM is useful for estimating the loss in WTP due to seasonal and area closures as, once set up, it is relatively easy to impose restrictions on the model to determine the effect on anglers of not having particular times or areas available to choose from when making site choices. Because the typical RUM for recreational fishing incorporates catch rate as an explanatory variable in the site choice decision, the RUM is also useful for estimating the welfare change as a result of a direct change in the quality of the fishing trip as measured by the expected catch rate. Indeed, there is a growing body of evidence from recreational demand literature using RUM methodology that catching fish is important to anglers.

Very few attempts have been made in the literature to use the RUM to analyze regulations that affect the quality of fishing trips indirectly (e.g., bag or size limits). One problem is that bag and size limits tend to be same for all anglers in a geographic region -- there is generally not much variation in observed data. The second problem, as discussed, is that bag and size limits might not affect the quality of the fishing trip; only if anglers care about keeping some of the fish they catch will the bag and size limits affect them. The standard RUM will overestimate the welfare loss from imposition of bag or size limits, because it implicitly imposes the assumption that the marginal utility of catching fish is the same as the marginal utility of keeping and releasing fish.

In this application, we incorporate an additional variable in the model, the expected keep rate, that allows for the possibility that anglers derive utility from both catching and keeping fish. This allows us to then estimate the welfare change when the keep rate is changed by changing the bag limit.

Contingent Valuation

An alternative method for eliciting change in welfare as a result of a change in a regulation is CV. The use of CV to elicit individuals' use and non-use values for a variety of public and private goods and services has proliferated since its first applications in the 1960's. The methodology relies on describing a hypothetical situation to a sample of individuals and asking them to state their WTP to avoid a particular change in that situation, or willingness to accept (WTA) compensation for the change. The name of the technique derives from the fact that reported WTP or WTA is *contingent* upon the scenario described to individuals. A common criticism of CV is that because of the hypothetical nature of the scenarios described to individuals, it often doesn't accurately assess individuals' preferences, or necessarily reveal choices individuals would actually make when faced with the real situation. Many applications of CV in the literature have focused on situations where no revealed preference data were available to test the validity of the CV responses, sometimes opening the results up to question. Applications that have tested the concurrence of results from CV and revealed preference models have had mixed results.

For the purposes of this application, we rely on anglers' respondents to a CV question about their WTP for an increase in the striped bass bag limit. The advantage is that we have information about actual behaviour of striped bass anglers that allows us to compare anglers' stated WTP with that estimated from the RUM.

The Data

The 1994 Northeast Survey:

For this analysis, data from a survey conducted from Maine to Virginia in 1994 as part of a catch-effort survey of recreational fishers are used.[1] Most of the data were collected during a telephone interview approximately 3-5 weeks after anglers were interviewed at a fishing site.

The RUM estimated focuses on those anglers who were targeting striped bass on the intercepted trip; that is, the model estimates the site choice for anglers contingent on already having chosen to go striped bass fishing. There are 1255 observations on striped bass anglers with complete socio-

[1]Complete details about the survey can be found in Steinback *et al*, 1999.

demographic information; and 63 sites from which those anglers could choose to fish.

During the telephone survey, all anglers (not just those who had targeted striped bass) were asked the following open-ended CV question regarding their WTP for 1-fish increase in bag limits:

> *The current daily bag limit for striped bass in (STATE of INTERCEPT) is (STATE BAG LIMIT) fish. Suppose you could choose to buy a special license that would increase your daily bag limit from (STATE BAG LIMIT) to (STATE BAG LIMIT + 1) fish. If you chose not to buy the license, your daily bag would still be (STATE BAG LIMIT) fish. What would be the maximum amount of money you would be willing to pay for this special license?*

The responses to this question provide the data for the stated preference analysis. For comparability with the RUM sample, we look at stated WTP for the bag limit change for those anglers who had targeted striped bass on the intercepted trip (i.e., the same sample as used in the RUM). Of the 1255 observations on striped bass targetters, 1133 had valid responses to the CV question. Thus, a side-by-side analysis is conducted using observations on the same sample of anglers -- those observed in the field and administered the telephone follow-up survey.

Finally, information about the existing regulations in 1994 was used. In the states from Maine through Maryland, the bag limit for striped bass was one fish; in Virginia, the bag limit was two fish. Additionally, each state had minimum legal size limits ranging from 18" to 36"; and some states had seasonal closures (annual season length varying from 32 to 365 days).

Descriptive statistics from MRFSS inter

	Striped Bass Targeters		
	% WTP = $0	Mean WTP[1]	Max WTP
Maine	57.7%	$6.81	$50
New Hampshire	57.6%	$7.44	$100
Massachusetts	57.0%	$11.65	$150
Rhode Island	59.3%	$17.30	$125
Connecticut	56.6%	$9.74	$200
New York	45.8%	$24.26	$100
New Jersey	50.5%	$5.29	$100
Delaware	47.4%	$11.43	$30
Maryland	22.3%	$7.00	$50
Virginia	50.3%	$5.66	$200

Table 1: Catch and harvest distribution of striped bass targetters in 1994.

x = # Striped Bass	% Obs with Striped Bass Catch = x	% Obs with Striped Bass Harvest = x
0	66.8	89.7
1	10.9	7.1
2	7.4	3.2
3	3.2	0
4	3.4	0.1
5	2.1	--
6	1.9	--
7	1.0	--
8	0.6	--
9	0.4	--
>=10	2.0	--

Table 2. Catch/release status of striped bass targeters in 1994 sample.

Descriptive statistics from MRFSS intercept data

Table 1 shows the catch distribution of striped bass by anglers in 1994 who were targeting that species. On well over half the trips (66.8%), anglers did not catch any striped bass. On almost 90% of angler trips, no striped bass were kept. As an indication of the degree to which the 1- and 2-fish bag limits might have been constraining in 1994, it can be seen that 85.1% of trips resulted in a total catch of 2 or fewer fish; conversely, on 14.9% of trips, anglers' catch was restricted by the bag limit.

To further try to identify which anglers might have been constrained by the bag limits, actual catch and release data for each angler is examined. Table 2 shows the percentage of striped bass targetters in 1994 who caught no striped bass, who caught and kept either one or two fish, who caught fish but released more than would be required by the bag limit, and who caught more fish than the bag limit and kept the maximum allowable number of fish. Catch-and-release practices for those who caught no fish cannot be determined; after this category, the most common practice was to release fish for reasons other than the bag limit (23.2% of the sample). Given the existence of minimum size limits, it is not possible to determine whether anglers released fish for this or other reasons due to data limitations.

Descriptive statistics from CV question:

Based on the 1994 sample used in the econometric analyses, Table 3 contains information about anglers' responses to the striped bass CV question. Just over half of the entire sample reported a sWTP of $0 for the bag limit change. It should be noted that the CV question posed to anglers did not specify a time frame over which the bag limit change would hold. Given that most recreational fishing licenses are issued either for a season or

Release Category	% of striped bass targeters
Caught no fish	66.8 %
Caught but did not release any fish	5.9 %
Caught and released some fish (not due to bag limit)	23.2 %
Released fish when over the bag limit	4.1 %

Table 3. Descriptive statistics from CV question [1] Mean WTP is calculated as the weighted mean, where the weight is the inverse of the number of fishing trips taken by the angler in the past twelve months. This converts the WTP to a per-trip basis.

an entire year, it is likely that most anglers interpreted the question to imply that their individual bag limit would be higher either for the remainder of the fishing season or for a year of fishing. The mean WTP values reported in Table 3 are weighted by the inverse of the number of fishing trips taken by the angler in the past twelve months, so that they reflect a per-trip value.

The estimated models:

The random utility model:

The usual assumptions made in specifying a RUM are followed in this application. First, an individual angler's indirect utility function for alternative i is specified as:

$$U_i(q_i, y - p_i, \varepsilon_i) = V_i(q_i, y - p_i) + \varepsilon_i \quad (1)$$

where the first term represents the observable portion of an individual's indirect utility function and the second term represents the unobservable, random portion of the indirect utility function. Given the recreational fishing site context of this application, $\mathbf{q}_i$ represents a vector of attributes of fishing site i; p_i is the cost of travelling to the site; and y is the angler's income. At each choice occasion, the individual compares his indirect utility over all alterative fishing sites in the choice set S, and chooses alternative i if:

$$V_i(q_i, y - p_i) + \varepsilon_i \geq V_j(q_j, y - p_j) + \varepsilon_j, \forall j \in S \quad (2)$$

or, rearranging terms to isolate the random from the non-random components:

$$\varepsilon_i - \varepsilon_j \geq V_j(q_j, y - p_j) - V_i(q_i, y - p_i), \forall j \in S \quad (3)$$

When the error terms have independent and identical type I extreme value distributions, then the difference in the error terms is assumed to have a logistic distribution, and the probability of the individual choosing alternative i can be written:

$$P(i) = P(i \mid i \in S) = \frac{e^{V_i}}{\sum_{j=1}^{N} e^{V_j}} \quad (4)$$

Equation (4) forms the basis of the RUM estimation. The most general specification of the vector $\mathbf{q}_i$, in terms of describing angler's preferences for catching and keeping fish, would include the angler's expected catch rate, expected keep rate, and expected release rate at site i.[2] That is, one could hypothesize that anglers derive utility from all three components of fishing, and each component could have a different effect on utility. Estimating such a model, however, is complicated for a number of reasons. First, the numbers of fish caught, kept and released are highly collinear. Second, somewhat restrictive assumptions need to be made regarding the marginal utility of catch, keep and release in order to recover these specific parameter estimates. Hence for the purposes of this model, we assume that an angler's utility is a function of the expected catch rate and the expected keep rate. That is, we implicitly assume that the marginal utility of releasing fish is zero, or, put another way, that those anglers who release fish derive all of their utility from catching, not keeping, fish.

Expected catch rates:

Following McConnell et al (1995), the expected catch rate at each fishing site is assumed to follow a Poisson process. The probability that an angler catches c fish at site i is written:

$$\Pr(c_i = n) = \exp(-\lambda_i)\frac{(\lambda_i)^n}{n!} \quad (5)$$

Expected catch is estimated as a function of the average historical catch rate at site i, the experience of the angler (measured by years of fishing), and the time spent fishing by the angler:

[2] It should be noted that other site-specific variables might also be included in $\mathbf{q}_i$. Here we only discuss those related to catch/release/keep .

$$\ln\lambda_i=\beta_0+\beta_1*\text{catchrate}+\beta_2*\text{experience}+\beta_3*\log(\text{hoursfished})$$

The parameter estimates from this model are then used to calculate the expected catch rate of each angler at each potential fishing site identified (63 sites in the 1994 data). Again following McConnell et al, we then calculate the expected keep for each angler at each site by truncating the expected catch rate to the initial bag limit (2 fish in Virginia; 1 fish elsewhere). Additionally, for anglers fishing when the season was closed, the expected keep rate is set to zero.

Welfare estimation in the RUM:

The RUM is estimated as a function of the expected catch rate, travel cost, travel time and a variable reflecting the number of interview sites in a county. The expected keep rate is included for those anglers who indicated that catching fish to eat was >somewhat= or >very important= and is set equal to zero otherwise. The estimated parameters (see Table 4) were all of the correct sign and were statistically significant.

To determine the effect of the proposed bag limit change on angler consumer surplus using the RUM results, the expected keep rate is recalculated based on the new bag limit (3 fish in Virginia; 2 fish elsewhere). The change in consumer surplus as a result of the relaxation of the bag limit is then calculated using the standard formula for evaluating a welfare change. The results, seen in Table 5, range from $6.46 to $22.28. As indicated, these are the per-trip welfare gains as a result of the relaxation in the expected keep rate. Comparing the results obtained from the RUM with the reported WTP for striped bass targetters (Table 3), it appears that the two methods provide reasonably comparable estimates of WTP for the bag limit change. In six out of ten states, a t-test of the means reveals that they are not significantly different. In the four states where the means are

Variable	Parameter Estimates
Travel cost	-0.024*** (0.001)[a]
Travel time	-0.759*** (0.044)
Ln(M), M=# MRFSS interview sites per county	1.418*** (0.057)
Expected catch rate	0.326*** (0.056)
Expected keep rate (=0 if season closed, or if catching fish to eat not important)	2.406*** (0.391)

Table 4: Results of RUM estimation. [a]Standard errors in parentheses, *** = significant at 1%.

State	Estimated Welfare Gain (per trip)
Maine	$6.97
New Hampshire	$12.34
Massachusetts	$11.38
Rhode Island	$14.45
Connecticut	$9.36
New York	$22.28
New Jersey	$15.18
Delaware	$14.68
Maryland	$15.45
Virginia	$6.46

Table 5: Welfare estimates of a 1-fish increase in striped bass bag limits (from RUM)

significantly different (New Hampshire, New Jersey, Maryland and Virginia), the stated WTP from the CV question is lower than the estimated WTP from the RUM. The biggest discrepancy is for New Jersey, where the RUM estimates a welfare gain of $15.18 per trip while New Jersey anglers reported an average WTP of $5.29. Similarly in Maryland, the RUM estimates a WTP of $15.45 for the bag limit increase, while anglers reported, on average, a WTP of $7.00.

Contingent valuation:

While we have reported the basic descriptive statistics related to the CV responses, it would be interesting to determine the effect of various socio-demographic and catch related factors on anglers' reported WTP. It is reasonably simple to specify a utility-theoretic model for CV data. One can assume, for example, that when an individual is presented with a hypothetical situation, he considers his utility under each of the alternative scenarios, and responds in such a way that his utility is maximized. In the context of recreational fishing, consider an angler who is asked his WTP to change an existing bag limit. We assume that he bids an amount $B such that:

$$U(CR,KR_{new},Y-B|Baglimit_{new})\downarrow U(CR,KR_{old},Y|Baglimit_{old})$$

where CR represents catch rate, KR is the keep rate and Y is income. The angler only bids if his utility with the new bag limit but reduced income is greater than his utility with the original bag limit and income level. From the utility function, one can derive a bid function to estimate the effects of various socio-demographic factors on $B.

The high percentage of >zero= WTP responses requires the use of an econometric model that incorporate the zeros when estimating the bid function. For this application, a Tobit model that simultaneously estimates the probability that an

Variable	Striped bass targeters
Intercept	25.89*** (6.93)
Expected catch rate	1.74 (1.10)
Expected keep rate (=0 if season closed, or if catching fish to eat not important)	9.37*** (2.90)
Age (years)	-0.50*** (0.08)
Minimum size limit for striped bass (in inches)	-0.41** (0.18)
Angler resides in Virginia (=1 if VA; =0 otherwise)	-10.71*** (3.83)
Caught striped bass (=1 if caught fish, =0 otherwise)	-0.30 (5.16)
Scale parameter (σ)	30.41 (0.99)
Log-likelihood	-3051.46

Table 6. Tobit Regression results. Dependent variable = WTP. n=1133. Standard errors in parentheses. *** = significant at 1%, ** = significant at 5%, * = significant at 10%.

angler will bid as well as the amount of the bid is chosen. The Tobit model is specified as:

$$B_i = \beta_1 z_i + u_i \quad \text{if } \beta_1 z_i + u_i > 0$$
$$B_i = 0 \quad \text{otherwise} \tag{7}$$

where $\mathbf{z}_i$ is a vector of explanatory variables and B_i is angler i's reported WTP to the CV question. The likelihood function is:

$$L = \prod_{i \in A_n} [1 - \Phi(\frac{\beta z_i}{\sigma_u})] \cdot \prod_{i \in A_p} \frac{1}{(2\pi\sigma_u^2)} \cdot \exp\left(\frac{(B_i - \beta z_i)^2}{-2\sigma_u^2}\right) \tag{8}$$

A_n represents the subset of anglers in the sample who bid zero to the CV question; A_p is the subset who responded with a positive amount. Φ is the distribution function of the standard normal, and it is assumed that the error term u_i is distributed $N(0, \sigma_u^2)$.

The empirical model specified hypothesizes that an angler's reported WTP is a function of the expected catch rate, the expected keep rate (as defined in the RUM, described above), his age, and the minimum size limit for striped bass in the angler's state of residence. Additionally, a binary variable for anglers in Virginia is included to capture the effect of the higher initial bag limit in that state. Lastly, a binary variable is included to test whether anglers who actually caught striped bass had a different WTP than anglers who did not. As discussed earlier, the keep-or-release practices of those anglers who are not observed catching fish cannot be determined. While the expected keep rate variable is estimated as an *ex ante* measure for each angler (and hence may be non-zero even though the angler caught nothing on the observed trip), this variable helps us test whether anglers unsuccessful on the observed trip had a different WTP than those who were successful.

The Tobit model results are presented in Table 6. Both the expected catch and expected keep rates have a positive impact on anglers' WTP, but the expected keep rate variable is much more significant than the catch rate. That is, for striped bass targeters, keeping fish was a more important factor than catching fish when bidding for the bag limit change. This is consistent with the relative magnitude of the estimated coefficients on the expected catch and keep rates in the RUM.

Older anglers had, on average, significantly lower WTP, perhaps due to a stronger conservation ethic, or due to greater objection to having to pay for a change in the limit. The minimum legal size of fish had a significant negative effect on anglers' WTP. The higher the minimum size limit, all else equal, the lower anglers' WTP for the bag limit change, presumably because anglers in states with higher minimum size limits expect to catch (and hence keep) fewer fish of legal size. Anglers in Virginia, where the bag limit was already two fish (with a proposed change to three fish) had a significantly lower WTP for the bag limit change. Two factors probably contribute to this. First, the lower WTP presumably reflects the declining marginal utility of fish kept; anglers should be less WTP to keep the third fish than they were to keep the second fish. Second, the probability of catching more than two fish is fairly small (Table 1), so fewer anglers expect to catch more than two fish and are therefore WTP less for the bag limit change.

Anglers who caught nothing did not have a significantly different WTP than anglers who did catch fish. This is an important finding because it suggests that trying to calculate the proportion of anglers who might be affected by a proposed regulation by examining catch records may not accurately capture the degree to which anglers believe they are impacted. While logic might suggest that

an angler who caught nothing would not be affected by a change in a bag limit, the angler himself might have a positive WTP for the bag limit change (either to avoid a more restrictive limit, or to bring about a relaxation of the limit).

Conclusions

Both revealed and stated preference models have their advantages and shortcomings. Common criticisms of CV in particular are that it relies on describing hypothetical situations to anglers and is potentially subject to numerous sources of bias, including strategic bias, information bias, hypothetical bias, starting point bias, non-response bias and payment vehicle bias. However, CV is often the only way to elicit information on non-use values. Revealed preference models, on the other hand, generally avoid these problems by relying on data on actual choices made by individuals, but are limited to estimating use values. There are few examples in the literature where the estimates obtained from both kinds of models are compared.

In this application, both methods are used to determine the value to anglers of relaxing the striped bass limit. Casual comparison of the results indicates that the two methods produced reasonably similar results. One caveat to using either set of results to estimate a total (i.e., population level) benefit from the policy change is that the results only capture the WTP of those individuals who targeted striped bass on the day of intercept. Since it is likely that anglers fishing for other species on the day of intercept might also benefit from the bag limit change (because they target striped bass on other occasions, for example), it would be beneficial to expand the analysis to include them. For the revealed preference method, this means estimating a more general RUM, where the choice process includes the choice of other species in addition to striped bass, incorporating observations on all anglers. For the CV analysis, this simply means including the responses to the striped bass CV question from all anglers, not just those targeting striped bass, in both the calculation of the descriptive statistics as well as in the econometric model.

Based on our experience, the biggest drawback to using the RUM to estimate the WTP for the bag limit change is the computational burden. Estimation of the RUM requires a significant amount of data (information on all relevant fishing sites), data manipulation, and computer resources. Analysis of the CV responses, on the other hand, requires at a minimum calculating descriptive statistics to get a sense of mean and modal WTP for the bag limit change. If an econometric analysis is required, at least for open-ended CV questions the Tobit model provides a much less complicated and data-intensive method. Given the similarity in the results found in this application, we are comfortable recommending CV as a defensible method for eliciting WTP for marginal policy changes.

For future research along these lines, it would seem that more sophisticated CV questions would be worth exploring, with explicit questioning about other constraints that might affect anglers' responses. More variation in the proposed scenarios would be useful for estimating more robust results. Of key importance is more information from anglers about their specific catch and release preferences for various species.

Since both the revealed and stated preference models tell us something about anglers' preferences, econometric models that jointly exploit information from both kinds of models would be preferable. For example, an ideal model might link anglers' responses to hypothetical questions about their preferences for various trip characteristics with information on choices the angler actually made before or during the intercepted trip.

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Questions

Margaret Merritt: Do the predictions reflect the observed data?

Robert Hicks: This was observed data; the paper presents both.

Margaret Merritt: When we first did studies in Alaska, we used license fees as the payment vehicle. In the next years, we used an increase in travel costs as the payment vehicle, and the results were very different; they were much higher. With fees, protest bids are elicited, because in Alaska, some folk don't want to pay taxes.

Amy Gautam: I agree - but what I was saying was that 66% percent of individuals did not land fish. If they said they would bid zero dollars, we asked them why,

and 10% said that they didn't feel as if they should pay more.

Margaret Merritt: People tend to be very sensitive about the payment vehicle used.

Amy Gautam: But in this paper, we were just comparing models.

Murray MacDonald. I noticed significant differences between some States in "willingness to pay".

Amy Gautram: We attributed those differences to political factors although in those states they all had the same percentage of low bidders.

Recreational fishery response to rebuilding and reallocation of the barramundi *(Lates calcarifer)* stocks in Australia's Northern Territory

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Abstract

Australia's Northern Territory has undergone rapid population and infrastructure growth in the past 30 years. As a consequence recreational fishing, largely targeted at barramundi, has increased rapidly. Over the same time period a commercial gillnet fishery developed to the point of overexploitation and stock decline which was followed by stock recovery after significant effort adjustment. As the recreational fishery expanded, the resource in some areas was reallocated to the recreational sector by exclusion of commercial fishing. Data from creel surveys show that in the Mary River recreational effort declined rather than increased following the exclusion of commercial fishing. This decline occurred despite the fact that stock recovery in the area was already well advanced. Assessment of non-fishery factors and modelling of the fishery provide some insight into the reasons for this contrary trend. It is likely that the growth overfishing which occurred did not radically reduce recruitment to the stock and, as the recreational catch mostly comprises fish smaller than the size targeted by the commercial sector, availability of fish to the recreational sector was not greatly reduced. Effects of habitat changes, infrastructure developments and economic climate are also discussed.

Introduction

Barramundi (*Lates calcarifer*) is a protandrous, generally catadromous, centropomid perch which grows to over 30 kg and is a popular angling target. In the Northern Territory (NT) it is the basis of a substantial recreational fishery and a commercial gillnet fishery providing high quality table fish to markets throughout Australia. The NT has a relatively short history of European-style development and has seen very rapid population growth over the past 30 years. Development of the commercial fishery and the recreational fishery have coincided over this time period and there has been considerable debate during the past two decades over allocation of the resource between the two sectors. Much of that debate has centred on the Mary River, 100 km east of Darwin, the capital city and major population centre. The Mary River has therefore been the focus of considerable research effort and this paper will describe, and try to explain the observed trends in the fishery in that region.

Fishery history

Commercial Fishery

The commercial fishery developed very rapidly in the early 1970's, reaching apparently unsustainable levels by the late 1970's. Stocks declined rapidly until around 1986. From 1980 to 1990 a number of new management measures were implemented beginning with commercial effort limitation and then effort reduction via a commercial licence buyback scheme (Fig.1). In 1986 and 1987 commercial fishing was excluded from within the confines of the river for half of the 8-month fishing season and in 1988 the river was completely closed to commercial fishing. In 1990 the closed area was extended to include areas adjacent to the river mouth. Those measures rapidly took effect and stocks have recovered to be close to those pre-exploitation. The Mary River has been very productive and has historically contributed a catch equivalent to 10-20 % of the total NT catch of barramundi. A small and sporadic commercial harvest is still taken from the area adjacent to the Mary River exclusion zone.

The recreational fishery for barramundi has also developed quite rapidly along with population growth over the past 30 years. The population of the Darwin region has risen from just 20000 in 1965 to over 100000 in 1998. Fishing for barramundi is a significant activity for approximately one third of non-aboriginal NT residents. It is also a highly sought after target for visiting anglers from throughout Australia and elsewhere. A substantial industry based on fishing tourism and guided fishing has developed over the past 10 years. Being relatively close to Darwin the Mary River is a major focus for that activity (Coleman, 1995). Assessment of the recreational fishery for barramundi has focussed on the Mary River and the rivers of Kakadu National Park to the east. Within the Mary River, recreational activity has been assessed by access point (roadside) surveys in 1978/79 and 1986, and by a combination of roving creel surveys and boat-ramp surveys between 1986 and 1995. Estimates of recreational harvest and effort based on those surveys are available for the period 1989 to 1995 (Griffin, 1982, 1989, 1993, 1995).

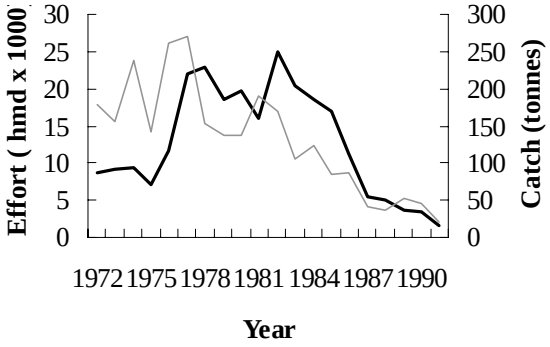

Figure 1. Commercial catch and effort for the Mary River barramundi fishery, 1972 to 1991.NB: Data after 1992 are included in modelling processes but can not be published for reasons of confidentiality as they are derived from a small number of operators. Both catch (thin line) and effort (thick line) have continued to decline to very low levels

Since 1986 there has been an increasing trend in management of the NT barramundi resource towards reallocation of access from the resource from the commercial sector to the recreational sector, particularly in areas of high recreational activity. In the case of the Mary River the fishery was slow to respond to effort restrictions which were effective elsewhere in the NT in the early 1980's and special constraints on both the commercial and recreational sectors were introduced. Commercial fishing was excluded from the confines of the tidal river channel in 1988 and a further exclusion zone around the mouth of the river was introduced in 1989. At the same time a recreational minimum size was introduced for barramundi and the possession limit of five fish per day was reduced to two in order to constrain the impact of the expanding recreational sector. Since the restrictions have been in place the level of commercial effort has declined to the point where the data from the fishery is not particularly useful as an indicator of abundance because of its patchy nature.

The progressive exclusion of the commercial operators from the Mary River coincided with significant improvements in access for anglers, particularly to the lower, tidal section of the river, generally known as Shady Camp. Prior to 1986 this area was private property to which access was restricted and the access road was impassable for much of the year. When land in the area came under government control as a park and an all-weather, public-access road provided, there was a shift of recreational effort to the area. Since then there has been a seasonal concentration of recreational fishing effort at Shady Camp in the period March to June, coinciding with the subsidence of monsoon floods. At this time the area is fished by 30-40 angler parties per day, targeting barramundi up to 130 cm total length (TL) and weighing up to 25 kg. The exclusion of commercial fishing in 1988 saw an almost instantaneous rise in angler expectations and activity in the area, fuelled by a few reports of good catches. The provision of open access to the tidal part of the river is significant in that, being a loosely catadromous species, mature, larger barramundi reside in tidal waters. Access on the Mary River had previously been restricted to freshwater sections, known as billabongs, which do not flow during the winter (or 'dry season'). These areas are generally occupied by smaller, immature barramundi up to 4 or 5 years of age. The majority of those fish are less than 80 cm total length, with a small proportion up to 100 cm. It was also during this time that much of the detail of barramundi biology was becoming more widely known and the knowledge base of anglers targeting barramundi was expanding rapidly through the popular angling press.

Population studies and modelling

The Mary River barramundi fishery and population has been the focus of considerable research and monitoring effort since 1985. Intensive monitoring of the commercial fishery was undertaken in 1986 and 1987 to assess the size and age distribution of the catch, prior to complete closure of the river to commercial netting. Surveys of recreational activity in the area commenced in 1986 and continued until 1995. Standardised roving creel and access point surveys provided estimates of recreational catch and effort from 1989 to 1995.

