Travel distance as an index of angling value: a preliminary study based on the 2001/02 National Angling Survey

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Prepared for

Fish & Game New Zealand

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Summary

The New Zealand Government's forthcoming Sustainable Development Plan of Action will include a review of water and energy management, and will attempt to characterise waters of national importance taking into account their value for all uses, including recreation. The present report has been prepared to help meet the information needs of this review with respect to the freshwater angling resource managed by Fish & Game New Zealand.

We use data from the 2000-2001 National Angling Survey to develop a conceptual model of New Zealand river fisheries in which their importance is related to their total annual usage, and to the distance anglers are prepared to travel to reach them. The basis of this model is that if two fisheries have similar levels of usage, then – other things being equal – the more remote fishery is likely to have a higher intrinsic value.

We give a brief overview of the 2001/02 survey and its component data sets. These contain data on all recognised river and lake fisheries, including map references to a nominal angling centroid; FGNZ licence sales for the 2001/02 fishing season; a database of New Zealand place names; and the main survey database, containing responses to 25 000 telephone interviews in which randomly selected licence holders were asked to identify all waters they had fished.

We used these datasets to compile a workfile of 12 503 records linking where anglers lived (based on their home address) to where they fished, allowing their straight line travel distance to be estimated. Because these distances were highly skewed, with a mean (83 km) nearly double the median (43 km), all calculations were based on log transformed data.

For many river fisheries the relationship between total usage and mean travel distance was consistent with our conceptual model. Several rivers which our analysis identified as likely to be of high value have previously been identified as such by FGNZ. These included the Mataura, Rakaia, Rangitata, Mohaka, Motueka, Buller, Ahuriri, and Maruia. Two other rivers which appear to be highly valued, the Tekapo and Waiau (Southland), have increased in value over the last two decades.

The datasets developed in this survey have considerable potential for more detailed analysis, particularly at a regional scale. We illustrate this with a case study for the Central South Island Fish & Game Region, which suggests a well-defined spectrum from locally important rivers fished almost exclusively by anglers living within 20 km to nationally important rivers which attract anglers from throughout New Zealand.

Notwithstanding these results, a comparison between our findings and importance rankings based on an earlier survey demonstrates that for many fisheries, factors other than travel distance influence the extent to which anglers value their recreational amenity. We believe the present analysis should be used to inform the process of identifying river fisheries of national priority, but not to dictate it.

1. Introduction

Fish and Game New Zealand (FGNZ) is responsible, through its Regional Councils, for administering the sports fish and game bird resource in the recreational interest of anglers and hunters[1]. Part of FGNZ's function is to monitor the sports fish and game bird resource, and the success and satisfaction of anglers and hunters. As part of this process, FGNZ has undertaken two National Angling Surveys, during the 1994-1995 and 2000-2001 angling seasons, to estimate angling usage by New Zealand resident anglers (Unwin & Brown 1998, Unwin et al. 2003).

The New Zealand Government has signalled that, as part of its Sustainable Development Plan of Action, it wishes to review the framework for water and energy management in New Zealand (Anon 2003). Part of this "whole of government" approach includes characterising waters of national importance, taking into account their value for recreation. FGNZ databases, such as those associated with the National Angling Surveys, hold a wealth of information which can be analysed objectively, and used to inform the debate about freshwater management in New Zealand. While simple statistics such as the number of anglers using a water body can be used to differentiate between some waters of higher rather than lower value, usage alone does not recognise all rivers which are considered significant. Anglers often value some of New Zealand's less heavily fished rivers and lakes very highly because of attributes such as peace and solitude, scenic beauty, the ease of catching fish, or the likelihood of catching a trophy fish (Teirney & Richardson 1992). Sometimes the absence of other anglers is a major drawcard.

This report details a preliminary analysis of the 2000-2001 National Angling Survey database, focussing on measures of the distance anglers travel to fish individual waters as a surrogate for their value as perceived by those anglers. In particular, we examine the relation between travel distance and total angler usage, with the aim of characterising river fisheries of national significance in terms of a spectrum ranging from rivers which are easily reached and hence sustain high levels of usage to more remote rivers which are only lightly fished but may be highly valued. This report summarises this analysis, and is intended to assist with the government's policy development. We emphasise that, although this report deals only with river fisheries, in keeping with the information needs of the Sustainable Development Plan of Action, the analyses undertaken here could equally well be applied to lake fisheries.

The objectives of this study were to analyse data on angler usage of New Zealand rivers, collected via the 2001/02 National Angler Survey (NAS), so as to identify river

[1] Section 26Q of the Conservation Act 1987.

fisheries of local, regional, and national significance based on the geographical spread of angler's home addresses. Specifically, this report:

- describes the data sets and methods used, noting any limitations and assumptions made;

- suggests possible criteria for differentiating between rivers of local, regional, and national importance; and

- presents and discusses the key findings.

2. Methods

2.1. Conceptual approach

Our approach to this study was based on the premise that, in general, there is an inverse relationship between the total angling effort expended on a particular fishery, and the distance anglers have to travel to reach it. That is, rivers which attract high levels of usage tend to be close to where anglers live, and hence to major population centres, whereas those which are more remote tend to be less used. When assessing the "importance" of any given river fishery, therefore, we should take into account not only its level of usage, but also its distance from centres of population.