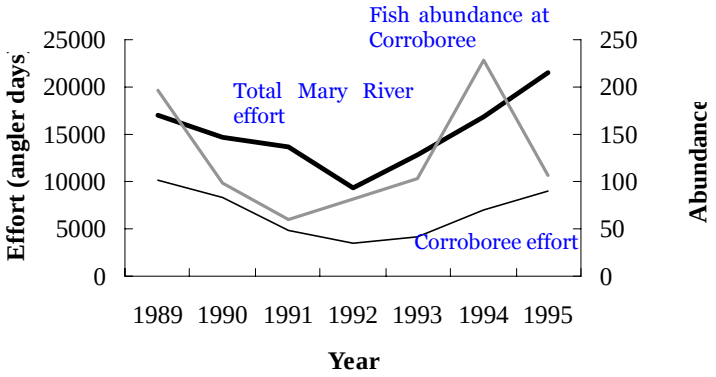

Figure 2. Estimated angler effort (angler days) for major fishing areas in the Mary River, 1986 and 1989 to 1995 and abundance of legal sized barramundi at Corroboree Billabong, 1989 to 1995

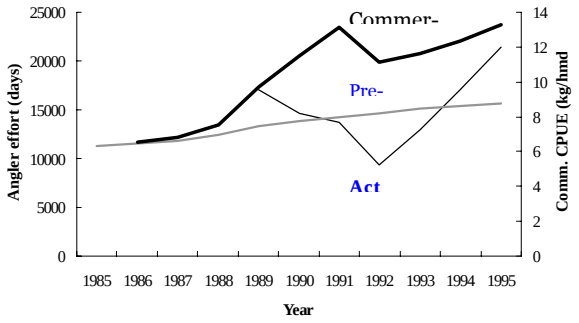

Figure 3. Actual angler effort in the Mary River compared to model prediction and to commercial CPUE, 1986

Fishery independent monitoring of the barramundi population in one freshwater section of the river has been undertaken annually since 1989. This sampling has provided annual estimates of abundance at Corroboree Billabong and provided a picture of population age structure. Estimated biomass has shown substantial variability, as has the abundance of legal sized fish (Griffin, unpubl.). The age structure has shown a consistent cycle in recruitment to the freshwater population with strong recruitment in alternate years. It is likely that survival of recruits is strongly influenced by the abundance of 1-yr olds from the previous year. It is not known if this cycling occurs widely or is peculiar to the particular locality. A recent study based on analysis of barium and strontium in scales (Pender and Griffin, 1996) has demonstrated that catadromy in barramundi is not obligatory and that a quite high proportion of barramundi do not undergo a freshwater phase. Thus a poor recruit year in freshwater might be compensated for by a strong saltwater recruitment. It also follows from this that a substantial proportion of the commercial harvest probably comprises fish which have reared entirely in coastal waters and therefore have not been available to the majority of anglers. This factor will be the subject of further study.

The population and fishery have been the subject of much modelling since the first basic assessment in 1979. The most recent assessment was undertaken by the authors and others during stock assessment workshops conducted in Darwin in 1996 and 1997 (Walters *et al.* in Ramm, 1997). Age-structured, delay-difference, and surplus production models have been applied and all give similar estimates of important stock parameters. Importantly, this modelling has consistently indicated that during the over-exploitation period of 1975 to 1983, recruitment was not significantly reduced. Given that the commercial sector of the fishery targets older, more-mature, fish in coastal waters and the recreational sector has historically targeted younger fish in inland waters, it is likely that availability of barramundi to the recreational sector was maintained at reasonably high levels. Output of the age structured model, using various combinations of vulnerability factors reflecting the different sizes of fish targeted by the two sectors, indicates that stock availability to the recreational sector declined by around 20% whereas commercial stocks declined by up to 50%.

According to Walters (1997), Walters and Cox (this volume) it is possible to predict the effect of changes in fish abundance on recreational fishing effort if it is assumed that: (1) recreational CPUE is proportional to abundance of fish available; and (2) fishing effort is also proportional to abundance; and (3) the abundance of fish available to be caught is actually only a small proportion of the total stock and that this available stock can be subject to rapid short term depletion. Combining these three relationships implies logarithmic or linear increase in effort with abundance. Such a model was used to estimate the changes in recreational effort which might be expected to occur in the Mary River as the stocks recovered from over-exploitation. The difference between the logarithmic and linear predictions was quite small, and only results from the log model are shown. How that prediction relates to observed effort trend is discussed below.

Trends in the recreational fishery

Data on recreational fishing in the Mary River is available from roadside surveys in 1978/79 and 1986 and from roving reel and access point surveys from 1989 to 1995. Of most importance in this context is the trend in total recreational fishing effort as it is fishing effort rather than catch, which brings economic input to a region. The two major fishing areas, Corroboree Billabong and Shady Camp, account for 85% of the fishing effort in the Mary River and surveys have concentrated on them. The term “total effort” in this paper refers to the combined effort for those two areas. While the early surveys of 1978 and 1986 used a different methodology, being essentially large-scale, access-point surveys on the only road into and out of the survey area, the effort estimates are included for historical comparison (Fig. 2).

Year	Harvest CPUE (fish/hr)		Total CPUE (fish/hr)	
1986	0.13	±0.023	0.11	±0.020
1987	0.17	±0.022	0.17	±0.022
1988	0.08	±0.014	0.29	±0.049
1989	0.10	±0.014	0.36	±0.040
1990	0.07	±0.008	0.341	±0.049
1991	0.08	±0.011	0.38	±0.043
1992	0.05	±0.007	0.21	±0.031
1993	0.05	±0.010	0.33	±0.060
1994	0.05	±0.010	0.21	±0.020
1995	0.05	±0.000	0.23	±0.020

Table 1. Recreational harvest rate and total catch rate (fish/hr ± SE) for the Mary River, 1986 to 1995.

Effort for the same area in 1978/79 was estimated to be 15000 angler days, by the same roadside survey methods as were used in 1986. Total recreational effort for the Mary River showed a quite marked decline from 1986 to 1992, contrary to the rising trend in abundance as reflected in commercial CPUE and as predicted by the age-structured model output (Fig. 3). Angler effort then increased rapidly between 1993 and 1995, to levels approaching those seen in 1986. The decline in effort overall is largely due to a decrease in effort at Corroboree Billabong, with remaining effort being concentrated in the Shady Camp area. Fishing conditions at Corroboree were substantially degraded by proliferation of red lotus lilies *(Nelumbo nucifera)* which covered a quite large proportion of the waterbody in the period 1990 to 1993. Dramatic reduction of lily coverage by floodwaters in 1994 and 1995 and substantial improvements to road access and boat launching facilities in 1994 probably contributed to the rise in effort at Corroboree.

For Corroboree Billabong estimates of abundance of barramundi are available for 1989-1995 (Fig. 2). Observed recreational effort for that area is not predicted by abundance in the same year (r^2=0.11) but is quite closely correlated with abundance in the previous year (r^2=0.86). Such a relationship suggests the possibility that angler effort at Corroboree Billabong is determined largely by abundance in the previous year. If this were the case it would be an unusually slow response by anglers to abundance changes. It is therefore considered equally likely that the correlation is coincidental.

The trend in angler catch per unit effort to an extent reflects the introduction of regulations aimed at limiting the impact of recreational fishing (Table 1).

Clearly there was a rapid rise in total catch rate from 1986 to 1989, with a slight fall in harvest rate. This rise coincides with the introduction of the minimum legal length and reduction of the bag limit in 1988, indicating that prior to introduction of the size limit most fish caught were retained. At the same time improved access to Shady Camp, where migrating juveniles tend to be seasonally aggregated, probably contributed to higher catches of sub-legal fish. It is also probably significant that the stock of older marine resident fish, as indicated by rising commercial CPUE, was rebuilding quite rapidly partly due to effort reduction and partly due very wet conditions and very strong recruitment in 1983/84. Despite the rise in availability of fish for the recreational sector, angler success rate has not changed at either of the two main fishing locations with consistently only around 50% of parties landing a fish (Griffin, 1995), as expected from the effort response models of Walters (1997) and Walters and Cox (this volume). The mean size of barramundi taken has increased substantially from 52 cm TL in 1986 to 71 cm TL in 1995, reflecting both the rebuilding of the stocks and the shift of fishing effort from freshwater juvenile habitat areas to saltwater inhabited by adult fish.

Discussion

The observed trends in recreational activity in Mary River, with the clear decline from 1986 to 1992 and subsequent rise from 1993 to 1995 do not match the trend which could be expected from both the observed rebuilding of the stocks which began in 1987 and from predictions of the age-structured model. There are some obvious factors such as lily infestation, changing angler habits and access changes which have affected the distribution and concentration of angler effort in the Mary River from 1986 to 1995. While abundance of fish is the

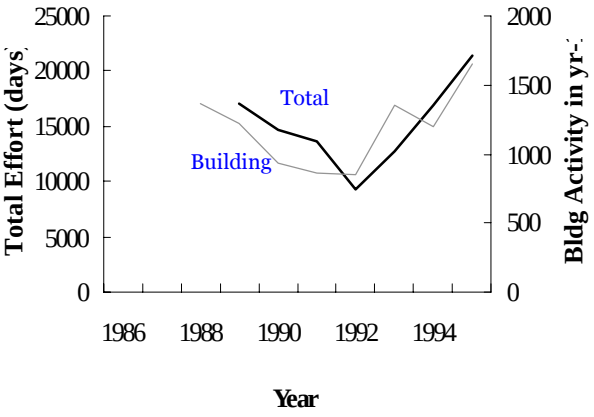

Figure 4. Observed recreational fishing effort in the Mary River compared to residential building activity in the NT in the previous year, 1989 to 1995. Building ac-

basic factor which determines whether or not fishing activity will occur, it is clearly not the only factor and in this case does not

In seeking to explain why recreational effort did not increase as might have been expected following the closure of the commercial fishery, we apparently need to look at the overall health of both the local and national economies. The period 1990 to 1992 was a period of recession in the Australian economy. The NT, as a fast-growing, frontier economy, was somewhat shielded from the effects of that recession but some major economic indicators in the NT do show downturns in that period. In particular the residential building industry, which in a fast-growing, young community is a major employer, showed a significant decline (Fig. 4). With a one-year delay, allowing for flow-on of effects, that decline correlates very closely with the observed decline in fishing activity in the Mary River.

Given that fishing at Shady Camp, the favoured Mary River fishing location in recent years, involves a round trip of over 300 km from Darwin, it is quite likely that cost has been a deciding factor in hard economic times. If that is the case then it is possible that a decline in activity in the more remote areas would be matched by a rise in local areas such as Darwin Harbour. Unfortunately there is no information available on activity levels in other, more accessible areas.

While in this case radical reduction of the commercial fishery was undertaken as much to ensure stock recovery as it was to reallocate the resource to the recreational sector, it can perhaps be taken as an example of how a fishery might respond to reallocation. There was a general community expectation that exclusion of the commercial sector from the Mary River would lead to increased availability of fish to the recreational sector and that this would result in an increase in recreational activity. It was also presumed that this increased recreational activity would generate economic activity which would more than make up for the loss of the commercial fishery. This study clearly shows that this expected increase did not occur and in fact a decrease in activity occurred despite a substantial increase in available stocks of barramundi. Because of the concentration of effort, both seasonally and spatially which has occurred there is a very strong perception that overall recreational activity has dramatically increased. In fact by 1995 fishing effort had risen back to the levels of 10 years before. With continuing increases in population, particularly an increase of defence personnel, it is likely that fishing activity will continue to increase. The fact that in the period 1993 to 1995 when effort did increase there was no increase in success rates, possibly indicated (as Walters, 1997 suggests is likely) that increased availability of fish translates into improved catches for only a small number of knowledgeable anglers. Further analysis of the economic benefits of commercial closure in this case is not possible but this case provides some evidence that closure of the commercial does sector does not guarantee an increased economic contribution from the recreational sector.

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Questions

Murray MacDonald: Could you please summarize the reasons why commercial Barramundi fishing was permanently closed in some Northern Territory waters?

Roland Griffin: It was closed to allow for the rebuilding of the stock, and at the time the commercial sector saw the loss of rights to fishing as robbery whereas at the same time the recreational fishers were blaming the commercial sector for the over-fishing.

Linking Water Quality Improvements to Recreational Fishing Values: The Case of Chesapeake Bay Striped Bass

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Abstract

A poisson expected catch rate model for striped bass in Chesapeake Bay is estimated as a function of historic catch rates, angler characteristics and water quality. Striped bass populations are stressed when ambient dissolved oxygen levels fall below 5 mg/l water temperature, and also when water temperature exceeds 25□C or. When the stress conditions are met in a fishing area, expected catch rates of anglers targeting striped bass in Chesapeake Bay decline. The relative changes in expected catch between different areas are captured in a random utility model of striped bass fishing, with resulting estimates of welfare changes. Nutrient reduction policies in Chesapeake Bay are evaluated using a spatially explicit 3-D model of water quality changes. Thus it is possible to simulate the benefits to recreational fishing from nutrient reduction by linking the predicted water quality improvements with the Poisson expected catch rate model and a random utility model.

Introduction

Freeman (1995) argues that in recreational fishing, "...the links between policy and the attributes of the activity that people value (catch rate) have not been established." In their paper on modelling angler catch as a Poisson process, McConnell *et al.* (1995) conclude that a fruitful area of research is connecting objective measures of the quality of a recreational experience with subjective expectations of the angler. This study is an attempt to address both of these important issues. We link objective measures of water quality to the subjective catch rate expectation of the angler. By so doing, we also create a link between the policy of water quality improvement through nutrient reduction in the Chesapeake Bay to the valued activity of recreational angling.

A recent estimate places annual incremental expenditures for water pollution control in the Chesapeake Bay drainage basin related to the Clean Water Act and related pollution control activities between $1.0 and $1.3 billion (Industrial Economics, Inc.). A major focus of these pollution controls is on excess nitrogen and phosphorus entering the system from point source sewage treatment plants and non-point sources such as agricultural and residential land uses. These excess nutrients accelerate eutrophication in estuarine systems, leading to hypoxia and subsequent negative impacts on living marine resources (USEPA, 1998). These impacts on living resources such as fisheries include physiological stress, modification of growth rates, modification of feeding rates, habitat restriction and direct mortality (Breitburg *et al.*, 1994). Demonstrating the economic benefits of either preventing further deterioration in water quality or improving water quality over current levels will become increasingly important as the marginal costs of improvements increase.

Modelling Catch Expectation

Random utility models (RUM) of recreational fishing may consist of a two-step process, modelling the expected catch rate and then using the catch rate expectation in a model of site choice from which welfare measures can be calculated. In McConnell *et al.* (1995), the expected catch is modelled as a function of characteristics of the angler, characteristics of the site and hours fishing:

$$Q_{ij} = \exp(\beta_o + \beta_1 cr_i + \beta_2 \ln(h_j) + \beta_3 s_j) \quad (1)$$

where Q_{ij} = number of fish caught at site i by angler j, cr_i = mean catch rate at site i from NMFS historic intercept data, h_j = hours spent at the site by angler j, and s_j = skill or experience in saltwater fishing by angler j. The policy relevance of this equation is obtained through altering the historic catch rate variable (cr_i) which would presumably be linked to a change in the fishing stock or water quality.

Since equation (1) is a model of how individual anglers form expectations about what their catch will be at the sites they are choosing among, it is important to examine in more detail the underlying assumption about these expectations. The angler typically is not directly aware of the objective measure of historic catch rate at a site. However, the inclusion of historic catch rate is implicitly based on the concept that it will become generally well known among anglers where and when fish are to be found. For example, striped bass anglers may choose to fish around the Chesapeake Bay

Bridge in the fall, because the aggregate experience of anglers over time has proven that to be a place with relatively high catch rates. Unfortunately, data limitations often require aggregating the historic catch rate for an individual species at a site over time to the wave level (2 month period) or to the entire fishing season as well as aggregating over area to the adjacent county or group of counties, making it difficult to determine the actual conditions under which an individual is fishing.

It is proposed that more current information play a significantly greater role in the angler decision regarding site choice. The same angler who knows about catching fish at a particular area and time, might choose not to fish there if recent reports in the local paper, discussions with other fishers or tackle shop operators are that fish are being caught more successfully elsewhere. The differential in fish catches in different areas may be reflective of the variability of water quality conditions among the fishing sites. Modelling by Brandt *et al.* (1992) have demonstrated that there are significant three dimensional spatial differences in water quality in Chesapeake Bay at any given time, thus affecting the habitat suitability for key recreational species. For example, if conditions are such that a significant volume of anoxic water is affecting a particular area, there may not be many fish there to catch. The poor fishing will be reported in the newspaper and through other means, but may not be captured in the historic catch rate, particularly if this is type of occurrence varies significantly from year to year.

The behaviour of striped bass, the species of interest in this study, is particularly susceptible to poor water quality conditions. Preliminary work by Breitburg (personal communication) shows that there is a significant reduction of striped bass caught in experimental bottom trawls when the measure of dissolved oxygen in the bottom layer of water is below 5 mg/l. A potential response of the fish would be to move up in the water column where more mixing is occurring and the dissolved oxygen levels are greater than 5 mg/l. Striped bass have also been shown to avoid water temperatures above 25°C. When both conditions are present in an area, our expectation is that few striped bass will be found, catch rates will be low, and that this information will become available through the aforementioned channels.

We capture this effect of water quality on expectations of recreational catches by appending the McConnell *et al.* (1995) model as follows:

$$Q_{ij} = \exp(\beta_0 + \beta_1 cr_i + \beta_2 \ln(h_j) + \beta_3 s_j + \alpha z_i) \quad (2)$$

where z_i = a vector of water quality variables for site i. The water quality variables act as proxies for the a priori information regarding fish catches that appear in the local newspapers and in discussions among fishers.[3]

Although Brandt (1992) has developed an index of potential productivity based on water quality for major recreational species in the Chesapeake Bay, we introduce them in equation (2) in their reduced form.

The expected catch rate model that was estimated is similar to the one estimated by McConnell *et al.*, but with the addition of dissolved oxygen and temperature variables:

$$Q_{ij} = \exp(\beta_0 + \beta_1 cr_i + \beta_2 \ln(h_j) + \beta_3\, \text{yrfish}_j + \beta \text{ffdays12} + \alpha_1 ST + \alpha_2 BT + \alpha_3 SDO + \alpha_4 BDO + \alpha_5 (BDO)^2) \quad (3)$$

where yrfish = the number of years the angler has been fishing, and ffdays12 is the number of days in the last 12 months that the angler has gone fishing, ST = surface temperature, BT = bottom temperature, SDO is surface dissolved oxygen, BDO is bottom dissolved oxygen. This model is consistent with Brandt *et al.* (1992) index of potential productivity calculations for major recreational species in the Chesapeake Bay. The key variables that comprise Brandt's index are water temperature, salinity, dissolved oxygen, chlorophyll a concentrations and prey densities. Prey densities are not collected in the monitoring data so we were unable to recreate that index. Salinity and chlorophyll a were tried in some of our earlier estimations, but were never significant.

Random Utility Model

The random utility model (RUM) has been widely used to examine discrete choices made by individuals. In this application of the RUM, fishing location choices made by recreational anglers are being examined. The RUM helps illuminate how anglers make trade-offs between travel costs of going fishing and fishing quality at competing fishing sites. It is well known that the RUM offers a convenient way to measure welfare changes

[3] Kaoru *et al.* (1995) appended water quality variables to a Poisson catch rate model of recreational fishing in Albemarle Sound. It is not clear in that study how the water quality measures of nitrogen loading and biological oxygen demand would enter the *a priori* decision of site selection.

from environmental quality changes (Bockstael, Hanemann, and Strand). An individual i is assumed to maximize utility by selecting one site from S_i possible alternatives, where the set S_i can be different for each individual. Let the set S_i be defined by the researcher and let the individual's indirect utility function for alternative j be represented by

$$U_j(q_j, y - p_j, \varepsilon_j) = V_j(q_j, y - p_j) + \varepsilon_j \tag{4}$$

where $V_j(q_j, y - p_j)$ represents the observable portion of the individual's indirect utility function (with vector of quality characteristics q_j, income y, and price of access to the i^{th} site p_j) and an error, ε_j, which is assumed to be distributed as a Type-1 extreme value distribution and arises from factors unobservable to the researcher.

Therefore, for a given choice occasion, the individual will choose j if

$$V_j(q_j, y-p_j)+\varepsilon_j \geq V_k(q_k, y-p_k)+\varepsilon_k, \; j \in S_i, \forall k \in S_i. \tag{5}$$

From the researcher's perspective, the probability that individual i chooses alternative j can be written:

$$P_i(j) = \frac{e^{V_j(q_j, y-p_j)}}{\sum_{k \in S_i} e^{V_k(q_k, y-p_k)}} \tag{6}$$

Assuming that the specification of the observable portion of the indirect function is linear in income, Hanemann (1982) shows that the compensating variation (CV) of a parameter change from q^0 to q^1 can be written as

$$CV = \frac{\ln\left(\sum_{k \in S_i} e^{V_k(q_k^1, p_k)}\right) - \ln\left(\sum_{k \in S_i} e^{V_k(q_k^0, p_k)}\right)}{\beta_Y} \tag{7}$$

where β_Y is the marginal utility of income.

Data

Two primary data sources are used to estimate the poisson and random utility model, the National Marine Fisheries Service's Marine Recreational Statistical Survey and the Chesapeake Bay Program Water Quality Monitoring Program. In 1994, the National Marine Fisheries Service expanded their intercept and phone survey in the north-eastern United States to include economic and demographic information that would facilitate economic analyses of the data. Details of this special survey are provided in Gautam and Steinback (1996). For this study, we used data from interviews of fishers at the 407 intercept sites that are located in the Chesapeake Bay and its tributaries. Site location, available by latitude and longitude, was overlain on a Chesapeake Bay coastline map, and the intercept sites that fall on the Bay and tributaries coastline were selected using ARCVIEW GIS software. The Chesapeake Bay water quality data has been collected since 1984 at a series of fixed station locations in the Bay and its tributaries. During the fishing season, water quality data is collected twice a month at 216 locations throughout Chesapeake Bay and its tributaries. These water quality stations were also geo-coded and entered into an ARC/INFO database.

The water quality and recreational fishing data were combined spatially and temporally. For spatial matching, all the intercept sites within the Bay were matched with the nearest water quality station that was within 5 km.[4] For temporal matching, the period of water quality sampling that was just prior to the fishing occasion was matched with the fisher. Water quality prior to the fishing date was used rather than the sample closest to the date of fishing because water quality is treated as impacting fishing expectations, not the realization of catch. Thus, for each fishing occasion, water quality was assigned to the intercept site and all alternative fishing sites in the Bay.

Model Results

Table 1 shows the results of the Poisson model of expected catch rate for striped bass in Chesapeake Bay. All parameter estimates have the expected sign and, except for number of times fishing in last 12 months, are significant. Of particular interest to this study is the role of water quality variables, particularly dissolved oxygen which is the target of extensive Chesapeake Bay management efforts. As anticipated, dissolved oxygen levels have a positive effect on expected striped

[4] Fishing may actually take place several miles from the intercept site, but information is not collected on the exact place where fishing occurred. For fishermen on trailered boats (the dominant form of boating access in the Chesapeake Bay), it is likely that they fish relatively close to the intercept site, since they have the choice of trailering their boat overland to alternative launch sites.

Variable	Estimated Coefficient	Standard Error	t stat -istic
Constant	-5.897191	0.89455	-6.592*
Historic Catch Rate	0.6314136	0.55408E-01	11.396*
Hours fishing (ln)	0.3437722	0.10302	3.337*
Years fished	0.1855453E-01	0.30553E-02	6.073*
Days fished in last 12 months	0.5524159E-03	0.37467E-03	1.474
Surface temperature	-0.2548078	0.98165E-01	-2.596*
Bottom temperature	0.3225429	0.11363	2.838*
Surface dissolved oxygen	0.2588551	0.58642E-01	4.414*
Bottom dissolved oxygen	0.2252537	0.11534	1.953*
(Bottom dissolved oxygen)^2	-0.1667067E-01	0.82389E-02	-2.023*
Observations			1806
CHI-SQUARED			424

Table 1. Parameter estimates for striped bass expected catch rate model. Denotes significance 95% confidence level

bass catch rates, but at a decreasing rate. Bottom temperature and surface temperature measurements had similar magnitude, but opposite effects on striped bass catch with higher surface temperatures lowering expected catch rates and higher bottom temperatures increasing expectations. This is consistent with the behaviour expected of striped bass when water temperature is in a stressful range -- seeking habitat that has both high oxygen and cooler temperatures. Other models, which attempted to incorporate salinity and chlorophyll a measures, did not improve the estimates.

The parameter estimates from table 1 are used to compute an expected catch rate for each angler sampled at the site they were intercepted and the remaining 406 potential fishing sites that form their choice set. The calculated expected catch rate is then used along with travel cost and travel time to estimate the random utility model. The random utility model results are given in Table 2 for both the expected catch rate and an historic catch rate model. The historic catch rate model uses the 1990-1994 average catch rate by mode and wave for a particular area instead of the expected catch rate from the Poisson model.

Both the expected catch rate and historic catch rate models perform well in terms of sign and significance of the variables. The parameter estimates for travel cost and travel time are similar between the two models, with catch rate playing a slightly greater role in the expected catch rate model compared with the historic catch rate model.

Striped Bass values

The welfare results are presented only for the expected catch rate model. Ultimately, we are interested in the change in welfare resulting from a change in water quality, but to place that in perspective we first determine the value of access to the fishery and to improvements in expected catch rates.

From our model and choice set specification it is not possible to determine an overall value for Chesapeake Bay striped bass fishing. This would require that Chesapeake Bay fishing sites were a subset of a larger choice set such as the north-eastern United States. If that were the case, the process would be to measure the welfare change with and without the Chesapeake Bay sites in the choice set. We can, however, measure the value of access of Chesapeake Bay striped bass fishing in Maryland and Virginia on a state by state basis by eliminating one state at a time from the choice set. This process yields a measure of the value of fishing access to Chesapeake Bay striped bass fishing in a state, given that when fishing in one state is not available, it is still available in the other state and the coastal (non-bay) fisheries of both states. Thus, adding together the two state estimates provides an underestimate of the value of access to the entire Chesapeake Bay striped bass fishery.

The per trip welfare estimates are provided in Table 3 and are presented by wave and fishing mode. The values were higher in Virginia compared to Maryland for all modes and waves, perhaps reflecting the larger number of alternative sites that would be closed down in Virginia if access were denied. As expected, the party/charterboat fishing

Variable	Expected Catch Rate	Historic Catch Rate
Travel Cost	-0.035476 (0.00242)*	-0.035758 (0.00243)*
Travel Time	-0.829109 (0.09626)*	-0.840207 (0.09621)*
Catch Rate (square root)	0.651972 (0.23796)*	0.456079 (0.15030)*
OBSERVATIONS	166455	166455
CHI-SQUARED	1260	1362

Table 2. Parameter estimates of random utility model of Chesapeake Bay striped bass. * Denotes significance 95% confidence level

STATE	MARYLAND			VIRGINIA		
Wave	P/C	PR	SH	P/C	PR	SH
3	na	$71.32	$44.94	na	$82.89	$51.91
4	na	$84.57	$67.76	na	$93.38	$77.77
5	$172.88	$60.60	$77.25	$186.23	$73.10	$86.33
6	$122.53	$57.20	$45.07	$134.38	$63.13	$48.29

Table 3. Benefits of access to striped bass by mode, wave and state. P/C = Party/Charter, PR = Private/Rental, SH = Shore, na = not available

mode had significantly higher net benefits than private/rental boat or shore fishing. The average value of access across all modes and waves was $62.22 per trip for Maryland access and $69.95 for Virginia access.

To determine the total welfare of access to Chesapeake Bay striped bass, the average values presented in Table 3 were multiplied by the estimated number of trips in 1994 for the corresponding wave and mode. The total value of access to Maryland striped bass fishing in 1994 was $38.5 million and $19.7 million in Virginia. The difference is due to the larger number of directed striped bass fishing trips in Maryland (505,067) compared with Virginia (316,346) and the greater number of higher value party/charter votes in Maryland.

Most studies of recreational fishing values presume some change in expected catch rate that might result from a change in water quality or from adoption of a particular policy (e.g., catch limits that will result in increased fish stocks). For our study we looked at an increase in the expected catch rate of 0.5 fish per trip. This marginal increase in expected catch would result in a $4.95 increase in the value of a trip. The total annual return from such an increase would be over $4 million, and this does not account for the potential increase in the number of trips taken due to the increased expected catch.

Our welfare estimates compare favourably with earlier studies such as McConnell and Strand and Norton *et al.* (1983). McConnell and Strand estimates were for a aggregate species groups, so that striped bass were lumped with weakfish and bluefish. Since striped bass fishing is one of the premier recreational species in the Chesapeake Bay, it is expected that our estimates of trip value would be higher since theirs is weighted by the catch of lower valued species. After adjusting for inflation, McConnell and Strand's estimate based on expected catch was $33.32 and $57.86 for Maryland and Virginia, respectively. Norton *et al.* (1983) employed the travel cost method to estimate for 1979-1980 consumer surplus for Chesapeake Bay striped bass trips of $70.14 in 1994 dollars. The marginal value for an expected increase in one fish per trip was $9.53 in the Norton *et al.* study and $8.79 in our study. Although the two studies used different methodologies which could explain the differences in the results, the lower marginal value in our study may also be due to the fact that the average catch per trip was higher in 1994 (Maryland 1.29, Virginia 0.66) than in 1979 (Maryland 0.71, Virginia 0.38). Thus, while each trip had a greater value in 1994 due to the higher catch rate, the marginal value of increasing the expected catch rate is lower in the more recent period.

Value of Water Quality Improvement

Improvements in water quality were modelled as entailing an increase in the dissolved oxygen level in all areas where the monitoring data indicated it fell below some threshold value. The thresholds chosen were dissolved oxygen levels of 5 mg/l and 6 mg/l. If the monitoring data indicated that the dissolved oxygen level fell below 5 or 6 mg/l, then the dissolved oxygen level was set to either 5 or 6 mg/l in order to determine a new expected catch rate. Dissolved oxygen levels above the threshold value were left unchanged. The welfare calculation was the compensating variation for the change in expected catch rate at the original and changed dissolved oxygen level. The results are given in Table 4, and show a very small return to improvements in water quality above the 1994 baseline level. The results reflect the relative small increase in expected catch rates due to these water quality improvements.

It is recognized that without the current policies and regulations to control nutrient inputs into the Chesapeake Bay, water quality would probably be much lower than under current policies. To test

	Per Trip	Aggregate
DO ↑ 5	$0.24	$193,032
DO ↑ 6	$0.30	$242,317

Table 4. Per trip and aggregate compensating variation for an improvement in water quality. DO = dissolved oxygen.

	Per Trip	Aggregate
DO ↓ 5	- $6.00	$4,928,480
DO ↓ 4	- $7.48	$6,144,171
DO ↓ 3	- $8.84	$7,261,294

Table 5. Per trip and aggregate compensating variation for a decrease in water quality

the benefits of avoiding poorer water quality conditions, we calculated the compensating variation when water quality at all the sampling stations was set so that dissolved oxygen levels was equal to either 3,4 or 5 mg/l. The resulting hypothetical welfare losses are presented in Table 5.

Summary and Conclusions

The major contribution of this study is to demonstrate the complete pathway between an environmental policy and measurement of the anticipated benefit. In the case examined, water quality improvements from current levels will have little benefit to striped bass recreational fishers. However, allowing water quality to deteriorate from current levels, will have significant impacts. Since there are many other potential ways that water quality improvements can produce economic benefits, it would be inappropriate to conclude from this partial analysis, that water quality should not be improved from current levels. There are many other fish species and other types of activities such as swimming and boating that may have larger responses to water quality improvements.

The one-year survey of economic benefits limits our ability to look at the dynamic effects of water quality improvements, particularly those related to the abundance of the striped bass population. Since current plans by the National Marine Fisheries Service include a regular collection of the necessary data, this advance to the analysis will be possible within a few years.

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Questions

Carl Walters: I think you have made a fundamental error in your calculations, as you tied your values to increases in CPUE, when in fact you need to consider fishing effort which is important.

Douglas Lipton: I don't follow you; we should talk in greater detail later.

Recreational Fishing in England and Wales

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Abstract

The size, economic value, administration and use of the freshwater recreational fisheries in England and Wales are described in the context of status and trends. Approximately 26,000 km of river and 30,000 lakes are fished by more than 1 million licensed anglers. Fisheries are in private ownership with the Environment Agency implementing legislation. The Agency's aim for fisheries and the role it fulfils in dealing with its enforcement duties alongside a wider remit to address environmental and anthropogenic pressures is outlined. Provisional estimates of the social importance and economic value of inland fisheries are given and reasoned proposals for a future strategy are discussed.

Introduction

Freshwater angling is one of the most popular participant sports in the country with an estimated 2.3 million coarse anglers and 843k game anglers. This compares to 1.1million sea anglers that fish around the coast of England and Wales, (National Rivers Authority, 1995). With approximately 26,000km of river and 30,000 lakes the fishery resource is rich and varied and ranges from highland streams to lowland rivers, natural lakes to water supply reservoirs, from canals to old gravel pits.

Since the days of Sir Isaac Walton fishing practices have evolved and developed. The traditional picture of the affluent game angler and the working class coarse angler has changed with the evolution of a whole variety of different angling practices. There are still the traditional salmon, sea trout and brown trout anglers and the coarse fish pleasure angler however, these have been joined by the match angler, the specimen hunter, the pole fisher and the angler who is after the exotic.

Recreational fishing in certain sectors of the sport is now big business; it can also be an important part of the rural economy. It is increasingly recognised that recreational fishing has a valuable role in raising environmental awareness of wildlife and the environment and in inner city areas it can play an important social function by providing an opportunity to "be with friends" and an alternative to drugs and crime.

All inland fisheries in England and Wales are in private ownership as, historically, all fishing rights were associated with the possession of the adjacent land. However, there is national legislation in place to regulate the exploitation of fisheries. The responsibility for implementation and enforcement of the legislation rests with the Environment Agency, which was established by the Environment Act 1995 and became fully operational on 1 April 1996. Anglers wishing to fish require both a rod licence from the Environment Agency and consent from the owner of the fishing rights, usually provided by a day permit or angling club membership ticket.

The Environment Agency

The Environment Agency is one of the largest and most powerful environmental protection agencies in Europe. The Agency's primary aim is to protect and improve the environment throughout England and Wales and to contribute to sustainable development through the integrated management of air, land and water. The Agency[5] has specific responsibilities for water resources, pollution prevention and control, flood defence, fisheries, conservation, recreation and navigation. The Agency's vision is "A better environment in England and Wales for present and future generations".

Agency Role in the Management of Inland Fisheries

The Environment Agency's principle fisheries aim is to maintain, improve and develop the fisheries of England and Wales as set out in the Environment Act 1995 and the Salmon and Freshwater Fisheries Act 1975. The Agency fulfils this role through the delivery of an integrated fisheries service.

The Agency's vision for fisheries is that "All waters in England and Wales will be capable of sustaining healthy and thriving fish populations and everyone will have an opportunity to experience a diverse range of good quality fishing."

The national fisheries service is funded by a budget of £22.3 million, of which £14.9 million is

[5] The Environment Agency's Internet address is: www.environment-agency.gov.uk

from fishing licence income and £7.4 million is from the government.

Over and above its core budget the Fisheries function exercises strong leverage on the Agency's £590 million of annual expenditure. For example the Agency's need to have 24 hour communication cover, which is well funded, enables Fisheries to operate an around-the-clock free telephone hotline for incidents.

Fisheries alongside the other functions of the Agency also plays an important role in influencing expenditure by others, such as the Waters Companies' Asset Management Plans. Since 1995 this programme has seen in excess of £1 billion per annum invested in sewerage and water supply infrastructure which has yielded significant water quality improvements and protected some river flows.

Most of the Environment Agency's fisheries work is carried out in partnership with fisheries, anglers and landowners. This partnership approach is formalised through Regional Fisheries, Ecology and Recreation Advisory Committees (RFERAC), local Angling Consultative groups and informal liaison groups.

Maintaining, Improving and Developing Fisheries

In order to maintain the fisheries of England and Wales, the Agency monitors the status of fish stocks, investigates fisheries environmental requirements, enforces fisheries legislation (including administering fishing licences and undertaking antipoaching operations), responds to and investigates fish kills, carries out fish rescues, regulates the movement of fish, protects and safeguards water quality and river flows and comments and seeks to influence planning decisions and the management of the wider environment.

To improve and develop fisheries the Agency carries out a large amount of habitat enhancement work, has a number of salmonid and coarse fish hatcheries, provides advice to fisheries and has a well-developed R&D programme. Nationally over and above the expertise in the field the Environment Agency's fisheries service is supported by a Salmonid Centre, Coarse Fish Centre and a National Fish Disease and Fish Ageing laboratory.
To help anglers the Agency produces a wide range of publications that includes information on fishing venues, fish species, fisheries bylaws, catch-and-release and the Agency's fisheries activities. Annually the Agency responds to over 6,500 requests for fisheries advice.

Providing an integrated fisheries service

- Enforcement and regulation;
  a) 1.2 million fishing licenses,
  b) 4,500 fishery prosecutions ranging from licence evasion to organized and violent poaching,
  c) >275 pollution and abstraction prosecutions;
- Monitoring the status of fish stocks;
  d) >8,500km of river monitored, 28 fish counters
  e) Radiotracking and hydroacoustic monitoring
  f) Statutory catch returns for salmon and sea trout
  g) Fish kill investigations and 1,000 fish kill incidents
  h) Fish rescues 400 emergency fish rescues saving > 1 million fish;
- Habitat enhancement;
  i) 300 river restoration and improvement projects
  j) 40 fish passes and 200 other fish passage improvements;
- Salmonid and coarse fish;
  k) 6 salmonid farms and 2 coarse fish farms
  l) hatcheries - 4.5 million fish are stocked each year;
- R&D;
  m) £500,000 per year provides leading edge technical advice. Major outputs include Trout and Salmon Habitat Manuals, The use of Hydroaccoustic fish counting technology, Fisheries Classification System, The impact of endocrine disrupters and Techniques for setting salmon spawning targets.
- (n) Provision of advice;
- (o) 6,500 requests for fisheries advice per year;
- (p) 100,000 planning applications.

Participation and exploitation of the recreational fishing resource

Amount of fishing

Freshwater angling is one of the most popular participant sports in the country with an estimated 2.3 million coarse anglers and 843k game anglers. This compares to 1.1million sea anglers that fish around the coast of England and Wales, (National Rivers Authority 1995). Recognising that many anglers fish for both coarse and game fish there are an estimated 2.9 million freshwater anglers in England and Wales equates to ap-

proximately 3.5% of the population. However, the National Angling Survey 1994, reported that since 1980 there has been an apparent decline in the number of anglers in England and Wales by 470,000(14%) (National Rivers Authority, 1995).

In terms of fishing trips, the National Angling Survey 1994, found that coarse fishers made on average 43 trips per year whereas trout and salmon fishers made 16 and 7.5 trips per year respectively, Hickley (1996).

The overall frequency with which coarse and game anglers fish appears to be stable however, it is apparent that many young coarse anglers having started, fish with increasing frequency until a proportion of them cut down in their 20's and 30's (National Rivers Authority, 1995).

Fish Catches

Coarse fishers usually return their fish to the water after capture. In overall terms there is minimal impact on the fish resource Wortley (1995). However, in the increasingly popular heavily stocked 'commercial' still waters, fish handling can exacerbate the stress that the fish are under in already environmentally poor conditions. Further research is needed on the survival rates of returned fish for different species and sizes.

Trout fishers by and large keep their fish following capture. Where exploitation exceeds natural recruitment or where spawning conditions are poor, regular stocking is the means by which the fishery is supported. However, there is the beginning of a movement towards catch-and release and the promotion of wild fisheries as exemplified by the recently formed Wild Trout Society.

The salmon and sea trout fisheries, which are virtually wholly dependent on natural production, the sustainable management of the fishery resource is particularly critical. In response to a nation-wide crash in the Spring salmon runs new national byelaws were introduced in April 1999, which make it compulsory to return all rod caught salmon before the 16th June.

Angler Preference for Different Fish Species and location

Preferences amongst coarse anglers for target species and type of fishery were also reported in the National Angling Survey 1994 (National Rivers Authority, 1995). One quarter of anglers did not mind which species they caught. Of those with a preference, 36% of coarse anglers expressed a preference for carp, 28% for roach and 21% for bream. This is a significant change from 1969 - 1970 (NOP, 1971) when the preferred species was roach (39%) followed by pike (29%).

In terms of fishing location 52% of coarse anglers fished still waters [=lakes. Ed.] most often, 35% rivers and 14% canals. The national trend is towards fishing in still waters with a reduction in fishing rivers. Canal angling is relatively stable (National Rivers Authority, 1995).

Referring to the Angling Press as a barometer of angler preference, the popularity of carp fishing has increased since 1994. There would also appear to be an increase in the specialist angler who wants to catch either large numbers of carp, specimen fish or the exotic, which includes species such as the wells cat fish, golden orf and Chinese blue carp.

In meeting this demand, there has been a proliferation of specialist still-waters that provide guaranteed high catches and specimen waters that now boast carp of over 40lbs.

This change in angler preference has lead to the intensive stocking of some waters together with the introduction of non-native exotic fish in others. Ecologically the impact of this change can be significant in terms of habitats and native stocks. Of particular concern is the demise of the crucian carp due to interbreeding, the introduction of fish diseases such as Spring Viremia of Carp (SVC) and in some waters stocking densities that create a situation where the fish's survival is dependant on anglers bait for food.

Amongst game anglers there is mismatch between preference and actual catch with salmon and sea trout anglers preferring to catch salmon but more often catching sea trout and trout anglers preferring to catch brown trout but more often catching rainbow trout (which are non-native) (NRA, 1995). This observation is very much influenced by the availability and status of the respective game fish populations.

Trout fishing has expanded in popularity over recent years with the opening up of a large number of still water trout fisheries which principally stock rainbow trout. This has made the sport much more accessible. There has also been a quest amongst some anglers for larger fish with the British record rainbow and brown trout having been broken on successive years as rearing techniques have developed. This preference for larger fish is most notable on still waters, though

it is increasingly apparent on some river fisheries. The ecological impact of this change is yet to be fully determined. In parallel with the above and in contrast, there has been a growing wild brown trout movement which has seen the founding of the Wild Brown Trout Society in 1996.

Salmon and sea trout fishing is virtually all for wild fish however, a few still waters have been stocked with landlocked salmon.

Socio-economics

Cost of fishing trips

Economically recreational fishing is big business. It is estimated that the total national expenditure on coarse angling is around £2.4 billion per year, with the average annual expenditure on coarse angling being around £1,070 per angler. It is estimated that the total national expenditure on game angling is around £0.92 billion, with the average annual expenditure on game angling being around £1,093 per angler. These figures are calculated on the basis of direct expenditure on fishing trips covering items such as travel, food & drink, bait, tackle and permits (National Rivers Authority, 1995). They do not take account of expenditure on accommodation that is a particularly important area of expenditure that benefits most notably rural economies (MacAlister *et al.*, 1999)

Economic value of fisheries

Environmental economics is an important tool for the strategic management of the aquatic environment Postle (1993) and in recent years attempts have been made to quantify the economic value of recreational fisheries. Radford et al (1991) evaluated the salmon fisheries of Great Britain and, with capital asset values, assessed each salmon to be worth £3,600 in economic terms. In promoting the importance of wild trout as a resource, Elliot (1989) considered the value of each fish to be worth £500.

A recent evaluation by telephone survey, commissioned by the Environment Agency's National Coarse Fisheries Centre, asked London residents how much money they would be willing to pay towards a Trust Fund to ensure that salmon do eventually live and breed in the Thames. It found that every household would be willing to contribute approximately £2.40 per year. Considering there are 5 million households in London, this puts the potential economic value of introducing living breeding salmon in the River Thames at £12 million per year, with a high and low of £24 and £6 respectively.

The survey also highlighted that the greatest benefit of having salmon in the River Thames would be derived from "Knowing it meant the river was clean", which was followed by "Knowing that future generations would benefit" (a form of bequest value) and "Just knowing that there are salmon in the river" (a form of existence value, MacAlister *et al*. 1999).

Social benefits

In Leeds, a large city in the north of England, a recent survey has found that an important reason for people going fishing is "being with friends". Many of the angling clubs are based at social clubs, pubs and places of work and the survey results highlight how fishing plays an important social, communication and relaxation role in the lives of the survey respondents, which were principally adult men.

In inner city Leeds recreational fishing also plays an important social and environmental awareness-raising role amongst young people giving them an alternative to crime and drugs. An annually organised fishing competition has the title "Get hooked on fishing, not drugs and crime" MacAlister et al (1999). In Hampshire the Environment Agency and the Hampshire Police Force have directly supported a number of inner city fisheries projects that have provided angling opportunities for the young and access for disabled anglers.

Conservation, Ecology and Raising Environmental Awareness

In England and Wales there are 30 riverine Special Sites of Scientific Interest (SSSIs) designated under Wildlife and Countryside Act 1981. Of these, 6 rivers have been put forward as Candidate Special Areas of Conservation, for amongst other ecological features, their fish populations, under the European Habitats Directive 1992. The fish species protected under the Habitats Directives include: Atlantic Salmon, Brook, Sea and River Lamprey, Bullhead, Alice and Thwait Shad and Spined Loach.

Nationally the numbers of Atlantic salmon returning to our waters has declined significantly over the last ten years most notably for spring salmon. Practising catch-and-release and managing fisheries habitat so as to maximise in river production are central tenants of the National

Salmon Strategy 1995, which is now supported by Salmon Action Plans for each of the major salmon rivers in England and Wales.

For many people recreational fishing provides them with their first introduction to learning about wildlife and the environment. By raising people's environmental awareness, wildlife and their habitats have a better chance of being protected and enhanced for the benefit of present and future generations.

Anglers play an important role as an environmental conscience for the nation raising issues such as diffuse pollution and over abstraction. They also provide 2.9 million sets of "eyes and ears", environmental watchdogs who are often the first to report a pollution incident.

Case Study – the lower Trent fishery
Introduction

Recreational fishing and its management in England and Wales today is a reflection of historical changes to legislation, altered environmental conditions and the varied perception of anglers as to what constitutes a good day's fishing. The following case study presents a fishery that reflects both specific local issues and the wider changes seen in recreational fishing across England and Wales in recent years.

The River Trent is one of the UK's largest rivers and represents an important recreational fishery at both a local and national level. Serving a population of six million people, it is 286 km long from its Staffordshire source to the Humber Estuary and drains an area 10 435 km^2. This paper relates to fishing on the lower river, from its confluence with the River Dove to its confluence with the Humber Estuary at Trent Falls. This reach is 169 km long and includes the major East Midlands conurbations of Derby, Nottingham and Leicester.

The river supports a wide variety of coarse fish with roach, bream, chub and gudgeon present in greatest numbers. Other species include perch, pike, barbel, dace, carp, bleak and eel.

The Lower Trent Area is part of the Midland Region. In 1997 annual rod license sales for the area were 101,421. This provided an income of around £1.1million, which is approximately 8.5% of the total national fisheries purse of £13.6 million generated from license sales.

Historical Perspective

Historically the sport fishery was centred on its status as a nationally popular venue for match anglers. Other forms of coarse fishing, namely specimen hunting and pleasure fishing have assumed a minor role. Traditionally the major target species were roach, bream, chub and gudgeon [European cyprinids. Ed.], a reflection of both their numerical dominance within the fish community and the high regard in which they were held by Trent angler's. Between the 1960's and the early 1980's the river reached its peak in popularity with many National and All England Championships being hosted. Since the mid 1980's there has been a steady decline in the river's popularity, culminating with a decision by the UK National Federation of Anglers to suspend holding UK National Championships on the river for at least the next five years.

The Issues

Environmental Conditions

Following improvements in sewage treatment works and industrial effluents over many years the nature of the river has significantly changed. Prior to the early 1980's high organic load and low clarity were typical along most of its length. In addition water used at power stations in the cooling process were discharged to the river causing elevated river temperatures. Recent improvements in sewage treatment works and industrial effluents, has led to both a significant reduction in organic loading and improved water clarity. Water temperatures have also returned to a more natural cycle following the closure of a number of power stations along the river and now reflect ambient air temperatures more closely. Hydro acoustic and angling census studies show that the fishery has responded to this environmental change. Prior to water quality improvements enormous numbers of roach and gudgeon whose distribution was highly regular along the whole river dominated the fish population. Today the fish population is more diverse in nature and their distribution along the river is more sporadic. Fish numbers are also lower which in part is a reflection of the reduced organic input. Lower water temperatures, slower growth rates, lack of cover, and predation are also factors that may be contributing to this population shift.

Match fishing for competitors usually requires a draw to be made at the start of a match to determine the anglers fishing position. The changes seen in the Trent fishery in recent years have meant a significant shift in the importance of this

draw. Lower numbers, diverse and clumped populations mean the importance of skill and experience has been in many cases replaced by luck.

Availability and Access

The Lower Trent has traditionally attracted anglers from a wide catchment. Regular visitors from Yorkshire, Lancashire, the West Midlands and East Anglia fish the river, with South Yorkshire providing the largest single contribution. For these anglers the attraction was due to two main factors, the good reputation the river commanded within the match fishing fraternity and the absence of good angling closer to home due to the highly polluted, and often fishless nature of local rivers.

In recent years improvements in the availability and access of local fishing in South Yorkshire has occurred. Large scale improvements in the water quality of local rivers, an explosion of still water fisheries catering for the match angler, and the loss of the River Trent's reputation as "the UK's premier match fishery"; have all contributed to a significant decline in this lucrative trade.

Economic Decline

a) Community. The dominant industry in many areas within the Lower Trent catchment was coal mining. For many towns and villages employment both direct and indirect relied on the prosperity of these mines. Since the early 1980's the majority of mines that worked the coalfields of North Nottinghamshire and South Yorkshire have closed. This has led to high unemployment and economic decline in many of the affected areas. Within these communities fishing was the largest single participant sport with many fishing the Trent on a regular basis. A typical day's match fishing on the Trent would include transport, bait, entrance fees, food and drink, little change being seen from £50. With lower prosperity the amount spent on fishing became a primary concern with many anglers. One way to reduce this expense is to fish closer to home. With the increase in availability of local fishing, both riverine and still water, these are now realistic alternatives to the River Trent.

b) Angling Clubs. The demographic shift seen in recent years in the Trent catchment whether voluntary or enforced has had a dramatic and in some cases a terminal effect on clubs that own or more significantly rent fisheries on the river. The majority of these angling clubs has in the past relied on a constant stream of match booking to cover their costs. Increasingly match bookings have become sporadic and in many cases no longer provide sufficient income for these clubs. A primary example is the loss of National Championships, each match often attracting over 2000 anglers, and estimated revenue of £100k. In addition current rents largely reflect this 'boom period' for match fishing on the river a situation far removed from the current climate. For those clubs that own the riparian land and its fishing rights a financial buffer exists. However most clubs rent their respective fisheries and hence this buffer does not exist leaving many with a financial imbalance. At worst bankruptcy occurs and some clubs have already suffered this fate.

In response to the position that many angling clubs now find themselves in the Environment Agency is beginning to address the situation through its remit to "optimise social and economic benefits from sustainable exploitation". The primary concern is the current rents levied on the fisheries. It is proposed that a forum between all interested parties be convened based on the key conceptual component of co-operation, the aim to determine a rent that best reflects the current economic conditions on these fisheries.

Social Change

As an integral part of the general public the angler reflects many of the aspirations and changes in perspective seen throughout society. The increased expectation among the general public for quick success and instant entertainment now exists within the fishing community. In addition competition for an individuals leisure time has also increased dramatically in recent years. Computer games and access to a wider range of sports and hobbies allied to improved transport facilities mean that local angling no longer enjoys the dominant position it previously held. A lack of new juvenile recruits to angling is not only confined to the Lower Trent Area. Nationally the present age profile compared with 1980 indicates fewer anglers under the age of 16, and more over the age of 55.

The requirements for remaining anglers have been met in many instances by the current explosion of small, highly stocked still water fisheries. Given their robust nature, cheap price and fighting ability, the majority of these waters contain a monospecific fish community of carp, most fish weighing between 0.5kg and 3kg. In addition to fishing these new fisheries also provide their customers with eating facilities, toilets bait and tackle supplies. A number now also cater for the non-angler providing entertainment for the whole family, creating a 'supermarket scenario' with its one-stop supply ethos.

Many such fisheries have been constructed in the North Nottinghamshire and South Yorkshire area providing local, sought after fishing conditions. These purpose built fisheries provide a fishing experience far removed from that which a large, natural river such as the Trent has to offer. These trends are also seen nationally with over half of all coarse anglers preferring to fish still waters instead of rivers, with carp the most popular quarry.

Whether this is good or bad for fishing is a hotly debated topic, its merits depending upon the individuals perspective of what constitutes a good days angling. It is clear however that in the Lower Trent area this move towards still water fishing has contributed to the decline in the number of anglers fishing the River Trent. One area of concern with this reduction is the loss of observers on the river who play an important surveillance role for the agency. This role and benefit to others that recreational fishing provides requires acknowledgement beyond the fisheries function of the Agency.

Anglers who fish natural lakes and rivers soon learn about the different fish species, their behaviour and the wildlife that surrounds them. The experiences gained from fishing small, purpose-built, newly constructed still waters does not provide the same benefits, as many of these fisheries aim solely to provide instant catches and often only one species of fish. While this does provide the benefit of instant catches for the new angler it takes away many of the benefits of recreational fishing such as wildlife observation and as such can reduce the "whole angling experience". This may cause recreational fishing to move from a life long pursuit to a short-term activity.

Scientific Information

Fishing catch data has been collected from Trent matches since the early 1970's. The collection of this information has provided valuable cost-effective data on fish populations. The approach has also meant that the Agency has been in direct contact with the anglers on a regular basis, which has been a tremendous for promoting good public relations.

Quantitative scientific information on the Trent's fish stocks is still relatively sparse. As part of a new initiative, hydroacoustic technology is being used to gather information on fish populations, which will considerably enhance our present knowledge.

Conclusion

Recreational fishing in England and Wales has some clear economic, social and environmental benefits. However, there is a counter side to this with a tension growing between natural self-sustaining fisheries and artificial stocked fisheries. With a move to purpose built still waters, single species fisheries, a desire for ever larger fish and exotic species many of the environmental benefits of recreational fishing are being lost.

This highlights a situation of countering pressures that are facing the Agency, whether the Agency's principal fisheries aim should be directed towards providing "what the angler wants" or achieving a balance between fishing and the environment. On the River Trent where significant environmental improvements have been achieved the fishery has in fact declined, creating new management issues that were unforeseen.

Evaluating the Benefits of Recreational Fishing - Future Challenges

As the statutory authority for environmental protection in England and Wales the Environment Agency has a pivotal role to play in the future strategic planning of recreational fishing in England and Wales. A fundamental requirement of this role is to assess and balance the pressures on recreational fishing against a background of limited and finite resources through a coherent fisheries strategy.

The challenge for the UK Environment Agency is to balance its statutory obligations of protecting and enhancing the environment whilst maintaining, improving and developing fisheries, the key to the success of its strategy lying in a partnership between the Agency and the anglers, clubs and the wider community.

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Economic Value of Northern Alaska Sport Fisheries and the Influence of Management on Stated Trip Frequency

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Abstract

In northern Alaska, quantitative measures of sport fishing benefits are used to evaluate the benefit to cost ratio to ensure that public benefits outweigh management costs, as specified in fishery management plans. Net economic values of angler trips and total annual values to recreational fishing sites were estimated based on the contingent valuation method. Mail surveys were administered to samples of licensed resident and non-resident anglers in 1995 and 1996 in a series of economic and social analyses of current and alternative conditions for stocked waters and Arctic grayling fisheries. Questions were designed to estimate net economic value by species of fish targeted, site, region, and residency status. Anglers' assessment of preferences for alternative management options were solicited. Additionally, contingent behaviour questions were incorporated in the mail surveys to estimate the influence of the hypothetical implementation of preferred management options on stated fishing trips, and thus the marginal value of the recreational site.

The estimated value per resident angler trip for stocked waters in the Tanana Valley ranged from a mean of $33.81 (se = 6.45) to $68.70 (se = 5.30). Using total estimated annual net economic value against expenditures, benefit/cost ratios range from 3 to 20 for major stocked waters. Residents value trips targeting Arctic grayling in flowing waters more highly than stocked waters, with estimated values at $123.24 (se = 14.93). Non-resident values range up to $559.08 (se = 50.13) for an Arctic grayling fishing trip in Region III waters. Implementation of preferred stocking options would result in estimated trip increases between 13-34%. Estimated increases in trips resulting from hypothetical changes to regulations for Arctic grayling fisheries ranged from 6-28%. However, changes in trips would come from a minority of anglers, and a percentage of this population said changes would come at the cost of trips to other waters. The majority of respondents reported that implementation of preferred management options would have little effect on their decisions to take fishing trips.

Introduction

This paper summarizes results from a multi-year economic and social analysis of current and alternative conditions for sport fisheries in a 490,000 mi² area of Alaska defined as Region III. Examples from research conducted on stocked waters in the Tanana Valley in 1995 (Duffield *et al.. In press,* a), and regional Arctic grayling *Thymallus arcticus* fisheries in 1996 (Duffield *et al.*, *In press,* b) are given.

The research had two primary goals. The first was the estimation of public benefits as net economic value or net willingness-to-pay (WTP) that anglers of Region III waters place on their sport fishing experiences. The net economic value of a trip is the amount of money a person would be willing to pay to take the trip in addition to what they actually did pay. Few studies to estimate the non-market value of sport fishing trips in Alaska have been conducted. Prior to this research, measures of sport fishing demand were estimated angler days. Objectives in fishery-specific management plans in Region III state that, in addition to managing for sustainable harvests and maintaining access, public benefits will outweigh management costs. The problem, then, was to estimate public benefits in dollar metric terms, and to evaluate the benefit/cost ratio for program planning.

The second goal was to estimate changes in angler trip frequency resulting from the hypothetical implementation of preferred management options. The few management options available to the Alaska Department of Fish and Game (ADF&G), Division of Sport Fish include diversification and increase in expected catch rates through stocking, and sport fishing regulations. Division goals, created in 1992, are to conserve wild stocks, provide for diverse sport fishing opportunities, and to optimize social and economic benefits from recreational fisheries. The question prompting this component of the research was: can we perform an optimization? There is a need to evaluate management policy for its influence on public welfare. Trip frequency is used in this study as one indicator of public welfare.

Methods

Survey and Sample Design

Mail surveys were administered following the procedures of Dillman (1978). The survey consisted of four sections: 1) general questions about recreational fishing patterns and trips to Region III waters; 2) specifics about the respondent's most recent fishing trip, including questions pertaining to contingent valuation used in estimating net economic value of trips; 3) questions on the respondent's preferences for management options, including how their trips would change contingent on implementation of management options; and, 4) socio-economic questions.

The survey was pre-tested on a randomly drawn sample of 200 sport fish license holders. The purpose of the pre-test was primarily to determine the top bid level for the contingent valuation question, and to test the effectiveness of the survey wording and question sequencing. Additionally, clarity of the survey questions was tested using a focus group of approximately 10 individuals.

The scope of the research was ambitious, given the limited resources available for survey implementation. Sample sizes ranged from 3,500 surveys administered for the stocked waters study, to approximately 8,000 surveys for the Arctic grayling study. The survey was ideally designed to estimate net economic values for targeted species by water body, given sufficient responses for model development. However, a more realistic objective was to obtain estimates for the more heavily used waters. To obtain sufficient responses for modelling, samples were aggregated to waters within a geographic area, and finally all geographic areas within Region III. Objective criteria for precision were $\pm$ 25% of the mean 95% of the time.

Various populations were either censused or randomly sampled. Resident 1995 license holders residing in the Tanana Valley comprised the population sampled for the stocked waters study, because creel surveys had shown that few non-residents' fish stocked waters. For the Arctic grayling study, five populations holding 1996 licenses were surveyed: Seward Peninsula residents, northwest Alaska residents, remainder of Region III (comprised primarily of Fairbanks residents), residents of Regions I (southeast Alaska) and II (south-central Alaska), and non-residents.

Contingent Valuation and Behaviour Methods

The contingent valuation method (CVM) determines values which people would place on non-market goods or services, such as fishing trips, as if markets did exist for these commodities. The CVM asked individuals their WTP contingent on a hypothetical situation. The resource of value was the fishing trip. The payment vehicle used in these studies is an increase in travel costs to the fishing site. The question format we used is dichotomous choice, with individuals responding either "yes" or "no" as to their WTP – for example, would you be willing to spend $25 more for your fishing trip than you actually spent? The advantages of using the dichotomous choice approach are discussed in Boyle and Bishop (1987). We used the truncated mean for the welfare measure (Bishop and Heberlein 1992), which is truncated at the highest bid level. The truncated mean is conservative, however is more precisely estimated than the overall mean (Patterson and Duffield 1991). The logistic model was used to relate the probability of "yes" to explanatory variables (model specifics are found in Duffield *et al.. In press,* a). The procedure used to identify the precision of the dichotomous choice welfare estimates was bootstrapping (Efron 1982, Duffield and Patterson 1991).

The contingent behaviour method (CBM) predicts how anglers' behaviour would change given a hypothesized change in the attributes of a fishing trip. In our studies, these changes consisted of various stocking options or fishing regulations. The key in using CBM is to present understandable questions, and to offer realistic management options. In the survey, the current management strategy was explained, then various changes were offered and the respondent queried regarding the influence of the hypothetical change on their decision to take a fishing trip (for details see Duffield *et al.. In press,* a). The distribution of anglers' predictions of trip changes contingent on the implementation of a hypothesized management option was constructed from responses to questions in Section III of the survey.

Stocked Water	Adjusted mean WTP / trip	1995 angler trips	Total annual net economic value
Quartz Lake	$68.70 (5.3)	25,179 (1,721)	$1,729,794 (178,524)
Birch Lake	$58.78 (6.3)	16,970 (1,574)	$ 997,524 (141,476)
Harding Lake	$46.68 (7.3)	8,753 (876)	$ 408,550 (76,425)
Chena Lake	$36.04 (5.4)	11,034 (961)	$ 397,658 (69,497)
Piledriver Slough	$33.81 (6.5)	13,763 (840)	$ 464,932 (93,299)
Total			$3,998,457 (266,949)

Table 1. Estimated mean WTP per fishing trip, angler trips, and total annual net economic value of sport fishing in five stocked waters of the Tanana Valley, 1995

Results- Net Economic Values

The response rate to the stocked waters survey was 49.2%. Approximately two-thirds of respondents indicated that their most recent sport fishing trip to one of five major stocked waters (Quartz, Birch, Harding and Chena lakes or Piledriver Slough) was worth more to them than they actually spent on the trip. The estimated coefficients for the bivariate models for Chena and Birch lakes and Piledriver Slough are significant at the 95% confidence level, and for the Harding and Quartz lakes models, are significant at the 90% level. The net economic value per trip estimates were adjusted to account for the one third of individuals with zero net economic value per trip. The ADF&G conducts an annual survey of sport fishing catch and effort (Howe *et al.*, 1996, 1997). Estimates of angler trips to the five stocked waters were multiplied by their respective net economic value per trip to estimate total annual net economic value of sport fishing, shown below with bootstrapped standard errors in parentheses.

Quartz Lake is significantly higher in total annual net economic value with a mean at $1.7 million, followed by Birch Lake at about $1.0 million; the remaining three waters have similar mean values around $400,000 (Table 1). The total annual net economic values were used against stocking expenditures to calculate the benefit/cost ratio (Figure 1). Mean benefit/cost ratios for Quartz and Birch lakes are approximately 20, much higher than those for the remaining three waters, which are around 3. Costs account for the hatchery component including transport, and also evaluation, however not management or supervision. Obtaining accurate estimates of costs associated with projects is difficult without activity-based cost accounting in place.

The response rate to the Arctic grayling survey was 36.7%. Over 75% of respondents to the Arctic grayling study indicated their most recent fishing trip to waters in Region III was worth more than they actually spent on the trip. All models developed for the Arctic grayling study had coefficients significant at the 90th percentile or greater. The survey design allowed for the possibility of estimating many sub-sample models of WTP, and only a few will be presented in this paper. Of particular interest was Region III fishing trips specifically targeting Arctic grayling (Table 2).

Population	Adjusted mean WTP / trip
Non-resident – Arctic grayling	$559.08 (50.13)
Resident of Region III – Arctic grayling	$123.24 (14.93)

Table 2. Estimates of mean WTP per sport fishing trip to any area in Region III by population, and targeted species

Non-resident anglers have a higher net WTP for fishing trips than do Alaskan residents (Table 2), consistent with the findings of many previous studies of recreational WTP (see for example Duffield *et al.*, 1992).

Mean WTP estimates for each of five populations fishing in Region III vary considerably among Alaskan residents, with residents of northwest Alaska valuing their sport fishing trips the greatest (Table 3).

Residents value fishing for wild stocks of Arctic grayling in flowing waters more than fishing stocked waters.

Preferences for Management Options

In the stocked waters study, respondents were presented with the following statement: “Fish and Game can produce limited numbers of fish for stocking. We would like to know your preferences for possible stocking options for Arctic char, rainbow trout, and salmon.” Within each group of options, respondents were asked to rank their most preferred. With regards to stocking Arctic char, there was a clear preference among anglers for increased expected catches of fewer, but larger char at Harding Lake (60.0%), than more, but smaller char at Chena Lake (40.0%). However, in regards to rainbow trout and salmon, the percentages of anglers preferring higher expected catch rates from additional stocking among three possible sites do not statistically differ: approximately 33% of anglers preferred additional stocking at each of the three possible sites. Thus, anglers have no clear preference for directing additional stock-

Population	Adjusted mean WTP / trip	1996 angler trips	Total annual net economic value
Non-resident	$590.84 (23.40)	23,325 (1,106)	$13,781,369 (851,819)
Northwest AK	$274.78 (38.72)	1,107 (313)	$304,180 (96,856)
Regions I & II	$192.25 (29.97)	12,235 (880)	$2,352,217 (404,691)
Seward Pen.	$149.69 (11.95)	10,602 (1,168)	$1,587,053 (216,370)
Region III remainder	$121.86 (7.22)	157,740 (4,801)	$19,221,742 (1,280,829)
Total			**$37,246,561 (1,608,133)**

Table 3. Estimated mean WTP per fishing trip, angler trips, and total annual net economic value of sport fishing to any area in Region III, by population for all species combined, 1996.

ings of rainbow trout and salmon among three possible locations.

In the Arctic grayling study, respondents were asked their preferences for various management options for fishing in area waters. The statistics presented in Figure 2 represent the percentage of respondents who rated a particular management strategy as a 4 or 5 on a 1 to 5 scale with 1 being least preferred and 5 being most preferred. For the Tanana area, managing Arctic grayling for catch and release was most preferred by 48.7% of residents; on the other hand, managing Arctic grayling for harvest was most preferred by 42.2% of the remaining residents. There are conflicting preferences for management, nearly evenly divided, for managing Arctic grayling in Tanana waters. Less residents on the Seward Peninsula (33.8%) favor catch and release management for Arctic grayling. Fewer non-residents whose most recent fishing trip for Arctic grayling occurred in either Tanana (31.0%) or Seward Peninsula (27.5%) waters prefer managing for harvest than residents. Preference for status quo management is rated high by residents in both Tanana (42.0%) and especially Seward Peninsula (60.9%) areas.

Influence of Hypothetical Management Options on Estimated Fishing Trips

Analysis of estimated trip changes under preferred stocking options was somewhat problematic due to small sample sizes. Aggregating responses to six preferred stocking options resulted in estimates of trip increases to the five major stocked waters from 13 to 34%. Thus, responses to the contingent behaviour questions made it clear that anglers were receptive to proposed stocking changes and would likely fish the waters more often if their preferred changes were made.

In one example from the Arctic grayling study, respondents were presented with three management options for harvest of Arctic grayling in the Chena River, which is currently under catch and release management. It is estimated that regulations allowing for harvest in the lower river would lead to a 10.7% increase in trips; regulations allowing for harvest of one fish per day in the entire river would lead to a 16.3% increase in trips; and implementing the most liberal option, a two fish daily bag with one fish over 15", would lead to a 28.7% increase in trips. However, when the distribution of responses to the most liberal option is examined (Figure 3), the vast majority (77.7%) of anglers indicated no change in their current average rate of annual fishing trips (2.9) to fish any species in the Chena River, regardless of changes in the options presented. The estimated increase would come from a minority of anglers. Negative trips would result as well, likely from anglers dissatisfied with the hypothesized liberalization of the harvest management strategy.

Discussion

Management policies must be at least minimally supported by anglers or these clients will use the political process to lobby for changes. The policy that brings about positive changes in social and economic benefits from sport fisheries, while still achieving biological objectives, is likely to enjoy public support. Information obtained from socioeconomic research can be used to evaluate particular management policies for their influence on net economic value, preferences, and fishing trip frequency. This research confirms that anglers are a diverse group, and it could be that there are few outstanding options that would be preferred by a clear majority. Optimization is made difficult by angler diversity. Further analysis, such as segmenting anglers into groups based on fishing motivation, may reveal less disparity in preferences for management policies.

Using the ratio of total annual net economic values to hatchery and evaluation expenditures as a measure of program cost efficiency, public benefits from stocking five major waters in the Tanana Valley do indeed outweigh management costs for 1995. The benefit/cost ratios for three of the five stocked waters were unexpectedly low, prompting

the question, "How low is too low?" The extent to which the benefit/cost ratio influences program decisions is still under discussion by policy-makers. The benefit/cost ratio is only one of several considerations in program planning, and its weight in the policy-making process is likely to be variable, depending upon the importance of other influences, such as conservation or political concerns. This research has demonstrated that net economic values in terms of net WTP can be estimated within objective criteria for precision, and can form the basis for estimation of economic benefits of sport fishing. A challenge for policy-makers is to define the cost basis, and to obtain accurate and consistent estimates of costs for purposes of program evaluation.

While the stocking and Arctic grayling studies indicate that implementing preferred options for management of these fisheries is likely to result in increased angler trip frequency, changes in visitation are relatively small. Estimated percent changes in trip frequency would come from a minority of the angling public. A portion of this minority stated that any increases to area waters from regulation changes would come at the cost of fishing trips to other waters. Consistently across models, the vast majority of respondents reported that the proposed options would have no effect on the number of fishing trips they currently take. Further analyses, such as correlating support for management options with stated trip frequency, may reveal greater information regarding the implications of management options. The ability of management to influence anglers' decisions to take fishing trips may be overshadowed by more significant variables such as weather, the angler's employment and economic situation, and the angler's motives for initiating a trip. The overall impact to public welfare in the region from the fishery-specific changes in management options examined in this research may be negligible, given the many substitute fishing sites available, and the minimal influence of proposed options on the majority of anglers' fishing trips. Further research on benefit estimation and optimization from recreational fishing is needed to guide policy-makers.

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Questions

Ratana (Ying) Chuenpagdee: The difference between willingness to pay methodology and travel cost methodology may be attributed to residents having different travel costs, because they have less cost for travelling.

Margaret Merritt: I initially applied the travel cost methodology but the results were not "believable". Then I applied the contingent valuation method. One way to examine believability of the results is to track data trends. For example, I compared the trends of willingness to pay with the rating of fishing quality. Non-residents had higher willingness to pay and fishing quality ratings than residents, which are trends supported in the literature. So, this helps me to believe that the contingent valuation method is giving good results.

Economic Benefits and Value of a Localized and Seasonal Walleye Fishery

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Abstract

The characteristics of a seasonal river walleye fishery were evaluated during an 8-week period in 1995, 1996, and 1997 as part of an overall assessment of the walleye fishery in Norris Reservoir, Tennessee, USA. Walleye traditionally made late-winter and early-spring spawning migrations into a 26 km reach of the Clinch and Powell rivers from mid-February through early-April. During this period, anglers sought these prized fish resulting in an intensive fishery in this restrictive reach. Angling effort was estimated to be 64,035+/-9,728 hr in 1995, 55,199+/-9,313 hr in 1996, and 48,189+/-5,852 hr in 1997 during this eight-week period. Although most anglers resided in adjacent counties, approximately 25 % were non-residents. Total daily expenditures exceeded $350,000 per season or approximately $44,000/week of which 38 % were expended by non-resident anglers. Anglers paid approximately $ 28,000 per season in state taxes $5,800 per season in local taxes, and $16,000 per season in federal fuel tax. Total economic output for the 8-week fishery exceeded $ 740,000 per season. The economic benefit of this fishery is heightened when the geographic setting is considered. Claiborne County is a rural, fairly isolated county with an economy based primarily in outdoor recreation. Local markets, gas stations, and restaurants rely on the economic input from walleye anglers especially during the late-winter and early-spring when other outdoor recreation opportunities are limited. Communication of economic value information also a primary aspect of this study. Examples in several arenas are presented.

Introduction

Fishery scientists have several tools to aid in the management of recreational fisheries. These include regulating harvest, introducing forage or sport fish, enhancing habitat, and educating anglers (Matlock 1991). To adequately monitor these activities, fishery managers often employ field-based techniques that may include population or community surveys, habitat inventories, or angler surveys. Angler surveys serve two purposes: 1) to assess the catch, harvest, and effort; and 2) to evaluate angler opinions, social and economic trends, and demographic involvement.

The importance of economic data have become increasingly valuable as more and diverse anglers, politicians, and the general public become interested and involved with fishery management activities (Pollock *et al.* 1994). Often the communication of biological data are difficult because of the type and format data biologists collect and often attempt to present. Economic data (dollars, jobs, tax revenue, and use of funds) are often easier to present because of the utilization of especially money in daily activities.

Techniques used to survey anglers are diverse and often complex. Off-site surveys (mail or telephone) are often used to assess anglers over a wide geographic range and are usually designed to evaluate angler attitudes towards new or existing regulations, management programs, or economic trends (Pollock *et al.* 1994). Access point surveys are a useful method to assess harvest, catch, and effort; as well as angler attitudes and economic input.

Traditionally, fishery management agencies utilized roving surveys to assess angling-based characteristics. Clerks transverse a specified area by foot, vehicle or boat, and interviewed intercepted anglers. Roving surveys produce estimates of harvest, catch, and effort. Rates of harvest and catch, as well as size at harvest information, also can be determined. Instantaneous counts provide an estimate of overall effort, which is very helpful for administrative purposes. Survey protocol is often set by probability of angling effort. Angler attitude, social, economic, and demographic information can be gathered, but as with any on-site interview technique, thought must be given to the length of interview. Benefits of roving creel method are that clerks actually converse with anglers on-site, thus recall bias is minimal. Several weaknesses include the collection of only partial trip information, excess costs, and avidity bias.

The need for angler-based information during the spawning-period walleye *Stizostedion vitreum* fisheries within the Clinch and Powell rivers of Norris Reservoir was apparent during the development of an adaptive management plan for the restoration of the walleye fishery. The Tennessee Wildlife Resources Agency (TWRA) did maintain a reservoir-wide creel survey on Norris Reservoir,

but the techniques employed did not provide adequate coverage of these river systems.

Walleye are an important sport fish with approximately 15% of all anglers seek walleye (O'Bara 1997). Walleye populations are maintained primarily through natural reproduction, but supplemental stocking has been employed. Recently, both anglers and biologists have voiced concerns about this fishery. The recent introduction of alewife *Alosa pseudoharengus* into the system and the potential catastrophic effects of this exotic species led biologists to become concerned. Many anglers felt that over harvest was occurring during the spawning period and that non-resident anglers were fishing at a disproportionate frequency, contributing to the over harvest, and not providing any economic input to the state and community.

To provide a sound data base to assess this fishery, this study was initiated.

Specific objectives were:

- 1. To determine effort by anglers during the spawning-period walleye fishery,
- 2. To ascertain angler demographics and motivations, and
- 3. To provide insight into the economic impact of the fishery on the county and state.

Study Area

Norris Reservoir is a 13,470 ha impoundment operated by the Tennessee Valley Authority located in northeast Tennessee. The reservoir is operated primarily for flood control, hydropower production, and as a source of cooling water for downstream nuclear power plants. Prior to the impounding of the Clinch and Powell Rivers, major tributaries of Norris Reservoir, walleye congregated in the rivers during the late-winter and early-spring and spawned over shoal areas. With the construction of the dam, walleye spawning was restricted to a restricted upstream sections of the reservoir that was free-flowing during the spawning period.

The Powell River was surveyed from PRKM 72 (PRM 45) to PRKM 85 (PRM 51) (13 km) in the vicinity of Earl's Hollow. The Clinch River was surveyed from CRKM 232 (CRM 140) to CRKM 245 (CRM 148) (13 km) near Beech Grove Access Area (Figure 1). Both reaches are located in Claiborne County, Tennessee. Historically, anglers concentrated in these reaches during the late-winter and early-spring to fish for both walleye. Boat angler access was primarily via two public boat ramps and bank angler access was primarily via roads parallel to the rivers. The number of potential access points dictated the use of a roving-roving creel survey design.

Methods

Survey Protocol

Surveys were conducted four days per week (two weekend days and two week days) from 17 February to 8 April 1995, 16 February to 6 April 1996, and 14 February to 5 April 1997. Each day was divided into a morning and afternoon diurnal period, and survey times and locations were randomly selected. Each river was surveyed at least two periods per week, if weather and water conditions permitted. Because no historic angling effort data were available, both rivers were afforded the same survey sampling effort.

A single clerk conducted all surveys. The clerk would initiate the survey at the downstream point of a given reach and interview all parties encountered. At a randomly selected time, the clerk would travel the entire length of the reach to acquire an instantaneous count of anglers. The time to transverse the entire reach was less than 15 min. Information collected included angling effort, number of walleye caught and harvested, as well as angler demographics, motivation, and economic expenditures.

Laboratory and Data Analysis

All data were analyzed using *SAS Version 6.08* and *Microsoft Excel 97*. Standard creel data analytical techniques were employed (Pollock *et al.* 1994). Because roving creel methods result in primarily non-complete trip surveys, catch and harvest rates were determined per survey day, not per angler trip. Both means and standard errors were determined and unless otherwise noted all measurements of variations are standard errors. Comparisons were made between both rivers and years when appropriate using the Duncan's multiple range test (alpha=0.05).

Estimated effort (h) was determined using instantaneous counts following the methods of Pollock *et al.* (1994). The period of record was 8 weeks or 56 days. Mean daily effort was determined for both week-day (Monday-Friday) and week-ends (Saturday-Sunday) for each river. Mean estimated effort was ascertained by multiplying the number of week-day and week-end days by the corresponding mean daily effort. Estimated effort and trips were determined for the period late-

Attributes	Clinch River			PowellRiver		
	1995	1996	1997	1995	1996	1997
Tennessee Residing Anglers	72	73	83	75	82	74
Kentucky Residing Anglers	26	21	17	21	16	26
Virginia Residing Anglers	2	6	0	4	2	0

Table 1. State demographics of all anglers participating in the Clinch and Powell Rivers walleye fishery, 1995, 1996, and 1997. Values are percents.

February through early-April for each river, as well as both rivers. Daily catch and harvest was determined by multiplying the daily catch and/or harvest rate by the estimated daily effort. Estimated catch and harvest for the period were determined in a similar manner as effort and trips, and are reported as means with corresponding standard errors.

The economic impact of these fisheries was determined using several data sources. Daily costs were developed on a per trip basis. Trips consisted of primarily two anglers per trip for this fishery, thus used in the analysis. Costs were divided into individual costs and trip cost. Total trip costs were the sum of these two components. All expenditures are reported in 1996 dollars.

Individual costs were either derived during survey interviews or from the *U.S. Fish and Wildlife Service's 1996 National Survey of Fishing, Hunting and Associated Recreation* (Maharaj and Carpenter 1997). The distance traveled from each county/state to the most used public boat ramp determined daily travel. It was assumed that vehicle mile per gallon was 15 and fuel cost was $ 1.20/gallon. Cost per trip was determined by county and expanded by the percent of trips taken by county residents. Thus, the daily cost per trip varied by county, as well as state. Contributions by Tennessee anglers and non-resident anglers also were determined.

State and federal revenue derived from the fishery consisted of state sales tax on all goods and services purchased in Tennessee (6% to state and 2.5% to county), state fuel tax on all fuel purchased in Tennessee (18% to state and 2% to county) and federal fuel tax (12%). Local tax revenue was determined by summing all local tax revenue generated in Claiborne County. Total economic output was determined by a multiplier (2.084) reported by Maharaj and Carpenter (1997). The analysis package was developed using *Microsoft Excel 97*.

Value per harvested walleye was determined for total daily expenditures, tax revenue to local, state, and federal government entities, and for total economic output. These values were determined by dividing the respective economic value by the number of walleye harvested for each year and for the entire study period.

Results

Demographics

Anglers residing in Tennessee exceeded 70% on both rivers for all years (Table 1). Anglers residing in Kentucky, Virginia, and West Virginia also utilized the fishery. Kentucky-residing anglers represented greater than 15% of all anglers for all years. Most Kentucky-residing anglers were from adjacent counties and were most likely very familiar with the systems. Virginia-residing anglers also were from adjacent counties, but were present in low numbers. Interestingly, no Virginia-residing anglers fished in 1997 on either river.

Tennessee-residing anglers were primarily from Claiborne, Knox, Grainger, and Hawkins counties, representing approximately 88% of all Tennessee anglers. With the exception of Knox County, the remaining three counties are in close proximity to both the Clinch and Powell rivers. Few anglers other than those residing in Claiborne County fished the Powell River especially in 1996 and 1997.

Effort

Mean length of a fishing trip ranged from 5.9h (+/-0.2) in 1995 to 4.6h (+/- 0.4) in 1997. The mean length of fishing trip in 1996 was 5.5h (+/- 0.2). This significant decline in mean length of fishing trip in 1997 was mostly likely the result of the reduction of anglers from non-adjacent counties or non-state anglers participating in the fish ery.

Anglers spent an estimated 64,035h (+/-9,728) fishing on both systems in 1995, 55,199h (+/- 9,131) in 1996, and 48,189h (+/-5,852) in 1997. A significant decline in angling effort (h) was evident between 1995 and 1997. Estimated trips were 10,835 (+/-1,646) in 1995, 10,018 (+/-1,657) in 1996, and 10,408 (+/-1,263) in 1997. Nonresidents or those anglers residing in Tennessee counties not adjacent to the rivers contributed greatest to the decline.

Attribute	Tennessee Resident		Non-Resident	
	Individual Cost	Trip Cost	Individual Costs	Trip Cost
Food/Beverage	6.41	12.42	19.57	39.14
Ice	0.53	1.06	0.32	0.74
Bait	2.00	4.00	2.32	4.64
Boat Fuel	-	7.20	-	7.20
Total Costs	8.82	24.84	22.21	51.62

Table 2. Daily costs used in economic analysis for the Clinch and Powell Rivers' walleye fisheries. Dollars are reported as 1996 value. Vehicle fuel not included here, as it was dependent on County/State of residence.

Angler effort on these two rivers during the eight-week survey was extreme in comparison to other Norris Reservoir fisheries. Anglers expended approximately 393h/ha in 1995, 339h/ha in 1996, and 296h/ha in 1997 on both rivers. In comparison, anglers expended 10.2 h/ha in all of 1995 in Norris Reservoir fishing for walleye. This effort declined in both 1996 (6.2 h/ha) and in 1997 3.3h/ha. Overall, approximately 31% of all walleye directed effort was expended on the rivers in 1995, 38% in 1996, and 51% in 1997.

Angler Motivation to Fish for Walleye

Angling for walleye during the spawning period was the central focus of all outdoor related activity for 48% of all interviewed anglers. Eighty-three percent fished only for walleye during this spawning period and 28% did not fish for other species during the remainder of the year.

Sixty-seven percent of Tennessee residing anglers felt that to catch a limit of walleye for consumption was the primary motive to fish for walleye and 18% felt that is was a secondary motive. Other important motivating factors included cultural and family traditions (18% primary, 57% secondary) and just to go fishing (7% and 16%). Non-resident anglers displayed similar trends with 68% felt that to catch a limit of walleye for consumption was the primary motive to fish for walleye family traditions and 24% a secondary motivating factor. Cultural and family tradition was less of a factor (12% primary and 43% secondary) for non-resident angers than resident angers Thus, for both angler groups, harvesting walleye for consumption was the primarily motivation.

Catch and Harvest

Estimated total number of walleye caught was 15,595(+/-5240) in 1995, 9,086(+/-3,884) in 1996, and 3,026(+/-654) in 1997. No significant differences were detected between 1995 and 1996, but both 1995 and 1996 were significantly different from 1997. Estimated total number of walleye harvested was 5,825(+/-1,527) in 1995, 5,302(+/-1,479) in 1996, and 2,432(+/-634) in 1997. Again, significant differences were detected between 1995-1996 and 1997.

Economic Impact

Cost per angling-trip was determined for several attributes for both resident and non-resident anglers. Cost per angling ranged from $24.84 for residents to $51.62 for residents excluding travel costs and travel-related taxes (Table 2).

Economic impact of the walleye fishery for the years 1995-1997 exceeded $ 1.14 million in daily expenditures and $ 2.3 million in economic output. Weekly economic output for this eight-week fishery averaged $ 98,860 for the three years. Daily expenditures and economic output have declined since 1995. Total daily expenditures were $ 416,870 in 1995, $ 356,570 in 1996, and $ 365,065 in 1997 (Table 3). The slight increase in daily expenditures in 1997 was attributed to an increase in the number of trips. The percent of non-resident daily expenditures decreased from 43% in 1995 to 35% in 1997 (Table 3). Virginia-residing anglers spent $ 19,310 in 1995, $ 21,010 in 1996 and $ 0 in 1997. In contrast, Kentucky-residing anglers spent $ 158,755 in 1995, $ 111,290 in 1996, and $ 128,020 in 1997.

Daily expenditures were divided into goods and

Year	Total Daily Expenditures	Total State Sales Tax	Total State Fuel Tax	Total Federal Tax	Total Economic Output	Percent TN State Residents
1995	416,870	13,129	23,291	17,800	868,755	57
1996	356,570	12,187	20,538	15,120	743,095	63
1997	365,065	12,299	20,441	14,845	760,795	65

Table 3. Total daily expenditures and total economic output for an eight-week walleye fishery on the Clinch and Powell Rivers, 1995, 1996, and 1997. Values are in 1996 dollars.

Year	Daily expenditures	State tax	Local tax	Federal tax	Economic output
1995	71.60	5.20	1.10	3.05	149.15
1996	67.25	5.10	1.05	2.85	140.15
1997	99.10	7.30	1.50	4.00	206.45
All	76.85	5.70	1.20	3.20	160.20

Table 4. Dollar value per harvested fish for several parameters for an eight week walleye fishery on the Clinch and Powell Rivers, 1995, 1996, and 1997. Values are in 1996 US dollars.

services, and taxes. Total daily expenditures for goods and services were $ 362,650 in 1995, $ 308,725 in 1996, and $ 317,480 in 1997. Tax revenue were $ 54,220 in 1995, $ 47,845 in 1996 and $ 47,585 in 1997. Approximately 13% of the total daily expenditures were spent on federal and state taxes. Local tax revenue generated by this fishery was $ 6,190 in 1995, $5,640 in 1996, and $ 5,661 in 1997.

Value for harvested walleye was one method to aid in the communication of these economic factors to anglers, politicians, judges, and administrators. Values ranged from $160.20 per fish for total economic output parameter to $1.20 per harvested fish for local tax generated revenue (Table 4).

Discussion

Economic benefit to the local community was fairly substantial for this short-term fishery. Economic output exceeded $ 850,000 in 1995, but has declined because of decreased effort and the tendency of fewer non-residents participating in the fishery. This decline will most likely continue if angling opportunities do not improve.

The overall loss in both reproductive success and recruitment to the fishery has been documented in O'Bara *et al.* (1999). One outcome of this failure was the development of management strategies to restore this fishery. One aspect of this task was to improve communications and information exchange with a wide diversity of individuals. The following is discussion of these communication activities.

Non-resident Angler Participation

One concern often heard from local anglers was that non-Tennessee residents were disproportionately fishing for and harvesting walleye, and not contributing financially to the fishery and/or community. During discussions with both anglers and local officials the importance of non-resident participation was explained.

Our data indicate that the majority of walleye anglers actually resided in Tennessee and within a close proximity to the rivers. Less than 30 % of all anglers were non-resident anglers. Interestingly, the percent of non-resident participation decreased in 1997, coinciding with the decline in angling success. Many non-resident anglers felt that fishing was so poor that the cost and time to travel to either the Clinch and/or Powell Rivers was not worthy of their time and sought other walleye angling opportunities, either in their state-of-residence or other states.

Economic input from non-resident was actually greater in proportion to participation. Non-resident anglers spent approximately $432,632 (32%) over the three years, but only participated at 22%. Non-residents provided $4,500 to local government in taxes during the three year period. Annual revenue would provide about 23% of the annual contribution by local government to a teacher's salary.

Local Interest in the Fishery

Another concern was that local government officials were often not interested in the fishery and viewed it as solely a recreation activity that was managed by state government. Local officials were provided economic data as to the benefit of the local fishery.

Local tax generated revenue related to the fishery ranged from $6,190 in 1995 to $ 5650 in 1996 and 1997. This would provide about 75% of the annual contribution by local government to a teacher's salary or 40% of the total salary for most unskilled labour position. In addition, the number of jobs generated by walleye fishery expenditures was estimated to be 17.

Angler's Concern that Judges were not Fining Individuals for Illegal Harvest

Illegal harvest of walleye was considered one of the top five problems on Norris Reservoir by anglers (NRTF 1994). Anglers felt that not only was illegal harvest (exceeding daily bag limits and illegal methods) a major problem, but the tendency of General Session Judges not to either recognize fish and game violations as important or to fine

individuals at an appropriate value. The During a meeting with the Tennessee Conservation League, a presentation was made concerning our findings. As a result of this meeting, the Tennessee Supreme Court provided financial support and an opportunity to present an economic value workshop at two semi-annual meetings. Judges were informed that fish did indeed have value. Anglers paid approximately $76.85 to harvest a single walleye that generate approximately $5.70/fish to state tax revenues and $1.20 in local tax revenues. The total daily expenditures provided 17 jobs to local individuals in Claiborne County which otherwise would most likely have to travel over 250km to find similar employment. Lastly, judges were informed that the value of 29 illegally harvested walleye was similar to the replacement of vehicles driven by many illegal anglers.

Justification of the Cost of Restoring Walleye Fishery via Stocking

The loss in successful reproduction and thus recruitment failure was evident in both the river and reservoir by 1996. Biologists and mangers felt that if a stocking program was not instituted, the fishery would fail. To provide guidance in this restoration, a model was develop to determine approximate number of fingerlings would be required to stock to restore the river fishery to 1995 levels. It was determined that 750,000 fingerlings would be required to be stocked over a two year period to at the minimum provide angling opportunities in 2-3 years, but to sustain the fishery stocking would be required indifferently. The cost of rearing these fingerlings would be approximately $112,500.

Data concerning the fishery was presented to both TWRA fishery administrators and biologists. The benefit/cost analysis was estimated at $3.75 of total daily expenditures to $1.00 of state funds or $7.72: $1.00 if total economic output value was used. In addition, loss to local and state governments would be approximately $36,400 per year or $256,490 over a 7 year period. Additional losses would be in local jobs and agency prestige.

Economic value was one of several factors utilized in both assessing this seasonal walleye fishery, communicating with a wide diversity of individuals, and justifying restoration programs. The ease of understanding dollars, jobs, and tax revenue as a measurement to these individuals provided improved communication.

Acknowledgements

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Questions

Carl Walters: How are you sure that they will not spend money on something else?

Chris O'Bara: They focus on fishing - it is a tradition therefore we expect they will only want to do that.

Current status and socio-economic aspects of recreational fisheries in Germany

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Introduction

Compared to North America there are only inadequate data concerning the current status and the socio-economic value of recreational fisheries in Europe and especially in Germany. However, recreational fishing is increasing in significance. In the first half of this century commercial inland fishery was dominant, in future, that means in the next century, recreational fishing will get more and more attention and importance in Germany and many other European countries.

Geographic and demographic situation

The Federal Republic of Germany, situated in the temperate zone between 47 and 55 northern degree of latitude in Central Europe, covers an area of 358 000 km². The precipitation in the northern lowlands is about 500 to 700 mm, in the high mountains (Alps) in the south of the country it comes to more than 2000 mm. The average temperature of January, the coldest month of the year, in the lowlands ranges from +1.5 to -0.5 °C. In July the average temperature in northern Germany is +17 to +18 °C. The mean temperature of the year is about +9 °C.

The inland surface waters cover about 797 200 ha, that is 2.2 % of the total area. The country comprises 16 states (Länder) of very different size. The population runs up to 82.1 million (1997), the density of population is high, 230 inhabitants per km².

Fish fauna of inland waters

Today about 70 fish species are living in German inland waters. Nearly half of them are cyprinids. Species rich families are also percids and salmonids. Important species for fishery, commercial as well as recreational, are eel (*Anguilla anguilla*) and pike (*Esox lucius*). Most cultured species in farms in Germany are rainbow trout (*Oncorhynchus mykiss*) and common carp (*Cyprinus carpio*).

Number of anglers, associations and fish catches

According to Hilge (1998) the number of anglers in Germany may be estimated to be about 1.4 million (Table 1). This corresponds to 1.7 % of the total population of the country. Surely, this figure is underestimated, since there are appraisals to up to 2 million anglers in Germany. About 850 000 out of these fishers are members of the two anglers´ associations. These are the Association of German Sport Fishers (VDSF) and the German Anglers Association (DAV). There is a slow but steady increase in the number of anglers in most of the states of the Federal Republic of Germany. For comparison, the estimated number of recreational fishers in European countries is given in Table 2.

Most of the anglers in Germany are male. According to several inquiries (see also Lederer 1997) the proportion of female anglers may be at maximum 4 %. Already Grosch *et al.* (1977) found only about 2% female anglers in Berlin.

In Belgium a survey by questionnaire resulted in 2.8 % female anglers (Frank *et al.* 1998). Surprisingly, in Switzerland a telephone survey revealed a high percentage of women anglers, that is to say 20 %. This may be particular to the Swiss and caused by the fact that fishing from lake-shores is free for everybody (Anonymous 1999).

State	No. fishing licenses 1994	Total catch (t)	Lakes angling area (ha)
Baden-Württemberg	151 593	2 500	75 000
Bayern	241 001	4 800	50 000
Berlin	40 656	139	5 500
Brandenburg	79 722	300	70 000
Bremen	17 100	46	343
Hamburg	22 521	150	
Hessen	120 000	3 000	
Mecklenburg-Vorpommern	79 068	800	4 300
Niedersachsen	111 600	921	12 085
Nordrhein-Westfalen	248 801	3 000	60 000
Rheinland-Pfalz	81 412	1 600	
Saarland	16 015	160	
Sachsen	31 426	100	7 000
Sachsen-Anhalt	44 353	155	5 950
Schleswig-Holstein	71 509	700	
Thüringen	20 591	500	9 000
Total	**1 377 368**	**18 871**	**c. 300 000**

Table 1. Data on recreational fisheries in Germany (*Hilge* 1998).

Country	Estimated number of anglers	Number of anglers as % of population
Austria	220 000	3.0
Belgium	300 000	3.0
Czech Republic	288 000	2.7
Denmark	250 000	4.8
Finland	2 100 000	42.0
France	5 000 000	8.9
Germany	1 400 000	1.7
Hungary	320 000	3.1
Italy	2 000 000	3.5
Netherlands	1 300 000	9.0
Norway	900 000	21.4
Poland	2 000 000	5.1
Sweden	2 200 000	26.5
Switzerland	200 000	3.1
United Kingdom	2 000 000	3.5
Europe total	**22 060 000**	**4.7**

Table 2. Number of recreational fishers in selected European countries (*Pintér* and *Wołos* 1998).

Individual catches of anglers in Germany may vary from 1 to 200 kg per annum. Corresponding to Table 1 the total catch of anglers from inland waters in Germany is estimated to be at least 19 000 t per year. Supposing a number of 1.4 million anglers the average individual catch is 13.6 kg per annum. From other estimates the average catch is, however, calculated to 25 kg per annum (Hilge 1998). Then the total annual catch for 1.4 to 2 million anglers would be 35 000 to 50 000 t. On a €5 per kg basis this represents about 175 million (to €250 million). [1€ = approx 1 US$. Ed.]

An inquiry in Berlin (227 answers) revealed an average catch of 25.8 kg fish per annum for organized fishers (Grosch *et al.*1977). In Bavaria, the average individual catch of anglers was 16.5 kg per year (Lederer 1997). In Sweden the average angler's catch is about 22 kg per year (Bogelius 1998).

Compared to the catch of recreational fishing in Germany the catch of commercial fishers in natural inland waters (mainly lakes and rivers) is only 4000 to 5000 t. Yield of fish farming is about 20 000 t rainbow trout and 12 000 t common carp.

Motivation for fishing

In a questionnaire anglers were given six possible choices in an attempt to identify the motives for them going fishing. For evaluation 550 answers could be used (Table 3). The main reason was to enjoy nature (77 %). Other significant motives were rest and relaxation (69 %), a good catch to receive fresh fish for consumption (65 %) and the occasion to have a family outing (60 %).

A comparison of the above mentioned motives recently ascertained by the German Anglers Association (DAV) with other published data is shown in Table 4. It can be stated that rest and relaxation as well as enjoyment of nature are the most significant reasons for going fishing.

Preferred fish species

In an inquiry more than 700 anglers were asked to nominate their top target species which they would like to fish preferably. Simultaneously they were requested to name the species they like best for eating. The results concerning the top ten species are listed in Table 5. According to these data predominated fish species for fishing in Germany are pike, common carp and pikeperch (*Stizostedion lucioperca*). Also interesting for anglers are eel and trout, cod (in marine waters) and perch (*Perca fluviatilis*). For consumption anglers like best pikeperch, trout and common carp, followed by eel, pike, cod and perch.

The questionnaire also revealed that 92 % of the recreational fishers consume the fish they have caught. This underlines the results of the inquiry cited in Table 3. Anglers enjoy nature and use their hobby for relaxation, however, a significant reason for fishing is to capture fish for consumption.

Economic aspects

There are only little informations available concerning the economic aspects of recreational fishing in Germany. Hilge (1998) has given some data obtained from an angling organization representative (Table 6). It has to be assumed that the total amount of 1753 million DM (ca. 900 million EURO) per year represents the lower limit. According to Hilge it can be supposed that more than 20 000 people are employed in jobs having direct links to recreational fishing. On the basis of a (very low) annual gross income of at least 30 000 DM this yields to 600 million DM (ca. €307

Motive	%
Enjoyment of nature	77
Relaxation	69
Catch fish for consumption	65
Family outing	60
Meet friends	50
Enjoyment of catch	50

Table 3. Motives for fishing as shown by the percentage number of replies in which the particular reason was given (Data of the German Anglers Association 1998).

Reason given	Germany[1]	Bavaria[2]	Belgium[3]	Sweden[4]	Switzerland[5]
Enjoyment of nature	77	87	92	69	81
Relaxation	69	89	93	71	
Catch fish for consumption	65		47		
Family outing	60		29	40	
Meet friends	50	28	47	32	9
Enjoyment of catch	50		45		3

Table 4. Comparison of the results of the German Anglers Association (1998) concerning the reasons for recreational fishing with other recently published data. [1]1998, [2]Lederer 1997, [3]from Frank *et al.* 1998, [4]Bogelius 1998, [5]Anonymous 1999.

million) which has to be added to the figures in Table 6. Thus it may be assumed that the annual turnover of recreational fisheries in the Federal Republic of Germany is at least 1200 million EURO. However, the chances are that this is a substantial underestimate. The value of club properties (buildings, waters, boats) was estimated to be 380 million DM (9500 clubs - each on average 40 000 DM).

Constraints to recreational fisheries

Water resources in Germany are very limited and are, therefore, generally under press at existing levels of demand. Strong efforts are undertaken for environment protection and to maintain or improve quality of lakes, dams and rivers. This can lead to excessive confinements to the prejudice of anglers and other groups of water users. Green movements and animal welfare affect recreational and commercial fisheries as well as agriculture and hunting to an increasing extent.

A very serious problem in Germany and other European countries are legally protected fish-eating birds, especially cormorants. These birds have multiplied considerably and expanded their distribution during the last two decades all over Europe. They cause high losses in fish populations and reduce the possibilities for fishing in many waters.

A lack of viable data collecting systems and of a practicable scientific basis is also disadvantageous for the evaluation and developing of recreational fishing in Germany. Research with respect to biological and socio-economic problems of angling is urgently needed.

Improving the image of fisheries

Responsible fishing has to be considered as a legal using of nature and waters, and image of fisheries must be improved in the public. To ensure a high degree of education and since angling in Germany is only permitted on the basis of a governmental fishing licence, in most of the states of the Federal Republic of Germany training and examination is realized for recreational fishers. This guarantees that anglers have adequate knowledge in the field of fish biology, water ecology and management, nature conservation and animal welfare (v. Lukowicz 1998).

To demonstrate that sustainable recreational fishing is not contrary to water protection the German Anglers Association published a position paper concerning the conservation of nature and environment (DAV 1997a). This paper challenges to a close cooperation between recreational and commercial fishers for a proper water management.

The code of honour of the members of the German Anglers Association refers to the ethical aspects of recreational fishing (DAV 1997b). In Baden-Württemberg a code of practice for anglers with regard to animal welfare has been published (Berg and Rösch 1993, 1998).

Species preferred for fishing	%	Species preferred for consumption	%
Esox lucius	21	*Stizostedion lucioperca*	18
Cyprinus carpio	20	*Salmo trutta f. fario* [1]	17
Stizostedion lucioperca	17	*Cyprinus carpio*	15
Anguilla anguilla	9	*Anguilla anguilla*	10
Salmo trutta f. fario [1)]	9	*Esox lucius*	8
Gadus morhua	6	*Gadus morhua*	6
Perca fluviatilis	6	*Perca fluviatilis*	5
Tinca tinca	2	*Salmo salar*	2
Rutilus rutilus	2	*Clupea harengus*	2
Silurus glanis	2	*Rutilus rutilus*	2

Table 5. The ten top species preferred for fishing and for consumption by German anglers (Data from the German Anglers Association 1999). [1]including *Oncorhynchus mykiss.*

Item	Million DM
Value of total annual catch of anglers (1.4 million anglers x 25 kg fish/angler x 10 DM/kg)	350.0
Sales of rod and line, accessories, clothing, etc. (in about 3 000 specialised shops)	583.0
Fish for stocking (anglers' clubs part only)	116.7
Labour supply of anglers (cleaning of nature etc.) (850 000 anglers x 8 h/yr x 15 DM)	102.0
Honorary functions in clubs and associations at various levels	41.8
Sales of fishing permits by owners of waters	140.0
Fishing tax (as part of fishing licence) (of angling club members only)	6.6
Fees for clubs and associations at district, state and federal level	92.0
Sales for journals and books (350 000 journals per month at 7 DM; 8 DM per book and angler)	40.6
Angling tourism (at home and abroad)	280.0
Total	**1 752.7**

Table 6. Economic aspects of recreational fisheries in Germany (*Hilge* 1998).

Conclusions and summary

Compared to North America there are only inadequate data on the socio-economic value of recreational fisheries in Germany. On the basis of first inquiries preliminary findings concerning current status and trends, numbers of fishers, motivation, preferred species, and constraints are presented. The number of fishers in Germany is estimated to be about 1.4 to 2.0 million. Individual catches of anglers may vary between 1-200 kg per annum, total catches are calculated to be at least about 20 000 t per year.

Most important motives for fishing are enjoyment of nature, relaxation and catching fish for consumption. Preferred fish species for anglers are pike, common carp and pikeperch. The annual turnover of recreational fisheries is at least €1200 million. Nature conservation and animal welfare issues impose increasing constraints to recreational (and commercial) fishing in Germany. Considerable losses in fish populations are caused by fish-eating birds such as cormorants. A close cooperation between professional and recreational fishers is essential in order to overcome the growing future problems and difficulties in sustainable water management. Codes of good practice for recreational fishing are useful and can help to improve the image of fisheries. It is stated that there is an urgent demand for research and improved data collection to consolidate the evaluation of recreational fisheries in Germany.

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Questions

Barbara Calvert: How widespread are your catch and release programs?

Werner Steffens: Catch and release is forbidden by animal welfare legislation, as in commercial fisheries, most fish are landed to eat. Catching fish for sport is not allowed in Germany.

Marty Golden: Is there recreational ocean fishing?
Werner Steffens: Yes, off the coast in the North Sea and in the Baltic, and there is one association that represents these fishers. Most of the recreational fishers are interested in the inland fishing.

Regional economic impact assessments of recreational fisheries: a case study of the marine party and charter boat service industry in Maine

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Introduction

In 1996, over 8 million saltwater anglers fished 64 million days in the United States[6]. Fishing offers an important leisure outlet for many individuals and also generates economic activity in the form of sales, income and employment throughout the country. Marine recreational fishing expenditures in the U.S. in 1996 generated approximately US$25 million in sales, $6 million in income and supported more than 287 thousand jobs (Maharaj and Carpenter, undated). At the subnational level, however, only a handful of published studies have estimated the economic activity associated with recreational fisheries. Unfortunately, these studies generally reported only the final results of the economic impact assessment (EIA), without describing the economic interdependencies that produced the impacts or how the results should and should not be used to guide decisions. This practice is likely to spread with the growing popularity of ready-made regional economic impact models, which enable regional scientists to generate economic impact estimates with limited knowledge or appreciation of the inner workings required for such analyses. This is particularly troublesome, because most resource managers only vaguely understand how EIA models work and how to interpret the results in a fisheries management framework. Thus, resource managers and EIA practitioners alike are becoming increasingly concerned about the operational techniques used in EIAs and in improving the information transfer between these two groups.

The purpose of this paper is to provide a starting point toward establishing consistent and defensible techniques for conducting regional EIAs of recreational fisheries and to explore the appropriate uses of EIA outputs as they relate to the growing needs of natural resource managers. Using marine recreational party and charter boat fishing in Maine in 1996 as an example, an EIA was conducted with the most widely employed ready-made regional economic impact model - the IMPLAN (IMpact analysis for PLANning) input-output system.

To provide information necessary for conducting an EIA of Maine's marine recreational party and charter boat fishing industry, the National Marine Fisheries Service, Rutgers University and the Maine Department of Marine Resources collected data on angler expenditures and associated operating expenses of for-hire fishing businesses in Maine during 1994 and 1996. In combination with angler expenditure information collected by the U.S. Fish and Wildlife Service, these data were incorporated into the IMPLAN input-output system to compute economic impacts of the for-hire marine recreational fishing industry in Maine. A schematic of data sources and analytical pathways used to generate economic impacts is provided in Figure 1.

Economic impact analysis

During the course of a for-hire fishing trip, anglers purchase a variety of goods and services. Angler dollars are spent on boat fees, lodging, travel costs, and food and beverages. Businesses providing these goods and services also must purchase goods and services and hire employees who, in turn, generate more sales, income and employment.

Three levels of economic impacts result from purchases by party and charter fishers: (1) direct, (2) indirect and (3) induced. Direct impacts are the sales, income and employment generated from initial purchases by anglers (e.g., party and charter access fees paid to owners of for-hire vessels). Indirect impacts are the sales, income and employment of industries that supply the directly affected industries (e.g., for-hire owners must purchase bait from supply shops, gasoline and oil from marine service stations, and procure loans from banks). Induced impacts represent the sales, income and employment resulting from expenditures by employees of the direct and indirect sectors (e.g., mates on party boats purchase groceries and incur auto loans). The summation of direct, indirect and induced impacts are total impacts.

[6] Estimates obtained from the U.S. Department of Commerce, National Marine Fisheries Service, Marine Recreational Fisheries Statistics Survey, electronic WEB page at http:// remora.ssp.nmfs.gov/ recreational/ index.html.

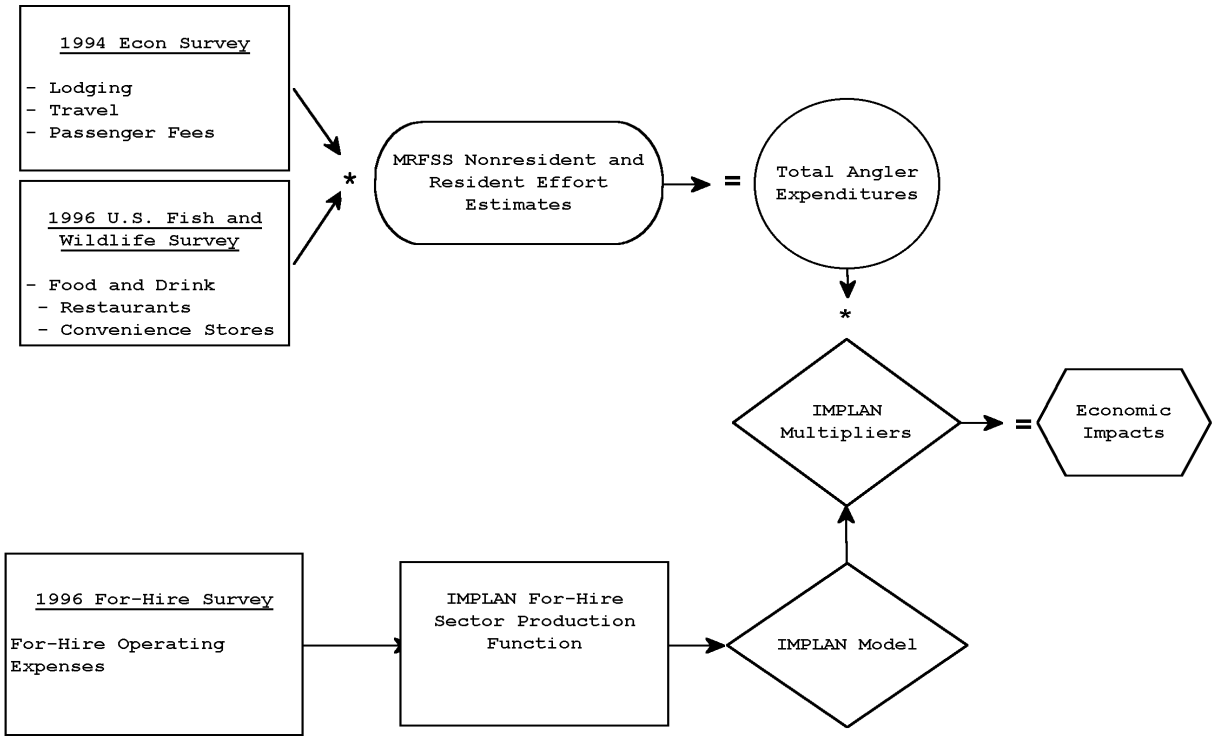

Figure 1. Schematic of data sources and analytical pathways used to generate economic impacts.

A variety of analytical approaches are available for developing regional EIAs. The most common approach is input-output (I/O) analysis. Input-output modelling describes the structure and interactions of regional economies. For a comprehensive description of the I/O modelling technique, including inherent weaknesses, see Miller and Blair (1985).

Historically, performing I/O analysis was expensive and time consuming. The need for large amounts of primary data on production functions, distribution characteristics and trade relationships made I/O modelling impractical in many cases (Propst and Gavrilis 1987). In response, the U.S. Forest Service developed the IMPLAN modelling system (Olson and Lindall 1996). This system provides secondary data collected from national, state and local government reports and a user-friendly media for customizing I/O models to an application. It is the most widely used ready-made regional EIA tool among I/O practitioners in the U.S., because the software is flexible in terms of geographic coverage and model formulation and can incorporate user-supplied data at each stage of the model building process.

Applications of IMPLAN have covered a large number of topics relating to agriculture, natural resources, and recreation and tourism. Several studies have evaluated the overall performance of IMPLAN, and although results are inconclusive, IMPLAN's outcomes have been shown to be plausible (Crihfield and Campbell 1991; Rickman and Schwer 1995). Nevertheless, it is prudent to be aware of several simplifying assumptions concerning the structure and data contained in the model. In addition to the I/O assumptions listed above, IMPLAN implicitly assumes national average production coefficients and margins, and uses a set of econometric equations to predict interregional trade flows. Users of IMPLAN must be willing to accept these assumptions and estimation methods or have the ability to incorporate user-supplied data to improve the accuracy of their impact estimates (i.e., hybrid approach). The analysis presented in this paper adapts a partial hybrid approach to the IMPLAN modelling system.

Methods

Anglers

Angler expenditures were analyzed separately for Maine residents and non-residents. Spending by non-residents contributes to the export market (i.e., sale of goods and services to people who live

Trip-related expenditures	Non-residents	Number of observations	Residents	Number of observations
Lodging	24.40 (42.50)	182	0.46 (3.85)	86
Travel by private auto	13.69 (5.94)	139	11.64 (4.34)	70
Passenger fees	41.36 (32.89)	71	29.85 (17.09)	41
Groceries	5.10	48	5.10	48
Meals	2.39	48	2.39	48
Total	86.94		49.44	

Table 1.-Average 1996 daily trip-related expenditures[a] (US$) per party and charter participant in Maine, by resident category (SD's in parentheses)[b].
[a]1994 average trip-related expenses adjusted for inflation to their 1996 equivalent using IMPLAN deflators derived from the Bureau of Labor Statistics Growth Model.
[b]SD's were not calculable for groceries and meals since a point estimate of total food and drink purchases of all anglers in Maine (from the 1996 National Survey) was used to generate these expenditure category estimates.

outside the state), and is generally considered new income for the state. Conversely, spending by residents is usually considered as only a redistribution of existing wealth (Miernyk 1965; Bergstrom *et al.* 1990; Storey and Allen 1993). Increases in non-resident angler spending contribute to an overall net increase in total sales, income and employment. Increases in resident angler spending, however, are generally thought to be offset by decreases in other leisure-related industry expenditures within a state. As such, only non-resident recreational expenditures are typically included in regional I/O models. Clearly, however, resident spending supports jobs in specific industries that would not otherwise exist, although at the "expense" of other sectors. Moreover, resident anglers who would go elsewhere to fish in the absence of the Maine for-hire fishery would contribute to the import market, representing a loss in regional business activity. In this scenario, residents could be viewed as an import substitution market and their expenditures would also be considered new income for the state (Anderson *et al.* 1986).

Jobs, sales and income depend on a state's ability to provide quality for-hire fishing trips to all anglers. Accordingly, resident and non-resident impacts as well as the total impacts of all anglers are delineated in this study. Public officials and fishery managers concerned with the appropriate interpretation and use of I/O assessments are nonetheless encouraged to bear in mind the distinctions between resident and non-resident impacts.

Expenditures by party and charter boat anglers in Maine were obtained from two independent sources: (1) the 1994 Northeast Region economic add-on to the National Marine Fisheries Service's (NMFS) Marine Recreational Fishery Statistics Survey (MRFSS) and (2) the U.S. Fish and Wildlife Service's 1996 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (National Survey 1996). The MRFSS provides bimonthly estimates of total effort, participation, and finfish catch by marine recreational anglers. The 1994 economic survey was designed as an add-on to the existing MRFSS to take advantage of sampling, survey design and quality control procedures already in place. Although the survey did not focus specifically on fishing-related expenditures, respondents were asked to provide demographic and economic information and report on their share of trip-related expenditures for lodging and party/charter fees. Anglers fishing from party/charter boats in Maine completed a total of 268 surveys; non-residents comprised 68% of the total.

Estimates of food and beverage expenditures were derived from the 1996 National Survey. Saltwater fishing information collected in the National Survey focused on the participation, characteristics and expenditures of U.S. residents 16 years of age and older. As part of the survey, anglers were asked to report food and drink expenditures on all of their saltwater fishing trips.

Calculation of angler expenditure estimates

Average daily food and drink expenditure per participant was calculated by dividing the 1996 National Survey's estimate of total food and drink expenditures for all marine recreational anglers in Maine by the MRFSS estimate of annual number of fishing days. A lack of detailed information precluded the ability to distinguish resident and non-resident party/charter anglers from all other anglers (i.e., resident and non-resident shore and private/rental boat anglers). The food and drink expenditure estimate was subdivided into restaurant and grocery expenditures according to proportions developed by the Sport Fishing Institute (currently known as the American Sportfishing Association; A. J. Fedler, pers. comm.).

Average daily lodging cost per fisher was com-

Trip-related expenditure	Non-resident	Resident	IMPLAN Sector(s)
Lodging	313,588	2,544	Hotels and lodging places
Travel by private auto	175,944	64,928	Petroleum refining
Passenger fees	531,520	166,496	For-hire fishing
Groceries	65,570	28,454	Food stores, miscellaneous retail
Meals	30,714	13,328	Eating and drinking
Total	**1,117,336**	**275,750**	

Table 2. Total 1996 daily trip-related expenditures[a] (US$) for party and charter participants in Maine, by resident category and associated IMPLAN sectors.
[a]Values were calculated from non-rounded numbers and differ slightly from the result of multiplying 1996 MRFSS effort estimates by Table 1 values.

puted from the MRFSS 1994 economic survey. Party/charter anglers reported making two types of trips: day trips and multi-day overnight trips. Overnight anglers were asked to report the length and total lodging cost for the trip; day trip anglers were assumed to incur no lodging costs. Both trip types were included in the average cost calculation by dividing total lodging costs by the sum of fishing days across the trip types.

Round trip miles travelled in the state of Maine, estimated using PCMILER software (ALK Associates, Inc. 1995), was multiplied by 10.1 cents per mile (American Automobile Association estimate of the average per mile variable cost of operating a car in 1996) to calculate the total in-state travel expense. This was done for each of the respondents in the 1994 MRFSS economic survey who fished from party/charter boats in Maine in 1994. Although information pertaining to anglers traveling together was unavailable, preliminary data from a 1998 MRFSS economic survey indicated that party/charter boat anglers in Maine in 1998 shared their travel expenses among approximately 1.56 people per trip. Thus, to make the travel cost estimates used in this study more tenable each angler's total daily travel expense was divided by 1.56.

Average resident and non-resident passenger fees (i.e., expenses related to renting a charter boat or buying a ticket on a party boat, including expenses for equipment, bait, etc.) were also estimated using the data obtained from the MRFSS 1994 economic survey.
Total average daily 1996 trip-related expenditures per party/charter boat participant in Maine by non-residents ($86.94) were substantially higher than for residents ($49.44, Table 1). Lodging costs and passenger fees accounted for most of the difference. Non-residents tended to make multi-day trips and therefore generally required overnight lodging. Almost all of residents, on the other hand, were day trip anglers and incurred no lodging costs. The difference in passenger fees between residents and non-residents, however, is not easily explained. Non-residents may have taken more trips that specifically targeted gamefish (e.g., these types of chartered trips are generally more expensive than trips that target bottomfish) or non-residents may lack the time or local knowledge that residents have to compare prices. Daily in-state travel costs were also higher for non-residents, although the difference was small because resident anglers travelled nearly as many miles in Maine during the course of their fishing trips. The remaining category costs (groceries and meals) were identical between residents and non-residents. These similarities, however, reflect the data limitations and assumptions previously mentioned, rather than uniform spending behaviour.

The average daily trip-related expenditures per participant in Table 1 were multiplied by MRFSS estimates of non-resident (12,852 days) and resident (5,578 days) total party/charter fishing days in Maine during 1996 to derive total expense estimates (Table 2). Because non-residents spent 2.3 times more days than residents, party and charter fishing in Maine during 1996 and incurred 76% greater daily costs, and non-resident trip-related expenditures were four times that of Maine residents.

For-hire Businesses

Party and charter boat angler expenditures reflect only the direct expenditures associated with for-hire fishing trips. For-hire businesses and other affected industries (e.g., lodging establishments, restaurants, grocery stores, etc.) purchase goods and services and hire employees in response to angler demands. These activities impact the economy of Maine through the mix of goods and services purchased and the income that is generated. While the IMPLAN software system provides detailed purchasing information for 528 industrial sectors, each sectoral production function (i.e., the mix of goods and services purchased to produce one dollar of output) characterizes aggregate purchasing activity of many businesses. In other words, IMPLAN's production functions represent weighted averages of individual businesses contained within a given industrial sector. Businesses

that purchase the most goods and services have the greatest influence on a sector's aggregate production function. For sectors with related but clearly distinguishable establishments, IMPLAN production functions will not accurately portray the purchasing behaviour of each business. For example, IMPLAN combines for-hire business activity into an all encompassing Amusement and Recreation Services sector; the production function, resulting trade flows and marketing margins reflect aggregate economic activity across numerous amusement and entertainment businesses.

To more accurately characterize the actual purchasing activities of marine recreational fishing for-hire businesses in Maine, primary cost data were collected in 1996 using two different methods. First, a telephone survey, was conducted during the 1996 fishing year (summer/fall) to acquire variable trip cost information (e.g., fuel, oil, bait) from party and charter boat owners. This survey was run in conjunction with the annual party/charter effort telephone survey administered by the Maine Department of Marine Resources (MDMR). Owners were drawn from a list of 39 party/charter vessels provided by the MDMR and four owners were randomly contacted per week for information about the previous week's trips. The MDMR believed the list was representative and encompassed most, if not all, of the charter and party boats operating in Maine during the 1996 fishing season. Secondly, a mail survey, designed to collect fixed cost information (e.g., loans, insurance, wages, maintenance, etc.), was performed after the completion of the 1996 fishing season. The survey was mailed to all 39 owners, followed by three reminder mailings and additional surveys to those who had not responded. Of the 39 surveys mailed, 28 were returned and completed resulting in a response rate of 72%.

Primary survey data were used to characterize the types of expenses that Maine party and charter boat businesses encumbered in 1996. A linear production function was developed by dividing the average expenditure in each category by the average total expense (including value added payments made to employees, taxes and profits, Table 3). The proportions shown in Table 3 denote the average dollar value of goods and services required from a particular category to produce one dollar of revenue for the for-hire industry in Maine in 1996. These proportions reflect the average purchasing behaviour of the industry in 1996 and were incorporated into the IMPLAN system according to procedures outlined in Olson and Lindall (1996).

Primary data categories	Prop. total cost	IMPLAN sector(s)
Wages/salaries/benefits	14.19	Value added (employee compensation)
Interest payments on loans	13.09	Value added (other property type income)
Mooring and dockage	8.29	Water transportation
Insurance	7.67	Insurance carriers
Repairs/improvements	7.32	Boat building and repairing
Fishing equipment and bait	6.76	Sporting and athletic goods
Fuel and oil	6.10	Petroleum refining
Office utilities (gas, electric water)	5.36	Gas production, electric services, water supply
Referral and booking	5.27	Management and consulting services
Advertising	4.79	Advertising
Business taxes	3.90	Value added (indirect business taxes)
Office lease/rent	3.57	Water transportation
Telephone	3.51	Communications
Haul outs/overhauls	2.86	Water transportation
Professional fees	2.35	Accounting, auditing, bookkeeping
Permit/registration	1.51	Value added (indirect business taxes)
Consumer apparel	1.38	Apparel
Business associations	1.11	Business associations
Food and beverages	0.53	Food stores
Ice	0.44	Manufactured ice

Table 3.--Estimated average 1996 Maine for-hire operator production function and associated IMPLAN sectors.

The production function represents gross regional purchasing behaviour, however, because it does not account for domestic and foreign imports. Imports contribute economic impacts to other regions and should not be included in a regional EIA. The IMPLAN system uses regional purchase coefficients (RPCs) to remove imports from the regional economic accounts during the model building stage. The RPC method is based on characteristics of the region and predicts trade flows from a set of econometric equations. An RPC represents the portion of the total local demand that is met by local production. Thus, each of the expenditure categories of the for-hire production function were adjusted by IMPLAN's RPCs to ac-

Category	Total angler expenditure	Direct impact	Indirect impact	Induced impact	Total impact
			Sales ($)		
Non-resident	1,117,336	646,318	227,280	163,891	1,037,489
Resident	275,750	143,860	50,880	29,819	224,559
Total	1,393,086	790,178	278,160	193,710	1,262,048
			Income ($)		
Non-resident	1,117,336	194,516	105,912	92,713	393,141
Resident	275,750	41,106	22,948	17,451	81,505
Total	1,393,086	235,622	128,860	110,164	474,646
			Income ($)		
Non-resident	1,117,336	31.1	3.8	3.7	38.6
Resident	275,750	8.3	0.8	0.8	9.9
Total	1,393,086	39.4	4.6	4.5	48.5

Table 4.-Total economic impacts (US$) generated from party and charter fishing expenditures in Maine in 1996, by resident category.

count for the effect of imports on local supply.

Economic Impact Assessment

Economic impacts were estimated by applying the five categories of angler trip-related expenditures to the appropriate IMPLAN sector multipliers (expressing relationships between sectoral economic activity). Each of the angler expenditure categories was associated with its corresponding IMPLAN producing sector (Table 2), and purchaser prices (retailer prices) were converted to producer prices (manufacturer prices) using margins provided with the software. In an I/O model, retail expenditures must be margined to assign the correct value to a product as it moves from producer to place of final sale. Lodging establishments, for-hire businesses and restaurants have no margins, producing their products and services at the time of purchase. However, angler expenditures for travel (fuel, oil) and groceries are made at the retail level and must be subdivided into appropriate producer values. The IMPLAN margins associated with petroleum refining were applied to the automobile expenditures, but a lack of detailed information on the types of retail food and beverages purchased by anglers precluded the ability to distinguish among manufacturers. Thus, the average estimated retail margin associated with grocery stores (24%; U.S. Bureau of the Census 1997) was multiplied by the grocery expenditure estimates shown in Table 2 and allocated to the retail food store sector.

Regional impacts were estimated for sales, income and employment. Sales reflects total dollar sales generated from expenditures by party/charter anglers in Maine. Income represents: wages, salaries, benefits and proprietary income generated from party/charter angler expenditures. Employment includes both full-time and part-time (including seasonal) workers and is expressed as total jobs.

Non-resident and resident impacts were estimated from the direct, indirect and induced effects associated with angler expenditures in Maine. However, spending by resident households on recreation-related activities is a part of household consumption and is endogenous in the I/O model. Therefore, to avoid overstating impacts resident expenditures were subtracted from IMPLAN's personal consumption expenditure vector prior to constructing the model. In this manner, the contribution of resident angler expenditures can be considered exogenous and modelled as a change in demand, while all other household expenditures remain endogenous.

Economic Impact Results

Economic impacts generated from party and charter boat fishing expenditures in Maine in 1996 are summarized in Table 4. The $1.12 million spent by non-resident party and charter boat anglers in 1996 generated a total of $1.04 million in sales as follows: $646 thousand in sales for the direct sectors in Maine ($474 thousand was transferred to out-of-state producers of trip-related goods and services purchased in Maine), $227 thousand in sales for the indirect sectors and $164 thousand in sales from households purchasing goods and services (induced impacts). Non-resident expenditures also resulted in an additional $393 thousand in income for the state of Maine. Of the total income from non-residents, $194 thousand was directly received by the spending of non-resident anglers (direct impacts), $106 thousand by indirect businesses and $93 thousand was generated from expenditures by employees of the direct and indirect businesses. In terms of employment, approximately 39 jobs were dependent upon non-resident expenditures

Expenditure category	Total expenditure	Direct	Indirect	Induced	Total impact
			Sales ($)		
Groceries	65,570	14,790	2,087	6,568	23,445
Meals	30,714	27,016	7,171	9,246	43,433
Lodging	313,588	218,833	72,088	77,519	368,440
Travel by private auto	175,944	56,137	10,116	4,060	70,313
Passenger fees	531,520	329,542	135,818	66,498	531,858
Total	**1,117,336**	**646,318**	**227,280**	**163,891**	**1,037,489**
			Income ($)		
Groceries	65,570	7,863	721	2,607	11,191
Meals	30,714	9,901	2,430	3,921	16,252
Lodging	313,588	75,788	36,085	41,434	153,307
Travel by private auto	175,944	20,738	7,202	4,746	32,686
Passenger fees	531,520	80,226	59,474	40,005	179,705
Total	**1,117,336**	**194,516**	**105,912**	**92,713**	**393,141**
			Employment (Jobs)		
Groceries	65,570	0.5	0.1	0.1	0.7
Meals	30,714	0.8	0.1	0.2	1.1
Lodging	313,588	5.2	1.1	1.3	7.6
Travel by private auto	175,944	0.8		0.3	1.3
Passenger fees		23.8	2.3	1.8	27.9
Total	**1,117,336**	**31.1**	**3.8**	**3.7**	**38.6**

Table 5.- Economic impacts (US$) generated from non-resident party and charter fishing expenditures in Maine, 1996.

Resident expenditures in 1996 totalled $276 thousand and generated $225 thousand in sales, $82 thousand in income and approximately 10 jobs. These effects are optimistic, however, and may not reflect the actual impacts added to the state's economy in 1996. If resident anglers would have gone elsewhere to fish in the absence of the Maine for-hire fishery, the impacts are appropriate because a net loss of that activity would have occurred. On the other hand, if residents would have found a substitute activity in Maine, a loss in marine recreational fishing expenditures would have been offset by a gain in some other type of expenditure resulting in little net change in impacts. Thus, the actual economic impact of resident expenditures depends on assumptions regarding the absence of the fishery in Maine.

The separate contributions of each of the five trip-related expenditure categories to total non-resident and resident impacts, respectively, are presented in Tables 5 and 6. Passenger fees were the single most important expense category in terms of generating sales, income and jobs for both non-residents and residents. Non-resident lodging expenses also contributed significant impacts, as did travel expenditures by residents.

Discussion

The impacts of expenditures by non-resident party and charter boat anglers on sales, income and employment in Maine in 1996 were generally five times greater than that of their resident counterparts. The actual economic impact of resident expenditures, however, depends on assumptions regarding the absence of the fishery in Maine. Taken as a whole, the non-resident and resident economic impacts presented in this paper provide an indication of the importance of the for-hire marine fishing industry to Maine's economy.

The results are conservative in the sense that they include only trip-related expenses of party and charter boat anglers. Auxiliary expenditures on fishing gear (i.e., bait, tackle, or equipment not included as part of passenger fees), clothing and incidental purchases by non-fishing companions were not included, even though they may have occurred as a direct result of fishing.

The partial hybrid I/O approach developed in this study suffers from a number of assumptions that had a direct effect on impact estimates. First, because of data limitations angler expenditures on

Expenditure category	Total expenditure	Direct	Indirect	Induced	Total impact
			Sales ($)		
Groceries	28,454	6,418	906	2,850	10,174
Meals	13,328	11,723	3,112	4,012	18,847
Lodging	2,544	1,775	585	629	2,989
Travel by private auto	64,928	20,716	3,733	1,498	25,947
Passenger fees	166,496	103,228	42,544	20,830	166,602
Total	**275,750**	**143,860**	**50,880**	**29,819**	**224,559**
			Income ($)		
Groceries	28,454	3,412	313	1,131	4,856
Meals	13,328	4,296	1,055	1,701	7,052
Lodging	2,544	615	292	337	1,244
Travel by private auto	64,928	7,653	2,658	1,751	12,062
Passenger fees	166,496	25,130	18,630	12,531	56,291
Total	**275,750**	**41,106**	**22,948**	**17,451**	**81,505**
			Employment (Jobs)		
Groceries	28,454	0.2	0.0	0.0	0.2
Meals	13,328	0.3	0.0	0.1	0.4
Lodging	2,544	0.1	0.0	0.0	0.1
Travel by private auto	64,928	0.3	0.1	0.1	0.5
Passenger fees	166,496	7.4	0.7	0.6	8.7
Total	**275,750**	**8.3**	**0.8**	**0.8**	**9.9**

Table 6.-Economic impacts (US$) generated from resident party and charter fishing expenditures in Maine, 1996.

groceries could not be converted to equivalent producer values. Thus, the estimated average retail margin associated with grocery store sales was applied to the resident and non-resident expenditures and allocated to the retail food store sector. This procedure resulted in conservative estimates of impacts, because it did not account for the margins attributable to manufacturing, wholesaling and transportation. Second, with respect to the use of IMPLAN, it was assumed that IMPLAN's estimated RPCs reflect actual demand-supply conditions and that the national average production coefficients and margins were appropriate for the state of Maine. The IMPLAN software provides procedures for users to modify these coefficients, but no attempt was made to do so here. Nonetheless, to ensure the effective use of EIA results, it is incumbent upon regional researchers to provide warnings on the probable inadequacies of user-supplied data and analytical techniques.

The frequency with which the I/O model should be modified depends upon the rate of technological change, price variability and the level of fishing activity. In the short-run, technology and prices are likely to change little; however, past annual MRFSS party/charter boat fishing effort estimates in Maine have exhibited variability over time. Thus, the usefulness of the reported impact estimates in near future years is conditional on similar effort estimates.

Perhaps more importantly, though, the model itself could be used in conjunction with updated data to predict changes in economic activity associated with future fishery policies. For example, if a proposed policy decision was expected to reduce out-of-state participation by 10% in 2000, updated effort estimates could easily be incorporated into the model (adjusted for inflation) to predict the impacts on sales, income and employment in Maine.

The IMPLAN system is also updated annually, including its regional databases. Thus, price and technology changes for the entire economy will be incorporated into future versions. In addition, the NMFS has recently committed to collecting detailed expenditure data from marine anglers along the Atlantic coast every three years. These data will express changes in tastes and preferences and could be used to update the mix of angler expenditures provided in this study. Efforts are also underway to collect fishery dependent cost data to characterize the actual purchasing behaviour of for-

hire businesses, by state. In combination, these activities provide the ability to continually update the I/O model presented here.

The effective use of the IMPLAN system for conducting regional EIAs of recreational fisheries may well depend on users' abilities to incorporate additional survey data, adjust region-specific technological coefficients, and to provide results that can be readily explained to fishery managers and the Public. From this perspective, it is crucial to develop consistent and defensible techniques for generating economic impacts with IMPLAN. Future regional EIA studies of recreational fisheries should attempt to include auxiliary expenditures on fishing gear and incidental purchases by non-fishing companions. In addition, there is a need to evaluate whether resident anglers would contribute to the import market or remain within the region in the absence of the fishery. The procedures and data sets applied here, if used in conjunction with future versions of IMPLAN, can serve as a foundation for updating the Maine input-output model provided in this study and for developing economic assessments of recreational fisheries in other states.

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Questions

Margaret Merritt: You are attempting to predict the effects of changes in policy by looking at expenditure whereas I was looking at the impacts of changes on management changes by using other factors, such as benefits.

Scott Steinback: By law, we have to examine the economic impacts; these assessments can look at impacts, but they are not used for allocation issues.

Marine recreational fishing participation in the northeast USA, 2000 - 2025

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Abstract

A socio-economic survey of marine recreational fishing in the Northeast USA (Maine to Virginia) was conducted in 1994. The survey was implemented in two parts as an additional component to the 1994 Marine Recreational Fisheries Statistical Survey. The first part collected demographic, attitudinal and economic data from intercepted anglers. These data were used to develop economic valuation models. The second part collected demographic data using a stratified random household telephone survey. The telephone survey was administered to both fishing participants and non-participants and was the first of its kind in the Northeast.

This paper presents results of a study projecting marine recreational fishing participation to the year 2025 using the 1994 telephone survey data. Demographic profiles of anglers and non-anglers and statistical models were developed to estimate probabilities of marine recreational fishing participation by gender, age, and ethnic group. Forecasted changes in population composition in the Northeast were then used to project marine recreational fishing participation in five-year intervals from 2000 to 2025. The results indicated that marine recreational anglers in the Northeast were predominantly white males with relatively high household incomes, and high levels of education. The number of marine recreational anglers is projected to increase modestly through 2025 but participation rates will decline. This is due to a decline in participation after age 65 and the fact that most of the Baby Boomer generation will reach retirement (ages 65 and over) by the year 2011.

Introduction

Two marine recreational fishing surveys were conducted during 1994 in the Northeast Region (Maine to Virginia). Data from the surveys provided demographic and economic information on marine recreational fishing participants and non-participants. This paper documents the socio-economic characteristics of recreational fishing participants and nonparticipants from a sample of households in the Northeast Region. A statistical model to project recreational fishing participation rates and forecasts of saltwater recreational fishing participation through 2025 is also presented. This paper summarizes selected findings from an earlier report (Thunberg *et al.* forthcoming). A more detailed treatment of the statistical methods and results can be found in the earlier report and is available from the author upon request[7].

Trends in marine recreational fishing participation

Two U. S. National surveys monitor trends in recreational fishing: the National Survey of Fishing, Hunting, and Wildlife Associated Recreation (referred to herein as the National Fish and Wildlife Recreation Survey or NFWRS) and the Marine Recreational Fisheries Statistics Survey (MRFSS). The Department of Interior Fish and Wildlife Service have conducted the NFWRS every five years since 1955. The NFWRS is designed to monitor trends in several consumptive and non-consumptive recreational activities. Snepenger and Ditton (1985) analyzed NFWRS data for the period covering 1955-1980, and found that recreational fishing participation (measured as a percent of the US population) increased over the 25-year period of analysis. However, they did not distinguish between trends in marine and freshwater participation rates.

Figure 1 shows numbers of participants and participation rates for total saltwater recreational fishing from 1955 to 1996 in the U. S. (U.S. Bureau of Sport Fisheries and Wildlife, 1955, 1961, 1965, 1972; U.S. Fish and Wildlife Service, 1977, 1982, 1988, 1993, 1997). Participation rates and numbers of participants trended upward between 1955 and 1975, remained relatively stable at a high level from during 1975 - 1985, but declined in 1991 and changed little in 1996.

Like the NFWRS, the MRFSS provides estimates of marine recreational fishing participation. The MRFSS data indicate a slight downward trend in marine recreational fishing participation in Atlantic and Gulf coastal states from 1981 - 1997 (Figure 2). The downward trend is more pronounced in recreational fishing participation rates and is particularly evident from 1983 to 1990. During 1990 to 1994, recreational fishing participation rates fluctuated between eight and nine percent but has declined every year since 1994.

[7] PDF version can be found under publications at (www.st.nmfs.gov/st1/econ/index.html).

Trends in marine recreational fishing participation in the Northeast Region do not follow the patterns shown inFtab Figure 2. Over the 1981-1995 period, participation rates in the Northeast were somewhat lower than in the other Atlantic and Gulf coastal states and did not follow the same downward trend (Figure 3). Participant numbers fluctuated between 1981 to 1984 but declined in 1985 to a record low of two million participants. Subsequently, participant numbers and rates have been relatively stable. With the exception of 1991, participation in recreational fishing ranged from 2.4 million to 3.2 million individuals over the past decade.

A variety of factors may influence participation in recreational fishing. Constraints or barriers to participation (Jackson 1988) can be grouped into five major categories: (1) lack of interest; (2) lack of time; (3) lack of money; (4) lack of facilities; and (5) lack of skill (Searle and Jackson 1985; Kay and Jackson 1991). Social and cultural constraints such as age, gender, and income can also affect recreational fishing participation (Aas 1995). Although economic and demographic factors are generally not sufficient to explain why individuals make the choices they do, simple relationships can and have been developed between demographic variables and recreational participation to make projections about future participation in recreational fishing (Loomis and Ditton 1988). This approach was used by Murdock *et al.*. (1992) in developing forecasts of recreational fishing participation to the year 2050 based on projected national changes in population growth, age structure, minority populations, and household composition. Edwards (1989) developed predictive models to forecast marine recreational fishing for coastal states to the year 2025. Similarly, Milon and Thunberg (1993) developed predictive models to forecast participation rates and produce forecasts through 2010 of Florida resident recreational anglers.

Methods

Demographic data for recreational fishing participants and nonparticipants were gathered through an add-on to the base MRFSS household survey. The base MRFSS household survey is designed to estimate numbers of anglers and numbers of fishing trips taken over a two-month recall period from a telephone survey of households in coastal counties (Fisheries Statistics and Economics Division 1996). For each fishing trip, detailed data are gathered on fishing mode and primary fishing location. The telephone survey is administered to residents of coastal counties and covers fishing activity for a two-month period or wave. The survey is conducted in six waves beginning with wave 1 (January/February) and ending with wave 6 (November/December). Interviewing is conducted during a two-week period beginning the last week of the wave and continuing into the first week of the next wave. Due to a general lack of fishing activity, interviews do not begin until wave 2 in the Northeast region. Other than a simple tally, data are not normally collected on individuals or households that have not fished during a given wave, nor are any demographic or economic data collected.

For the participation component of the add-on each interview sought to determine the marine recreational fishing participation status (i.e. never fished; has not fished in past 12 months; fished at least once in past 12 months but not during past two months; fished in the past two months) for a sample of individuals 16 years and older. During the interview, demographic data (age, ethnicity, education, gender, income, and employment status) were also gathered. Individuals that had fished during the previous two months were also asked about boat ownership and target species sought in each recent fishing trip.

Since the MRFSS survey is based upon a stratified random design, demographic profiles for fishing participants and nonparticipants were based upon standard statistical weighting procedures appropriate to the stratified design (Cochran, 1977). A predictive model of participation was developed as a dichotomous choice where a value of 1 was assigned to a respondent that had fished in the past 12 months and a value of 0 was assigned otherwise. Dichotomous processes are typically modeled using either probit or logit regression. Both of these approaches are based on cumulative probability distributions (the cumulative normal for the probit, and the cumulative logistic for the logit) which assure predicted values cannot exceed the 0 to 1 interval for the dependent variable (Pyndick and Rubinfeld 1981). Although logit and probit models produce similar results, logistic regression was selected in this study because of its computational simplicity.

	Total House-holds	Never Fished	No Fishing in Past Year	Fished in Past Year, Not in Past 2 Mos.	2-Month Angler
Households Screened	53,553	44,714	2,081	2,590	4,168
Interviews Initiated	11,060	3,109	1,618	2,461	3,872
Respondent Not Available	1,553	0	582	868	103
Respondent Less Age 16	840	328	68	113	329
Not Completed	46	0	0	48	0
Completed Interviews	8,621	2,781	968	1,432	3,440
Percent Initiated	20.7%	7.0%	77.8%	95.0%	92.9%
Percent Completed	77.9%	89.4%	59.8%	58.2%	88.8%
Sampling Rates					
North Atlantic					
Wave 3		10.0%	34.6%	100.0%	100.0%
Wave 4		9.8%	100.0%	100.0%	100.0%
Wave 5		9.9%	100.0%	100.0%	100.0%
Wave 6		10.2%	100.0%	100.0%	100.0%
Mid-Atlantic					
Wave 3		5.2%	25.2%	76.3%	100.0%
Wave 4		5.8%	100.0%	100.0%	100.0%
Wave 5		5.5%	100.0%	100.0%	100.0%
Wave 6		6.8%	100.0%	100.0%	100.0%

Table 1. Summary of Participation Survey Sampling and Completion Rates

Defining a participant as an individual that had fished during the 12 months prior to being interviewed, demographic variables (age, income, education, ethnicity, and gender) were used as a set of explanatory variables in the logistic regression. Household income and education were treated as continuous variables, while a series of dummy variables were constructed to represent ethnicity and gender-age group effects. Ethnicity was represented by a single dummy variable set equal to 1 if the respondent was non-white and 0 otherwise. Based on previous research, fishing participation for men and women was found to change with age with participation initially increasing early in life and then decreasing late in life (Milon and Thunberg 1993). To reflect this participation pattern, combinations of gender-age group dummy variables were constructed. Specifically, a total of five dummy variables were defined (males 16-24, males 65+, females 16-14, females 25-64, and females 65+) using males age 24-64 as the base group. Estimated participation rates for 1994 indicated some regional differentiation in participation across states. Several alternative specifications to account for these regional differences were specified. Of these, a single regional dummy variable for the sub-region including the states of Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, and New York provided greatest overall fit.

The coefficients from the logistic regression provide the basis from which participation probabilities were calculated for subgroups of the coastal county population. A forecast of numbers of saltwater recreational anglers over time was then calculated as the product of the predicted probabilities and U.S. Census Bureau estimates of population change in each subgroup.

Results

A total of 53,553 households were sampled in 1994 as part of the base MRFSS (Table 1). Of this total, the participation survey contacted a sample of 11,060 individual households, with no more than one person from each household interviewed. The total number of completed interviews was 8,621; a completion rate of 77.9 percent. Initial target sampling rates were assigned to each of the four different participation categories. These target rates were implemented during the first wave of the survey. However, these target sampling rates were subsequently adjusted because the number of respondents by participation category fell short of prior expectations. As individuals who had never fished comprised the largest number of total contacts (83.5%), sampling for this category was reduced to 9.0% and 4.2% respectively for the North Atlantic and Mid-Atlantic regions. Sampling rates for the other three participation categories were set at 100 percent.

Demographic profile of marine recreational fishing participants

The majority (80.1%) of saltwater recreational fishing participants in the Northeast were males while the majority (61.8%) of non-participants were female (Table 2). Among age groups the largest differences between participants and non-participants occurred among ages 16 to 25, 36 to 45, and 66+. Proportionally fewer (11.7%) participants were aged 16 to 25 as compared non-participants (18.3%). By contrast, a higher proportion (17.1%) of non-participants were over age 66 as compared to participants (7.1%). The par-

Demographic variance	Participants (%)	Non-participants (%)
Gender		
Male	80.1*	38.2
Female	19.9	61.8
Age Group		
16 to 25	11.7	18.3
26 to 35	23.5	21.7
36 to 45	27.2	18.5
46 to 55	18.1	14.2
56 to 65	12.5	10.2
66+	7.1	17.1
Ethnicity		
White	88.7	73.5
Black	5.8	13.4
Hispanic	2.1	7.8
Asian	1.0	1.1
Other	2.5	4.2
Education		
Less than High School	7.5	12.1
High School Graduate	33.6	30.4
Vocational or Associate	4.4	4.2
Some College	23.5	19.6
College Graduate	22.4	23.5
Graduate/Professional	8.7	10.2
Household Income		
$15,000 or Less	5.3	13.6
$15,001 to $30,000	16.8	25.0
$30,001 to $45,000	20.8	22.5
$45,001 to $60,000	22.5	17.8
$60,001 to $85,000	18.6	10.8
$85,001 to $110,000	10.0	5.7
$110,001 to $135,000	2.8	2.2
$135,001 to $160,000	1.0	1.0
$160,001 or More	2.2	1.4

Table 2. Demographic Profile of 1994 Marine Recreational Fishing Participants and Non-participants in the Northeast, U. S. * All proportions differed, except household income $135,001 to $160,000, among participants and non-participants based on a Chi-Square test of equal proportions.

ticipant population consisted of more Whites (88.7%) and fewer of all other ethnic groups than either non-participants or the Northeast region-wide population. Relatively few differences existed in educational status between saltwater recreational fishing participants and non-participants in the Northeast region. The only notable difference was that the proportion of marine recreational fishing participants who did not graduate high school (7.5%) was lower than non-participants (12.1%). Household income distributions of Northeast region saltwater fishing participants and non-participants were similar. However, compared to the non-participant population, a larger proportion of fishing participants occurred in each income category above $45,001 and a lower proportion in every income category below $45,000. The tendency for participants to have higher household income than non-participants may be due to the joint impact of the higher proportion of Whites in the participant population and the relatively higher proportion of participants between the ages of 35 and 55. Whites tend to have higher income than non-Whites in the general population and individuals between the ages of 35 and 55 and likely to be at their peak income earning potential.

Forecasting Recreational Fishing Participation

With the exception of the age group 16 to 25 all estimated coefficients for the logistic regression model were statistically significant (Table 3). Positive coefficients indicate that the probability of participation increases as the variable increases and vice versa for negative coefficients. For example, the probability of being a recreational fishing participant increases with income, but decreases with educational status. Several alternative specifications to account for these regional differences were specified. All dummy variables are interpreted relative to the base; the base is a White male age 25 to 64 living in a coastal county from New England/New York. Relative to this base, a non-White New England/New York coastal resident male age 16 to 24 is less likely to participate. Similarly, non-White and White female coastal residents in New England/New York are less likely to participate than 25-to 64-year old White males.

By setting income and education equal to their estimated population median values and systematically applying the ethnicity and gender-age group variables, an expected probability for each demographic sub-grouping can be calculated (Table 4). The model results indicate that White males age 25 to 64 are most likely to participate in saltwater recreational fishing, while non-White females over the age of 64 are least likely to participate. The expected number of participants in any given subgroup can be calculated by the product of the predicted participation probability and the total population size of the subgroup. Summing products across all demographic subgroups gives an estimate of the total number of saltwater recreational anglers in the Northeast region.

Variable	Estiated Coeffcient	Stanard Error
Intercept	-1.2012*	0.0979
Household Income	0.1139*	0.0200
Education	-0.1217*	0.0212
Ethnicity	-0.7882*	0.0925
Female 16-24	-2.2180*	0.2325
Female 25-64	-1.5325*	0.0818
Female 65+	-3.0222*	0.2880
Male 16-24	-0.1853	0.1146
Male 65+	-0.3971*	0.1312
Region	0.2155*	0.0624

Table 3 Coefficient Estimates for Reformulated Northeast Region Saltwater Recreational Fishing Participation Model. Statistically significant at the five percent level or greater for X^2 with one degree of freedom.

Data from the U. S. 1990 census provided population size estimates by age, gender, and race for coastal counties in the Northeast region. Summing the product of the expected probabilities in Table 3 and the Census population estimates gives an estimate of 3.165 million anglers in the Northeast region. Compared to the 1990 MRFSS estimate of participation in the Northeast region (2.561 million) the predicted number of participants is approximately 24 percent higher than the MRFSS. However, the MRFSS provides an annual estimate of participation while the participation model provides estimates of longer-term trends in participation. The two estimation methods meet different needs and should be regarded as complementary. For example, from 1990 and 1997 the estimated number of recreational participants from the MRFSS ranged between 2.4 and 3.2 million participants. The estimated number of participants based on the participation model falls within this range.

There are several other reasons why the estimates from MRFSS and participation model differ. First, the 1990 MRFSS estimates are based on data collected in that year while the forecast using the participation model was based upon sample data collected in 1994. Second, the MRFSS estimates are based on a combination of household and intercept data. By contrast, the participation survey sample frame was coastal county residents with participation estimates based on demographic variables. Last, the participation survey sample may not be representative of the coastal county population. Relative to Census Bureau estimates, males in the participation survey were slightly over-sampled, non-Whites generally under-sampled, and participants were typically older and had higher income than the general coastal county population. Thus, the participation model is likely to introduce some upward bias in the participation probabilities for White males and some downward bias in the participation probabilities for non-Whites and females. On balance, the upward bias created by the joint effect of a higher probability of White male participation and a higher proportion of Whites is likely exceeds any downward bias associated with the non-White and female participation estimates.

The exact magnitude of bias in the participation model is not presently known. The bias may not be severe since the predicted number of participants is within both the range of historical levels of participation and the range of recent MRFSS participant estimates. Nevertheless, the participation model forecasts are likely to be biased upwards and should, therefore, be regarded primarily as indicators of potential trends in recreational fishing participation in the Northeast region.

The Bureau of the Census has produced forecasts of population by age, gender and race in five-year increments through the year 2025 (Campbell 1996). These are provided on a state-by-state basis, but are not broken out by coastal and non-coastal counties. For states that are completely (Connecticut, Rhode Island and Delaware) or nearly completely (New Jersey, and Maryland) covered by the MRFSS telephone survey, this presents no problem. For other states, however, the census forecasts had to be prorated by the ratio of the 1990 coastal county population to total state population by demographic grouping. This procedure assumes that the proportional population growth by demographic groupings in coastal counties and non-coastal counties will remain constant over time. If population growth rates in coastal counties exceeds that of non-coastal counties, then participation forecasts will be underestimated and vice versa if non-coastal county growth rates exceed that of coastal counties.

	Whites		Non-whites	
Age Group	Females (%)	Males (%)	Females (%)	Males (%)
ME to NY				
16 to 24	2.8	17.8	1.3	8.9
25 to 64	5.3	20.6	2.5	10.6
65+	1.3	14.9	0.6	7.4
NJ to VA				
16 to 24	3.4	21.1	1.6	10.9
25 to 64	6.6	24.4	3.1	12.8
65+	1.5	17.8	0.7	9.0

Table 4. Predicted Probability of Participation by Ethnicity and Gender Age-Group

Year	Predicted Participants (millions)	Participation Rate
1995 Base	3.214	11.0%
2000	3.284	10.9%
2005	3.372	10.9%
2010	3.472	10.8%
2015	3.549	10.7%
2020	3.609	10.5%
2025	3.656	10.4%

Table 5. Predicted Number of Coastal County Resident Saltwater Recreational Fishing Participants Age 16 and Over (2000 to 2025) · U. S. Census Bureau preferred series "A " was used for all forecasts (Campbell 1996).

Although the number of recreational fishing participants is forecasted to increase gradually through the year 2025, the proportion of coastal county residents participating in recreational fishing is predicted to decrease (Table 5). The projected increase in participant numbers is due to a general increase in population, while the decline in participation rate is due to demographic changes in the composition of the population. A portion of the participation rate decline is also attributable to the relatively greater growth in population components that have historically had low recreational fishing participation rates. However, the overwhelming factor is aging. The Baby-Boom generation (individuals born between 1946 and 1964) will reach retirement age in the year 2011 (Campbell 1997) and individuals age 65 and over are predicted to have the lowest rate of participation.

Conclusions

The present study is the first of its kind to develop participation models and forecasts of saltwater recreational fishing in the Northeast region. The total number of coastal county recreational fishing participants in the Northeast is projected to increase by an average annual rate of 0.5 percent through 2025. However, as a proportion of total coastal county population, participation rates were predicted to decline from 11 percent in 1995 to 10.4 percent in 2025. The projected increase in the number of saltwater participants is due to a general increase in population in the Northeast (based on estimates from Census Bureau preferred series 'A'). The decline in the participation rate will arise due to changes in the underlying structure of the population (i.e. the 2025 population will be older relative to 1995 and have proportionally more non-Whites). Participation will decline at age 65 and older and increases in the non-White population will exceed those of the White population.

These general participation trends are similar to findings by Milon and Thunberg (1993) for Florida resident saltwater fishing participation. Their forecasts also indicated a modest increase in total numbers of recreational fishing participants and a decline in fishing participation rates. Similarly, Murdock *et al.* (1992) predicted that total U. S. recreational fishing (freshwater and saltwater) participants would increase at a rate of less than 0.5 percent per year through the year 2050. Edwards (1989) projected an average annual growth rate in marine recreational participation across all coastal states of less than 0.2 percent from 1980 to 2025. The most recent population projections (Campbell, 1996) show an annual average growth rate of 0.9 percent in the U. S. population through 2025. Assuming the population growth rate remains relatively stable, these studies indicate that recreational fishing participation rates appear to be likely to decline at a National level.

Projections of future participation cannot be used to predict how many people will actually participate in any give year. Inter-annual differences in participation are likely to depend on fluctuations in short run economic, climatic, and resource conditions. Estimates of annual participation may be best left to the current MRFSS random household survey. By contrast, the participation projections are likely to provide reasonable estimates of longer-term trends in the size of the potential population from which recreational fishing participants may be drawn.

Forecasting participation based solely on demographic change has its constraints. All of the forecasted participation estimates provided in this study (an assumption common to other similar studies; Edwards 1989; Milon and Thunberg 1993; Murdock *et al.* 1992; and Loomis and Ditton 1988) are based upon the assumption that the factors that influenced participation in 1994 will not change. However, these factors are not likely to remain constant nor are they merely a function of demographics. Individual attitudes, experiences, social norms, and opportunity determine whether or not an individual will choose to engage in any given recreational activity. The extent to which demographics are correlated with these decisions is not static. For example, changing gender norms may lead to increased participation rates among women relative to current and past levels of female participation. Similarly, lifestyle changes among older individuals may result in

higher participation rates among this segment of the population. Thus, tomorrow's participant population may differ from today's.

While social attitudes, preferences, and norms do change they do so only gradually. In spite of its limitations, the likelihood that any given individual may be a recreational fishing participant was shown in this and other studies to be correlated with specific demographic characteristics. Given the consistent relationship between demographics and participation, and the evolutionary pace of social change the forecasts of recreational fishing participation reported in this study are likely to be reliable indicators of trends in fishing participation at least in the short term (5 to 10 years). Obviously, longer-term trends are less certain. However, given the dominant effect an aging population will have on Northeast region it seems likely that the region will experience only modest increases in marine recreational fishing participation over the next 25 years.

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Questions

Douglas Lipton: Would boat ownership make any difference to your data?

Eric Thunberg: Some of the data was not used in the forecast model; boat ownership is one of them, and it was held constant for the purposes of our calculations. The only variables we used were the ones that could be changed. But boat ownership is a significant factor, as well as whether they had been angling in their youth or whether an individual lived in an urban or non-urban environment.

Anne Coleman: Who do you consider a participant?

Eric Thunberg: We had four participation categories:

A. Someone who has fished in the last 2 months
B. Someone who has fished in the last 12 months
C. Someone who has fished sometime in their life but not within the last 12 months
D. Someone who has never fished at all.

The former two were considered participants, while the latter two were considered non-participants.

Measuring the total economic value of recreational fisheries in Scandinavia

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Abstract

This paper describes a survey design for capturing the total economic value of recreational fishery in the Nordic Countries. The economic value will be defined separately for the different segments of recreational fishers and will cover both coastal and inland fisheries. The Contingent Valuation Method will be applied. In the survey both open-ended questions and multiple bounded discrete choice questions will be applied. Conceptual differences within segments of recreational fishers are discussed. The elicitation questions are described in-depth. The national population registers are used as sampling frames.

Introduction

Recreational fishing is a popular free-time activity in the Nordic Countries. The operating environment for the pursuit is ideal. There are 130 000 lakes sized 4 hectares or more in the Nordic Countries (Henriksen *et al.* 1997), long coastlines and genuine archipelagos. On average, 27 % of the Nordic citizens are recreational fishers (EIFAC 1998). There are differences in the activity between countries, though. In Finland the hobby interests over 40 % of the population, in Sweden and Norway nearly 30 % whereas in Denmark 10%. For comparison, the percentage of recreational fishers in all of the EU countries is 6%. In Scandinavia, there is a living tradition of fishing. To many people, especially in the coastal areas, fishing has been a way of living rather than a hobby. Later on, the significance of fishery as part of the livelihood has decreased but subsistence fishery still takes special forms. Recreational fishery with standing gear like gill nets is a unique phenomenon.

The existence and accessibility to fishers of nature and wilderness is experienced as being almost self-evident. People are not used to pay for outdoor recreation in the nature. Recreational fishery is usually classed as being non-commercial, in the sense, that these fishers do not do it to earn a living. This, on the other hand, does not imply that fishing is free. On the contrary, there are costs incurred by all types of recreational fishery (Sipponen 1999).

The total economic value, TEV, of recreational and subsistence fisheries is not directly reflected in the market prices for fish and fishing licences. In conflicting situations, it has not been possible to treat the recreational fishery in the same way as other waterway uses, because the total value of recreational fisheries in monetary terms has usually not been known.

The increased use of cost-benefit analysis as a decision making tool in governmental and local planning in the Nordic countries has further strengthened the importance of finding the total economic value of fish and fishing resources. The estimates of the economic value of recreational fisheries will also be very useful as input in models for social optimal management of fish stocks in terms of the distribution of catch volume between different, and often conflicting uses, of a fish stock. The results will provide insight into the size of damages from pollution accidents, and thus, improve the estimation of compensation payments.

Any leisure activity involving the use of a scarce natural resource is subject to a public management scheme in the Nordic Countries. Just as the abundance of fish and angling sites in the Nordic Countries varies quite much, as well as the historic traditions for angling and fishing associated with them, so too, does the choice of management tools available for monitoring the resource. The tools deployed may have different aims and objectives, but common for them are the overall aim to protect the environment and the fish stocks, safeguard the historic property rights, minimize conflicts towards other users of the same resources and lay down rules for proper behaviour on the angling sites. A common problem for the management in use to date, however, is the lack of a common denominator for benefit and costs involved in this area.

The joint Scandinavian project aims at measuring the economic value and describing the cultural significance of the recreational fishery. The survey will be executed simultaneously in all of the Nor-

dic Countries, Denmark, Finland, Iceland, Norway and Sweden, with standardised methods and definitions. The economic valuation of the non-market value of recreational fishery is carried out as a mail survey based on contingent valuation method, CVM. The measuring instruments used in the survey for both the economic valuation and the segmentation of recreational fishery will be identical in each country. Since recreational fishery has a special weight in the lifestyle of many Nordic people, a high response rate and thereby representative and useful estimates can be expected. This paper describes the preparations for the survey that is going to be executed in October - November, 1999.

Survey method

The economic theory has, during the last 25 years, developed the theoretical framework and some basic tools, especially for the valuation of natural resources and their exploitation. Also, these tools may be used for valuation of non-market goods, where very different benefits are derived from the activity, as is the case concerning recreational fisheries. Conceptually, the total economic value of a resource consists of its use value and non-use value (Munasinghe 1992). Use values may be broken down further into the direct use value, the indirect use value and the option value. The categories of non-use value are existence value and bequest value.

The total economic value of the environmental resource can be established by the CVM that is widely used for valuating immaterial goods and resources. The contingent valuation technique uses surveys to determine consumers' willingness to pay for protecting or improving environmental quality or services by creating hypothetical markets (Mitchell and Carson 1989, 86-87).

The difference between what a commodity costs and what people actually are willing to pay for it, is theoretically captured in the consumers surplus. The market demand curve shows the quantity of the good that would be demanded by all consumers at every price that might prevail. Those consumers who would have been willing to pay the biggest price get the biggest consumer surplus.

The fact that services from nature might be consumed for free does not mean that the service does not have a value to people. On the contrary, the service has a large consumer surplus. The more people are finding pleasure in fishing, the more value it has to the society. This without counting external damages and costs to others.

The Hicksian equivalent and compensating variation, EV and CV, are examples of money measures of welfare change. The individual is kept at the same utility level throughout the change one is studying. Depending on the utility reference level, EV and CV give the maximum sum of money a person would be willing to pay to acquire a higher environmental quality, or the minimum compensation required to accept an environmental degradation.

Some of the changes that are subjects of trade-offs cannot be produced overnight; instead, there is a time interval involved. More so is the case in connection with future benefits of preservation, for instance. The discount rate is an important parameter which is applied to future costs and benefits to compare them with those of the present (Munasinghe 1992).

Sampling method

The fishing licence register has a few serious drawbacks as a sampling frame. Some forms of fishing are free, like angling and ice fishing in Finland or fishing with a spinning rod on the coast of Sweden. Those fishers do not need a licence and thus are necessarily not included in the frame. Secondly, licence frame mainly measures the values of those who actually fish and therefore the direct use value can be overemphasized.

A representative sample of the population, including both fishers and non-fishers, makes it possible to capture at least a part of the existence value. In national surveys the best frame population is the population register. The register may have to be sorted geographically before systematic sampling or the sample may be taken geographically stratified. Every sample of a given condition has to have an equal chance of being chosen. The sampling criteria may be a certain age interval for instance. For calculating the estimates, the likelihood of the sampled item to be included in the sample is needed. The research unit can be either the individual person or the whole household.

For our survey, the sample size is 25 000 persons, aged 18 - 69. The sample includes 5 000 persons from Denmark, Finland and Norway, 7 500 persons from Sweden and 2 500 persons from Iceland.

Questionnaire

For ensuring highest possible response rate and for avoiding cultural conflicts between participating countries, the questionnaire was designed as easy and simple as possible. The intention of direct optical storage of the data favours questions where the responded chooses from a given set of choices.

Some of the background variables like age, sex and size of the household are asked in the questionnaire and also driven from the sampling frame. That gives a simple way of cross checking. Education, type of domicile and income level of the household is also asked. Background variables are used for both adjusting the estimates and as categorical variables.

Asking the respondents about their general attitude towards outdoor recreation collects more subject oriented categorical variables. The operational environment is checked by asking whether anybody in the household fish. Fishing area and activity are recorded and the respondents are asked to rank the fishing areas according to their preference.

The questions targeted to the recreational fishers start by asking the respondents to characterize the type of fishers they are. A recreational fisher is defined as a person who at least once a year, for recreation, carries out fishing activities. The segmentation is based on the type of gear used. A sports fisher mainly uses rod and line. A subsistence fisher is catch oriented and mainly uses gill nets or other standing gear. A generalist uses all sorts of gear. In Sweden the concept of a sports fisher is well established and it also includes those who sometimes by chance may fish with a simple rod, line and hook. In all other Nordic countries that would not be considered sports fishing. Therefore a fourth category, an occasional angler, was designed for all others except the Swedes.

Elicitation

The set-up of the first willingness to pay -question is based on consumer surplus and it is targeted to recreational fishers only. First the respondents are asked to estimate how much money they spent in recreational fishery during the last 12 months. Several variable cost type consumption categories are given. Next the respondents are asked to think about the experience they gained for that money and what it really is worth to them. The respondents have to estimate how much more would the same amount of fishing have to have costed until they had considered it too expensive.

The next type of questions is also targeted at fishers only. The scenarios are based on the idea of launching a new fishing site that so far has been closed. This might be a former military area or a restored lake or river, for instance. It is supposed to be situated close to the respondent and have good species composition, water quality and environmental status, expected catch rate above average and no crowding. Three different scenarios are designed based on the type of fishing area, species composition and permitted gear type. Exclusive fishing rights are auctioned to a number of fishers. The collected amount of money would be administered by the local fishery authoritative and refunded for maintenance of the site.

The respondents are asked how much they would be willing to pay to be one of the fishers who get the access to this new fishing site. In general, the question is designed to elicit the equivalent variation for improving the welfare of the recreational fisher. It is a multiple bounded discrete choice question. The intensity of preference for willingness to pay for each monetary sum is stated by ticking: would certainly pay / would almost certainly pay / would almost certainly not pay / would certainly not pay.

The last willingness to pay -question is targeted to all respondents regardless of their fishing activity. The scenario is built on threatened natural fish stocks. The numerous threats to fish stocks are described. National programs for preserving the fish stocks are introduced. The payment vehicle is taxation. The highest willingness to pay of the respondents is asked with the same multiple bounded discrete choice scale. The question elicits the respondents' compensating variation, as the utility level is not decreased. This question attempts to get at the existence value through the answers of non-fishers. At the end there is a set of questions designed for finding out the attitudes toward the payment vehicle.

Execution of the survey

Finland Post Ltd will execute the mailings of the survey. The survey is designed on three contacts. Firstly, the questionnaire, a cover letter and a return mail envelope is sent to all recipients. The second contact is a simple reminder and the third contact includes the questionnaire again. The return mail is directed to Finland. Nordic Printmail Ltd prints the questionnaires with print-on-demand -technique, POD. That enables printing

the recipient's name and address on the first page of the questionnaire and record number on each page. The returned questionnaires will be collected in Finland and Nordic Printmail Ltd will store the answers optically.

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Curtis Coast, Central Queensland recreational fishers: importance, impact and involvement

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Introduction

Gladstone is a modern industrial city located within the Curtis Coast close to the Tropic of Capricorn. It is presently home to seven major industries. Queensland Aluminium Limited (QAL), operates the largest alumina refinery in the world, using bauxite imported from Weipa in North Queensland. Part of QAL's output is converted to aluminium by Boyne Smelters Limited (BSL), which has a world class aluminium smelter. It has recently undergone a major expansion by establishing a third potline, which will double its present production. Power for the aluminium smelter is provided from Queensland's largest power station, NRG, purchased in recent years by Comalco, from the Queensland Government. Queensland Cement Limited (QCL) produces clinker and cement from locally produced limestone and has also recently undergone expansion. Adjacent to QCL are two chemical plants Orica (previously ICI) and Ticor, which produce solid sodium cyanide and liquid cyanide for use in gold extraction and chlorine. Major significant strategic oil shale resources exist in Central Queensland. A pilot extraction plant is being built and will be in operation in Gladstone along with a mine, later in 1999. The Gladstone area is presently being considered as a site for a magnesia plant, a further aluminium refinery, a steel works and other major developments. The population of Gladstone trebled between 1965 and 1985, to approximately 25,000 people, with another 8,000 in nearby Boyne Island/Tannum Sands area.

The key to Gladstone's growth and further potential is its port, Port Curtis. Port Curtis is a natural protected deep water harbour which services a resource rich hinterland abounding with mineral and energy. Through a carefully planned program of expansion over several years, this port has attained an international status as a port of efficiency and high esteem. The strength of the port lies in its diverse network of individual facilities, each with specific functions, that lie within the harbour. Efficient direct rail links, upon which massive train units drawn by modern electric engines, provide the main artery that carries products to Gladstone and ultimately to every corner of the globe. The Port of Gladstone currently is rated the sixth largest coal port in the world by throughput and third largest by capacity. Initial port facilities and some industry were established on the seaward side of the city. Since then large tracts of natural and reclaimable land, west of the city towards the Calliope River have been set aside for industrial and port use. A $349m expansion program is planned for Port Curtis involving commercial wharf, reclamation and dredging infrastructure over the next ten years. This industrial and port land is separated from the city by a green belt buffer zone incorporating Central Queensland University – Gladstone Campus, a marina and a recreational park.

A large proportion of this industrial land is reclaimed from the marine environment being in the past salt flat, mangrove or shallow marine environment. Since 1941, in excess of 16.5% of mangroves and 26% of coastal saltflat has been lost to development (QDEH, 1994)

The Curtis Coast includes Port Curtis and adjacent islands, Curtis Island and Facing Island and extends from Port Alma at the mouth of the Fitzroy River to the Town of 1770. It includes Wild Cattle Island, Turkey Beach, Rodds Peninsula and Eurimbula National Parks. The area presents opportunity for recreational fishing activities within the rivers, near harbour, outer harbour, the surrounding coastal areas and at the nearby Great Barrier Reef.

Recreational fishing within the Curtis Coast

Recreational fishing within the rivers, streams, creeks, harbour and coastal environment of Port Curtis is an important activity both during the weekends and the week, due to the prevalence of shift workers. Few descriptions of the activity are available. Walker (1997) describes Central Queensland Fisheries Resources, while Platten and Thwaites (1998), Blaney and Hundloe (1993) describe some recreational activities for the period 1980-1990 for the Rockhampton region, which includes the Curtis Coast. Blaney and Hundloe (1993) centered their attention upon fishing activities involving Great Barrier Reef.

Figure 1. Map of the study area, showing locations named in the text.

QDEH (1994) report approximately 2800 boats registered for Gladstone and WBM (1989) report 2383 registered boats. The Queensland Department of Transport reported 3069 boats for Gladstone postcode of 4680 and 307 boats for Gladstone and 4783 for the adjacent Calliope Shire. Thus it would appear that the current number of registered boats in Gladstone is 3069-5090, i.e. from 8 –14% of the population owning a registered recreational fishing boat.

This document focuses attention on recreational fishing activities as an added contribution to the description of the Port Curtis and Curtis Coast recreational fishery. Data and information resources examined and or collected were:

- a survey undertaken by the Gladstone Marine Resources Advisory Committee of recreational activities for the Great Barrier Reef
- telephone surveys commissioned by the Queensland Fisheries Management Authority.
- a study undertaken by Platten and Walker on behalf of the Gladstone Area Water Board during 1998/99 which includes examination of fishing club records, fish tagging records, creel surveys and boat ramp surveys
- newspaper records from the Gladstone Observer from 1997-1999.

Gladstone Regional Marine Advisory Committee survey of river, estuary, reef and sea use

The Gladstone Regional Marine Resources Advisory Committee, a diverse group of people and representatives of organisations which have interest in management and utilisation of the Port Curtis and Curtis Coast marine environment. In 1997, GRMRAC conducted a survey by questionaire of recreational usage of the Port Curtis, Curtis Coast and adjacent reef areas on behalf of the Great Barrier Reef Marine Park Authority. These were similar to two other surveys undertaken for GBRMPA by other Regional Marine Advisory Committees (Cooktown and Whitsunday Islands).

1034 survey forms were distributed and collected in the period December 1996– March 1997 via the mail, by constituents of the committee personally or in fishing tackle and dive shops. Only 47 forms only (4.6%) were returned. Such a low level of return is typical of surveys by forms. A limited analysis of the returns is, however, of value in understanding the usage and opinions of the 47 respondents.

Respondents were predominantly single or family groups. Only one member of a fishing club responded. The most popular recreational activity was fishing in the estuary, harbour, the coast and on the Barrier Reef. Other important interests included snorkelling, diving and sightseeing. Gladstone Harbour and its islands were most frequently visited, at an average rate of 20 days per year. Some respondents claimed to visit the harbour daily. Beach/coastal visitations rated 11 days per year. The average number of people visiting a destination was 2.72 consistent with the prevalence of family groups responding to the survey. Nearly 80% of the respondents owned their own boat of which 75% were outboard powered, 14% inboard and 11% were sailing vessels. Boats ranged from 3.7m to 14.0m (average length 6.4m) and carried an average of 3.25 passengers or crew. The most popular fishing sites were: Port Limits of the Harbour, followed by South Curtis, Capricorn Bunker Group of the Great Barrier Reef, The Narrows and Rodds Harbour.

Table 1. Significant % fish species composition of Gladstone area as determined by various sampling methods.

Species	"Observer" Recreational Catches %	1998 Club Data %	Creel Survey Boyne River %	Creel Survey Calliope %	QFMA Recreational Survey %
Barramundi	4.4				3.1
Bream	18.3	3.3	21.9	29.7	6.3
Cod	7.1	0.2	3.8	10.4	0.8
Dart	0.2	2.1			1.1
Flathead	6.6	2.2	5.1	6.5	10.6
Garfish		3.8			0.1
Grunter	9.2		24	17.2	1.3
Hairtail		0.2			
Jewfish	4.2				1.4
Longtom	0.2	1.4	0.3		
Mackerel		0.5			5.3
Mangrove Jack	7		0.7	0.5	1.7
Morwong	3.3				
Mud Crab	9.2		10.3	6.3	6.8
Oatfish			2.7	6	
Pike	0.2	0.4			
Queenfish	3.8	0.8	2.4	0.3	0.3
Salmon (bl)	6			4.6	1
Salmon (Fl)	0.2	2.1			
Sand crab			2.3	0.3	2.6
Shark			1.7	0.5	0.2
Sickle fish			4.1	1.1	
Sickle fish	4.4		2.7		
Stripey		0.2			
Tarwhine		0.4			
Trevally	3.1	0.4	8.9	6	1.4
Whiting	3.5	81.4	4.5	8.7	15.3

The Calliope and Boyne Rivers did not appear to be that popular among the respondents of this survey.

Respondents generally expressed a genuine concern for their marine resources and the pressure placed upon them by commercial users. Generally respondents were concerned about environmental issues as well as the general inadequacy or ineffectiveness of resource management.

Telephone survey commissioned by the Queensland Fisheries Management Survey

Roy Morgan research undertook a telephone survey on behalf of the Queensland Fisheries Management Authority in 1996. This survey consisted of 21290 contacts from Queensland residents approximately 1420 from each of 15 geographical areas. This led to 16004 short interviews with Queensland residents 18 years or older and the collection of information about fishing participation for each household member (41972 household members) and 5730 long interviews with a fisher older than 15 and selected randomly from each fishing household. Port Curtis is included within the Fitzroy Statistical division, which encompasses a large area including Rockhampton, Capricorn Coast and Western Central Queensland.

Information provided in this report provides some insight into recreational fishing in the Gladstone area, as follows:

- 65% of the people surveyed that said they fished the Gladstone area, 3.9% of Queensland population came from the Fitzroy Statistical Area and 8.6% from Brisbane City.
- 30.9% of the people that fished Gladstone were aged 40-49 and they accounted for 4.3% of this group of fishers across that state.
- 98.1% of anglers that fished the Gladstone area did so for recreational purposes.
- 3.7% of fishers were current angling club members.
- 43.1% were in households that owned a boat.
- 19.4% fished from the shore.
- Most anglers fished less often than once a month or on holidays.
- 73.1% of anglers fished mostly in salt water.
- In terms of species targetted by anglers the recorded percentages of anglers for the Fitzroy Statistical Division were – 16.4% mackeral, 12.3% mud crabs, 11.0% whiting and 7.9% flathead.
- The average catch recorded per angler trip was 4.9 fish.

Recreational Catches – Wanderers Fishing Club Records

No central long-term database exists of catches for recreational fishers. In 1997, QFMA has established RecFISH, a state-wide survey.

A Gladstone based recreational fishing club Wanderers have recreational fishing club records form 1977/78 until the present. Some of this data was previously reported by Walker (1995) after examination by Platten (unpublished).

Wanderers Fishing Club conduct monthly competitions, associated with spring tides, of about five hours duration in estuaries from Bustard Head to Cape Capricorn. The Club fishes similar locations each year (eg Gladstone Harbour, Cape Capricorn and Turkey Beach). Rod and reel gear is utilised along with natural baits. Fisheries are in a competitive mode thus their motivation is to catch fish and to record catches accurately and their activities receive considerable peer review. Their catches are dominated by whiting followed by garfish, bream, flathead, dart, steel back, flat salmon, longtom and queenfish (Table 1). [Linnean names not supplied. Ed.}

Catch data with time for the Harbour, Cape Capricorn and Turkey Beach, fluctuations trended downwards and in 1997/98 ranged from 6-11.5 fish per person (Platten, unpublished). Catches were significantly different in terms of composition to those found during creel surveys by Plat-

ten (1997) for the Calliope and Platten and Walker (1999, unpublished).

This is a result of the fishing methods used and the fact that the Wanderers Fishing Club target whiting to maximise fishing competition points, which are calculated on the number of fish caught as well as the weight.

Platten (1997) and Sawynok (1998) suggest that fish catches correlate with Department of National Resources monthly flow estimates for the Boyne and Calliope Rivers which ultimately flow into Gladstone Harbour/Port Curtis. While there appears to be some relationship with total flows, the general decline in catch rate equally could relate in full or in part to habitat deterioration and habitat loss.

Fish Tagging Records

The Central Queensland affiliates of the Australian Sports Fishing Association have conducted a joint tagging project (Suntag) with the Queensland Department of Primary Industries since 1985. This project involves the capture using lines baited with either natural baits or artificial lures. Data for the Boyne and Calliope Rivers were purchased from this program through Infofish Services. Results indicate differences in species composition and tagging rates between the two rivers. The Calliope River is more estuarine than the Boyne River which is dammed upstream by the Awoonga Dam. The Calliope River has higher tagging rates for the more freshwater associated species ie barramundi, mangrove Jack and tarpon compared to the Boyne River which is generally more marine and has higher rates for cod, flathead and trevally.

Over the 13 year life of the program, 3050 fish have been tagged in the Boyne and 1170 fish in the Calliope. In all, 32 species have been encountered but not all were common to both systems. Recapture rates overall have been 9.1% for the Boyne and 11.1% for the Calliope. Fish tended to be captured sooner in the Calliope than the Boyne.

Recovery data showed that fishes moved freely between the Fitzroy system, the Harbour, Calliope and Boyne Rivers especially for barramundi, cod species, blue salmon, flathead and mangrove Jack. Growth rates were faster for barramundi in the Calliope River than the Boyne with similar results for two cod species and mangrove jack.

Creel Surveys

Creel surveys were undertaken on behalf of the Gladstone Area Water Board during 1998 and 1999 following techniques outlined in Platten and Thwaites, 1998. Survey times were chosen at random with emphasis on morning rather than afternoon activities. A survey of boat trailer occurrences at boat ramps was also recorded. In each season 8 randomly chosen weekend or public holiday and two mid week surveys were conducted, supplemented with four surveys on the Calliope to allow comparison with Platten and Thwaites, 1998. Few anglers fish alone so recordings were made of groups with their group dynamics noted. Groups were questioned to determine their initiation time of fishing and success.

Both river systems supported differing species composition. In reality the recreational fishery was based upon four species – grunter, bream, mud crab and trevally. Fishers take a greater proportion of trevally and mud crabs in the Boyne and more bream, whiting and catfish in the Calliope.

The average catch rate for this Boyne study was 0.37 fish per angler trip. The compares with an average rate of 0.73 for the Calliope, (Platten and Thwaites, 1998) and 4.9 fish per angler trip in the 1996 QFMA Recreational Fishing Survey.

The most common group encountered as surveyed on the Boyne River either angling from a boat or the shore was 2 people (43.2%) followed by 3 people (17.9%) and 1 person (17.6%). In terms of structure, the most common group was an adult couple (23.6%), followed by an adult male (20.3%), 2 adult males (16.5%), 1 parent and child (8.2%), 2 parents and child (5.5%), 2 teenagers (5.5%) and 2 parents and 2 children (5.5%).

Boat ramp vehicle and boat trailer survey

Boat ramp vehicle and boat trailer surveys were undertaken at two Boyne River boat ramps during the period 1998/99. The Toolooa Bends boat ramp, which services Gladstone Harbour and the lower Boyne River to The Lillies was monitored on a regular basis during this period. The occurrence of boat trailers and vehicles were monitored twice daily, at Toolooa Bends, at some time between 0730-0815 and 1630-1830 and during the weekends at random. A summary of the data collected for the period July – December, 1998 shows indicates that recreational fishers using boats prefer mornings during the week and that Saturday was clearly the most popular day for fishing, followed by Sunday. A further summary

of this data in terms of tides (ie high tide, approaching high, high to low, low tide and low to high) day of the week and month indicates the importance of high tides and around high tides for fishing. The necessity for high tides for mud crab fishing using traps is obvious. Also, the fact that a making tide being generally best for live angling is also indicated. It also appears that during weekends some recreational fishers will fish irrespective of tide.

Analyses of cars present at the Toolooa Bends Boat Ramp according to the number of times its vehicle registration plate was observed yield suprisingly 8.5% of the vehicles from 222 vehicle plates recorded were only recorded on one occasion. This is an interesting result.

Observer newspaper fishing records

The Observer newspaper, which is published 5 times per week and services the Gladstone, Curtis Coast area. It regularly publishes photographs of successful recreational anglers with their catch and also lists: the species caught, its size, the locality and date of capture and the christian name of the successful recreational fisher. The successful recreational fisher and his catch are photographed at a weigh in station at a tackle shop in the Curtis Coast area.

The Observer in association with some tackle shops and boating suppliers, hold a fish of the week and fish of the year competition. The largest fish of the week by species is published in table form along with the location caught, weight of the fish, the recreational fishers name and the bait and line specifications used.

This data resource was utilised to determine the species caught and weighed in for Port Curtis (Table 1). The most popular weighed in species were bream (18.3%), mud crab (9.2%), grunter (9.2%), cod (7.1%), mangrove Jack (7.0%), flathead (6.6%), blue salmon (6.0%), barramundi (4.4%), sickle fish (4.4%), queenfish (3.8%), whiting (3.5%), morwong (3.3%) and trevally (3.1%). These results agree with the distribution of recreational fishers from the 1996 QFMA Recreational Fishing Survey.

Photographs were also examined to determine the approximate age and sex of the recreational fisher weighing in the catch. This data is presented summarised by location for a sample size of 522 photographed weigh ins, selected over 12-18 month period. Male adults were the largest group weighing in fish (36.2%), followed by boys (27.8%), male teenagers (12.5%), adult females (7.7%), girls (6.1%), female teenagers (5.8%), retired males (2.7%) and retired females (1.3%). These results agree with the distribution of fishers from the QFMA 1996 Recreational Fishing Survey.

Summary and discussion

Examination of six differing sources of data/information pertaining to Curtis Coast recreational fisheries revealed differing results in terms of information reliability and bias. The sources examined were as follows:

- GRMRAC forms survey
- 1996 QFMA Recreational fishing survey telephone survey
- Wanderers fishing club records examination
- Creel survey
- Boat trailer survey at a boat ramp
- Newspaper records

These 6 sources have been scored (Table 2) in terms of their importance as data sources for the Curtis Coast/Port Curtis. Information of interest to recreational fishers and managers with a 90-100% certainty was given a score of 1, 75-89% a score of 2 and 50-74% score of 3, and less 50% a score of 4.

The information of interest is catch: species composition, species retained, species discarded, species size, species targetted, trip catch, season catches, annual catches; and effort: method, shore/boat, location, trip effort, season effort, annual effort, age, sex, and social position.

Overall, best results were achieved by survey of fishing club records (22) and creel surveys (24) followed by telephone (37) and form surveys (39). Boat trailer surveys and use of the newspaper scored 61 and 41 respectively.

The examination of fishing club records provides good information upon species caught, targetted fishing effort and location. The information, however, only represents fishing club events and club members and is influenced by targetting of species to achieve the best points. When the species caught are compared with species composition retained determined from creel surveys or the newspaper, they are found to be different. The data cannot claim to represent the fishing population or the general population.
Creel survey information provides accurate information on fishing effort and catch on a trip basis. There is, with this source, some doubt over the truth of replies given especially regarding the

Table 2. Assessment of value and accuracy of recreational fishery assessment techniques for Port Curtis.

	Form survey	Telephone Survey	Fishing Club record survey	Creel survey	Boat trailer survey	Newspaper
Catch Data						
Species composition	2	2	1	1	4	1
Species size	4	3	1	1	4	1
Species retained	1	1	1	2	4	1
Species discarded	2	2	3	1	4	4
Species targetted	1	1	2	1	4	4
Trip basis	3	3	1	1	4	4
Season	3	3	1	2	4	2
Annual	3	3	1	2	4	2
Effort						
Method	1	1	1	1	4	1
Shore	1	1	1	1	4	1
Boat	1	1	1	1	1	1
Location	3	3	2	1	3	2
Trip	3	3	1	1	1	4
Season	3	3	1	2	4	4
Annual	3	3	1	2	4	4
Age	1	1	1	1	4	1
Sex	1	1	1	1	4	1
Social position	3	2	1	2	4	3
Total	39	37	22	24	65	41

Key: 1 = 90-100%, 2 = 75-89%, 3 = 50 -74%, 4 = <50%

catch. If groups are also scored for age and sex then good sociological data is obtained. Interestingly, this accurate data for Port Curtis was slightly different to that obtained using survey forms and telephone surveys, which are usually assumed to be accurate in this regard. The difference was the importance of adult couples fishing from boats.

The telephone survey information (QFMA Recreational Fishing Survey) achieves a greater participation rate than survey forms. In the case of the GBRMPA survey of the Curtis Coast the returned participation rate was 4.9% and did not justify the effort involved in this process.

The survey is, however, of value when compared with the QFMA survey which covered a broader geographical base eg the Fitzroy region, as it reflects local values more accurately. Extrapolation of the telephone survey as being typical of Gladstone and the Curtis Coast presents problems. A recreational fishery in an industrial town area clearly will differ from a wider area which includes the Capricorn Coast (with a high proportion of tourists, retirees and upper class urban) the inland city of Rockhampton and the western hinterland of Central Queensland as well as the Curtis Coast.

The form survey was of value in its demonstration of the lack of confidence of respondees in management agencies. It, however, downgraded the importance of the Boyne and Calliope Rivers and overemphasised the importance of the Barrier Reef.

The telephone survey estimated a catch rate per trip of 4.9 fish compared to the creel survey of 0.49 fish per trip. This indicates that respondees overestimated the catch. They also overestimated their fishing effort. When the trailer data from a boat ramp is considered, 85% of the sample of 255 of the trailers and cars observed over a 9 month period were only observed once. This is an important finding as it suggests that the importance and value of recreational fishing, when compared to commercial fishing, is overestimated.

Examination of the excellent newspaper records in the Gladstone Observer over an 18 month period produced three useful accurate results. Species composition retained over a 12 month period, the larger fishes encountered and information regarding the fisher who caught the fish.

The most successful group of fishers was adult males (36.2%) followed by young boys (27.8%.) and teenage males (12.5%). This result was different to the groupings encountered during the creel surveys where the most common groupings were adult couples (23.6%), single males (20.3%), 2 adult males (16.5%), 1 parent and 1 child (8.2%), 2 parents and 1 child (5.5%), 2 teenagers (5.5%) and 2 parents and 2 children (5.5%). It is possible that the creel survey technique, samples boat fishers and unsuccessful fishers rather than recreational fishers from the shore. During the creel survey, larger fishes photographed regularly in the Observer were not/seldom encountered during the creel survey events. It is likely that the successful young boys after school, in the evenings and weekends are not being sampled adequately by creel and telephone surveys. The QFMA recreational survey for Queensland achieved similar findings but missed the importance of adult couples in boats.

In summary, all recreational survey methodologies and techniques produce slightly differing results in general and specific major differences (omissions, overestimates and underestimates). To avoid such problems Fisheries Management should ensure that when recreational surveys are undertaken, a comprehensive bag of techniques and information must be utilized.

Acknowledgements

The large amount of enthusiasm and work in the collection and analyses of recreational data sets utilised in this research paper by John Platten, Lee Hackney, Jill Campbell, Samantha Lewis and Liz White is thankfully acknowledged. The Gladstone Regional Marine Resources Advisory Committee conducted the form survey on behalf of the Great Barrier Reef Mark Park Authority. John Platten is further thanked for developing my research interest into recreational fisheries. Funding for various aspects of this work came from the Gladstone Area Water Board (EDCM study), from the QFMA (Curtis Coast Resources Report), the Gladstone Port Authority and Curtis Coast Consulting Pty Ltd.

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Questions

Ann Coleman: How did you know that it was not dads giving the kid the fish, to go and have his photo taken in the paper?

Michael Walker: Well, I don't think it would occur every single time. It can occur once, but it does not occur on a continuous basis. You do see a lot of boys out there fishing by themselves. Who knows, but when they go get their pictures taken in the photo all their friends know about it, and they do not just have it on one page, it's all over the paper. These are small communities, where the landing of these fish are something of a social status, so if it does occur it is not major and not a problem.

Papers in Abstract

This section reports the abstracts of papers, and their discussion, that were delivered orally at the conference, but that were not submitted as papers for this publication.

A Comparison of Stated Preference Methods for Valuing Multiple Species Recreational Fisheries

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Abstract

This paper estimates the economic value of single and multiple species recreational fishing trips to saltwater anglers who fish off the Kenai Peninsula, Alaska. In this fishery, Pacific halibut and several species of salmon are targeted by anglers. The stated preference method is a natural choice for such economic valuation problems since anglers' valuations will likely depend on many trip attributes including the different species targeted, and the number and size of fish caught. However, several different preference elicitation methods have been used in the literature including preference ratings, rankings, and choices. An important research question is whether these different elicitation methods yield the same observable preferences. If they do, then the choice of elicitation method is potentially a matter of efficiency, but not consistency. If they do not yield the same observable preferences, then choice of elicitation method does matter, with important implications for policy. We use a split, random sample approach to test this issue. The fishing trip attributes we consider are the cost of a fishing trip, number of each species caught and the size of each species. The survey focuses on Pacific halibut, king salmon, and silver salmon. This design allows for the estimation of the marginal value of each species caught, the marginal value of differences in species size, and the rate at which anglers are willing to substitute one species for another species. Combining the survey responses with a recently developed econometric model for comparing rankings with ratings, a test of consistency between the methods is formulated. Beyond the methodological contribution, the valuation estimates should be of interest to policy makers when setting catch limits and deciding allocation issues.

Questions and Discussion

Tony Pitcher: Referring to the last slide I noticed that the rating technique has a much smaller variance than the ranking technique.

Todd Lee: This may be due to our ability to resolve a tied issue, as less weight is placed on tied issues.

Tony Pitcher: Why do you score between 1-7 in some and 1-10 in others?

Todd Lee The 1-7 scoring system is accepted in the social sciences: it has a mid-point, whereas 1-10 does not.

Tony Pitcher: Does variance change when you use a 1-10 scale rather than a 1-7 scale?

Todd Lee: Yes, it probably would. Market research has probably looked at that.

Economic importance of the charter and party boat fishing industry to Texas, Louisiana, Mississippi and Alabama

Steve Sutton, Robert B. Ditton, John R. Stoll and J. Walter Milon
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Public and Environmental Affairs Department, University of Wisconsin-Green Bay
Food and Resource Economics Department, University of Florida

Abstract

The purpose of this study was to assess the importance of the charter and party boat fishing industry to the local and regional economies of Texas, Louisiana, Mississippi, and Alabama. Personal interviews were conducted with a representative sample of 100 charter boat operators and 20 party boat operators between June and September 1998. This sample constituted approximately 22% of the estimated population (430) of charter boat operators and 90% of the party boat operators (23) in the four state study area. Data were collected on each operator's business structure, capital investment, operating costs and expenditures, labor expenses, total revenue, and degree of reliance on income from the charter/party boat industry. Estimated economic output generated by the charter and party boat industry in the four states was $46.7 million. Estimated income and employment generated by the industry in the four

states was $17.6 million and 1089 jobs. These impacts constitute regional benefits to communities and areas engaged in support of the recreational fisheries and which are affected (positively and negatively) by public policies directed towards management of recreational fisheries for the benefit of recreational anglers. These results provide information that can be considered in regulatory impact analysis of current and future management initiatives.

Questions and Discussion

Bill Price: A point of information: use caution when you compare your data with the American Sportfishing Association's (ASA) data; it is a sports trade organisation and its data is derived from the US Fish and Wildlife Service surveys that take place every five years, and the Fish and Wildlife Service has admitted that their saltwater data is not as accurate as their inland and freshwater data. In addition, it is in the ASA's best interest to optimise expenditures, so their multipliers are pretty high.

Steve Sutton: Yes, the multipliers were higher than we expected. We realised that the data wasn't really accurate, but we had no other place to go to for the data.

Modelling the Choice Behaviour of Anglers in a Lake-specific Experiment of Regulations and Expectations: a Case Study of Walleye Anglers in Timmins

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Abstract

In human dimensions research, the experimental modelling of choice behaviour is slowly emerging as an alternative to the modelling of behavioural antecedents. Discrete choice experiments (DCE) are particularly useful for evaluating management or policy alternatives, since these methods permit the explicit modelling of trade-offs between both management alternatives and expected outcomes. A discrete choice experiment is a multivariate method that involves the creation of hypothetical alternatives based on the principle of fractional factorial designs. Respondents choose the most preferred alternative from a set. Analysis is typically based on the multinomial logit model. When the Ontario Ministry of Natural Resources considered regulatory changes to the walleye fishery in the Timmins District, the acceptability of the proposed changes was tested with a DCE. The regulations consisted of slot limits, possession limits, season length, and for ice fishing the number of lines. Each choice set consisted of a pair of profiles, and the fractional factorial design was set up in such a manner that different combinations of the eight largest lakes in the study area were offered between the two alternatives in each choice set. Given that local anglers use the surrounding fishing opportunities at many different occasions in course of a year, respondents were asked to allocate a total of 10 typical fishing outings among the two profiles in a choice set, and they were also required to repeat the allocation task for the summer and the winter season separately. The results showed that the water bodies were most influential on angler's choice than were the regulations or expectation attributes. Furthermore, the lakes identified as most important for angler's choice also correlated strongly with their respective quality of walleye. Anglers were also able to determine differences in walleye quality among water bodies by the season of fishing. The prominence of the water bodies is not surprising, and indicates the strong commitment anglers have to their respective favourite angling locations. However, the result also raises an important methodological issue: should trade-off and choice behaviour be modelled in generic types of experiments, or is the modelling of locational context equally important?.

Questions and Discussion

Gordon Gislason: You have two variables, bag limit and increased catch. What is the actual catch? My point is that deciding on or evaluating the 1 fish per day increase depends on whether the angler is presently catching one a day or five a day.

Wolfgang Haider: Yes! But it is not my preferred way of doing it. Here it's all relative to the number that the individual fisher is catching. I'd rather use actual numbers for specifying variables.

Are Anglers Liars? A Comparative Evaluation of Catch Motivation and Consumption reported in Creel Diaries

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Abstract

Motivations for angling are linked to the psychological benefits of fishing. However, there is great distrust among fisheries managers and biologists about an actual relationship between the importance of various motivations and the catch and release behaviour of anglers. For this reason, we conducted a study to determine the relationship between motivations and catch and release behaviour of anglers using various resource based tourism establishments in northern Ontario.

During 1995, anglers were intercepted and instructed to record their daily catches in a creel diary, which was collected after their trip. Besides providing surrogate biological information, anglers also provided information relating to socio-demographics and motivations. The importance of various motivations for fishing were solicited from a maximum difference conjoint (MDC) task, which requires individuals to select, from predetermined item lists, the two most different items along a particular measurement theme. For this MDC, respondents selected their most and least important reasons for undertaking their angling trip from seven separate lists each having five experimentally controlled items (motivational reasons). After segmenting anglers by their motivations, the degree of conformity of recorded angling behaviour among the segments was determined. This analysis showed that anglers who were less motivated to bring home fish actually released a greater proportion of caught fish. This result should provide greater credence of the link between motivations and actual angling behaviour. However, the strength of the relationship between motivations and angling behaviour was weak data.

Questions and Discussion

Nick Baccante: The sample you have has me confused, your results are only specific to that situation as the fishers travel so far.

Len Hunt: They have access to these environments which are exclusive, they are flown in, so they expect good fishing, and they have average catch rates of 50.

Nick Baccante: Is that important to your results?

Len Hunt: For tourists or non-residents, yes.

Ann Coleman: Would their motivations be different whether you asked them to fill it out before or after their trips?

Len Hunt: We asked them to fill out their surveys before they left; however, we could not control when they did it and many may have done so later.

Bill Romberg: Can you comment on the context with respect to how many fish were actually caught?

Len Hunt: We looked at the rate of retention. If they had caught more, they might have kept more.

Getting from Competition to Cooperation: a Choice based Decision Support System as a Consensus Tool

George Morgan
Co-op Freshwater Ecology Unit, Laurentian Univ., Canada

Abstract

The French River is a 110km long waterway park flowing westward from Lake Nipissing into Georgian Bay, Lake Huron. Creel surveys indicate that angling pressure exceeds the sustainable limit by two-and-a-half to five times. As a result, people are spending more time trying to catch a fish and they are catching fewer smaller sized fish. Traditionally, anglers are unaware of their impacts and usually blame other activities or resource users for problems in the fishery. This attitude further complicates the fishery problems and leads to increased friction between stakeholder groups, resource users, and resource managers. To evaluate possible management strategies, a survey was mailed to individuals of the two largest angling groups, i.e., cottagers and lodge guests. A major part of the survey contained a discrete choice experiment, which is well suited to evaluate the angler preferences for a large number of currently non-existing management alternatives. Attributes included in the model were: distance to the fishing spot, scenery, shoreline development, crowding, fish species, catch rates, size of fish caught, size limits, and catch limits. Results indicate that neither angling group was satisfied with the current status of the fishery and would rather change the fishing regulations than go elsewhere to fish. In fact, any regulation that would result in the opportunity to catch a "large" fish was acceptable. These results were presented in an interactive decision support system (DSS), which was used extensively during the consultative process with the stakeholders. The user-friendly DSS allows stakeholders and resource managers to explore many possible management options, including the scenario that maximizes market share, or alter-

nately, determine the market share of the ecologically most preferred alternative.

Questions and Discussion

John Willow: How was angler activity affected by the restrictions?

George Morgan: Creel surveys cost a lot, and we haven't done any follow up surveys, so we're looking to the businesses. The lodge owners reported a shift in clientele, from anglers who came to target 6 fish a day to those seeking trophy fish. However, finger pointing still goes on. The local anglers will be the next group to point fingers as they want the size limit restrictions removed.

Carl Walters: How would you apply this to coho in B.C. and get them to maintain a positive attitude?

George Morgan: The public tends to understand the implications of their actions, so once the denial phase is over, they tend to be conservative. It may work in a larger context. We're not seeing people shift away from fisheries in this model, even if they shift species. A neat experiment would be a combination of both.

Use of Lorenz Curves and Gini Coefficients in Angling Fisheries

Dominic Baccante
BC Environment, Canada

Abstract

Inequality is a concept that is not restricted to natural resource utilization. It is believed that 10 percent of the people have 90 percent of the wealth, and 20 percent of the people are responsible for 80 percent of crime. Similar patterns are found in recreational angling fisheries. The distribution of the catch among anglers is typically skewed, due to few anglers catching the largest proportion of fish. Lorenz curves and Gini coefficients are techniques that have been used to quantify inequality in economic wealth, commercial and recreational fisheries. Lorenz curves are a graphical representation of distribution of the catch among anglers. The shape of the curve gives an indication of the degree of skew, or inequality of the catch, among anglers. The Gini coefficient measures the magnitude of the inequality, by comparing how far the observed Lorenz curve departs from perfect equality. There are strong, inverse correlations between Gini coefficients, CPUE and HPUE for a number of angling fisheries. This indicates that, when angling quality is higher, the catch is more evenly distributed among anglers. Factors affecting catch equality and management applications of these techniques, will be discussed.

Questions and Discussion

Ian Cowx: On a study on the River Trent that Jim Lyons did a while back with regards to the river and politics, the anglers were asked on their angling experience, and it was found that the answers fit the Gini curve very well.

Nick Baccante: Yes, I did notice Jim's paper. There's not much in the literature with regards to this topic, though.

Using Social and Biological Reference Points in Managing Sport Fisheries

Mike Sullivan
Alberta Environmental Protection, Canada

Abstract

Fisheries managers in Alberta, Canada are faced with the dilemma of low productivity, boreal fisheries and a large and increasing human population. Commercial fisheries for the most desirable species collapsed in the 1940s, and many of the remaining sport fisheries for native fish species have recently collapsed. Existing management strategies (requiring extensive biological data) were ineffective in preventing these collapses because of there being very few biologists responsible for managing the fisheries in a large geographical area. As a result, meaningful regulations were seldom instituted or were implemented too late for providing effective protection. In response to these problems, a new system of fisheries management is being developed. Instead of attempting to separately manage hundreds of individual fisheries, all fisheries are classified into three broad categories: collapsed, vulnerable, or stable. Each fishery is classified based on a few, easily obtainable field parameters. These reference points include social measures, such as Gini coefficients, as well as more traditional biological indices, such as growth rates. We have conducted extensive public workshops, and specific regulations for each broad category have been developed in close cooperation with anglers. Biologists are now able to quickly determine the status of a fishery and implement major changes to regulations within a fishing season.

Questions and Discussion

Carl Walters: How did you provide feedback to the anglers to let them know that catch and release is not necessarily sustainable management?

Mike Sullivan: We used models. At high angling pressures, the model fails, so they know the direction the fisheries would go, given the direction the present trend is going.

Marty Golden: Once the group voted on regulations, were they fixed in concrete?

Mike Sullivan: Yes, they were told right at the beginning that whatever came out of the meeting, it would be fixed in concrete, so they knew that they would have an impact on regulation making. Also, by talking about categories of lakes rather than specific lakes themselves, they were allowed to pull back from the emotional reactions associated with a particular lake. Instead of talking about "Moose Lake", they talked about a "vulnerable lake". The politicians loved it: we went up to them and said, "this is what the public wants, and here's the scientific data to prove it." How could they not listen?

Gordon Gislason: Did the fact that there is not much of a commercial fishery in Alberta help the method work so well?

Mike Sullivan: There is a commercial fishery, and we did pull them into the meeting. Because we were talking about types of lakes rather than specific lakes, there wasn't any of the rivalry between the sectors over the lakes they traditionally clashed on. We found that the commercial fishers really pushed the recreational fishers to help with the conservation effort.

Ussif Rashid Sumaila: How long has it been implemented and is it working?

Mike Sullivan: What a good lead-in to my next talk!

How and Why Fishers Lie and Cheat

Mike Sullivan
Alberta Environmental Protection, Canada

Abstract

In response to the decline and collapse of sport fisheries for walleye and pike in Alberta, restrictive angling regulations (mainly size limits) have been implemented. Simulation modelling shows that compliance with these regulations is critical for their effectiveness. Field studies were conducted at 20 walleye fisheries in Alberta to determine the level of compliance. On average, 19% of the protected-sized walleye that were caught by anglers were not released, but rather, were illegally harvested. There was a strong negative exponential correlation between catch rates and illegal harvest. Analysis of the sizes of illegal walleye that were harvested indicated that anglers were aware of the size limit, but chose to ignore it. Enforcement officers would seldom encounter anglers with illegal fish (because of the low catch rates), resulting in an apparent paradox of high illegal harvests with a small percentage of anglers breaking the law. These high rates of illegal harvest will negate any benefits of the regulations at lakes where they are most needed (low-density populations). These studies also determined the degree of exaggeration of reported catches of protected-sized walleye. It is commonly assumed that anglers will exaggerate their catch rates consistently, regardless of population densities. In our studies, exaggeration was not constant, but strongly increased with declining catch rates. This has profound implications for managers who monitor populations using reported harvest rates.

Questions and Discussion

Sean Cox: What does this mean for regional management where they don't have access to catch data?

Mike Sullivan: It doesn't really matter. As soon as the catch rate falls, you shut the lake down. It's a more reactive method, a much faster method. There are no grey areas.

Sean Cox: Do you do creel surveys on over-fished lakes?

Mike Sullivan: If a lake has collapsed, we just close it down and walk away from it; our effort is focussed on vulnerable lakes.

Kerry Brewin: Do you think the trend you found with the cheating is related to the new regulations? That is, did it show up after they were implemented?

Mike Sullivan: The new regulations were implemented in 1996, and slots were introduced in 1990. The trend was there in the old data, and it goes back at least 9 years. It's a cool system, because all you need are creel surveys and tournament data.

Bill Romberg: Have you taken the evidence that fishers lie and cheat back to the public and confronted them with it?

Mike Sullivan: We've done presentations to angling groups and put the results in magazines. That's sparked a lot of discussion, but people don't comply. Some of the people who lie and cheat are biologists. It's a basic human response.

Sean Cox: The basic form of CPUE is the negative binomial where the variance (or spread) is directly pro-

portional to the mean (CPUE). So why use a Gini Coefficient at all since the mean CPUE is all you need?

Nick Baccante: Yes, when looking at CUPE by itself as a number, but if you look at the distribution, it may point us out to something.

Sean Cox: It's just that anglers might be able to understand it better.

The role of economics in evaluating the benefits of recreational fishing

Tor Hundloe
University of Queensland, Australia

Abstract

There is a long history of the misuse of monetary measures in attempting to value recreational fishing. This paper outlines the correct approach for the use of economics for this purpose and illustrates its application in a major fishery resource sharing conflict in Australia.

Questions and Discussion

Rob Hicks: You mentioned multi-objective decision-making setting and I would like to know what weight you placed on the economic factors in your evaluations?

Tor Hundloe - We worked with a multi-criteria decision-analysis framework and we "played" with it, assigning different weights; however, it is subjective. We "walked" the participants through it using the Delphi technique and showed them how sensitive it was to any changes.

Aboriginal Issues and Interests and Recreational Fishing in B.C.

Fred Fortier,
BC Aboriginal Fisheries Commission

(no abstract received)

Questions and Discussion

Margaret Merritt: Jobs are scarce in rural Alaska, and some Alaskans become fishing guides for tourists. Guided anglers are not necessarily after the fish, but the experience. Maybe that's a benefit of the recreational fishing sector: the jobs that they create.

Fred Fortier: That's a good point. Ecotourism is something that can be done. It deals with the experience of going to a river, especially when there's no fish to catch. It also helps towards understanding the First Nations' point of view.

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