This approach has previously been used in New Zealand to characterise river fisheries as being locally, regionally, or nationally important (Teirney et al. 1982). Conceptually, we can think of each fishery as occupying a point in a two-dimensional space, where one axis represents effort and the other represents proximity to angler's homes (Fig. 1). Given two fisheries with similar levels of usage – other things being equal – we would tend to regard the more remote fishery as having a higher value. Thus, a river which is relatively lightly fished, but which attracts anglers from throughout New Zealand, may be just as important as one which sustains a much higher level of usage but is fished mainly by anglers living locally. In Fig. 1, importance can thus be represented by a series of contours running diagonally from upper left to lower right, so that importance increases towards the upper right.

Given that the NAS provides consistent and up to date estimates of annual usage for all river fisheries of interest to FGNZ[2], it is straightforward to locate any given fishery with respect to the horizontal axis in Fig. 1. Somewhat fortuitously, the NAS database

[2] At the time of writing, concurrent usage estimates for rivers in the Taupo Conservancy, administered by the Department of Conservation, were not available.

also provides a means for locating each river on the vertical axis, in that it can be used to derive various indices of the mean distance anglers travel in order to fish there. Developing and interpreting these indices, and hence assessing the validity of our underlying model and its utility for comparing different fisheries, was the main purpose of this study.

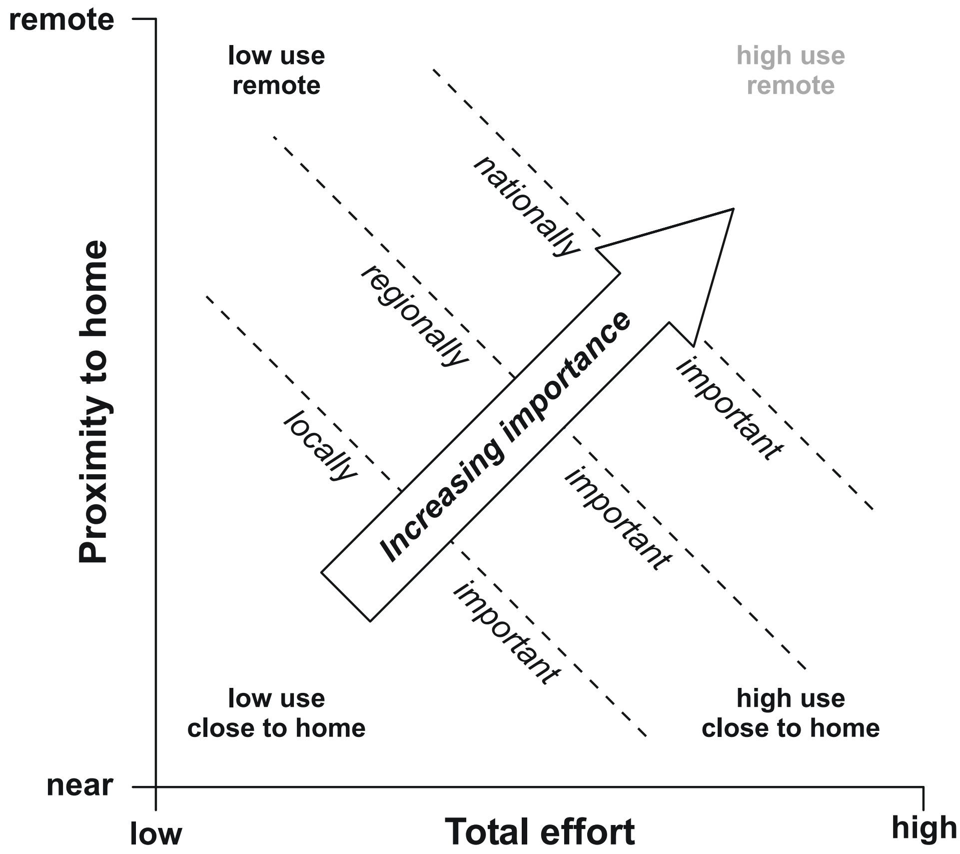

Figure 1: Conceptual model of the approach used in this study, where (for any given fishery) the horizontal axis represents angling effort, and the vertical axis represents the average distance anglers travel to reach the fishery. The basic assumption is that an increase in one of these parameters tends to be associated with a decrease in the other, so that fisheries of similar value will tend to lie along a common diagonal.

2.2. The 2001/02 NAS: an overview

In mid 2001, FGNZ engaged NIWA to help design, implement, and analyse a nationwide telephone sample survey to estimate annual angling usage, for all waters managed by FGNZ, during the 2001/2002 angling season (October 2001 to September 2002). This survey, the second in what is intended to become a series repeated at intervals of 5-7 years, was based on the first such survey in 1994/95 (Unwin & Brown

1998), and used essentially the same design. A final report on the 2001/02 results (Unwin et al. 2003) is being written in parallel with this one.

Like its predecessor, the 2001/02 Survey was a sample survey based on records of fishing licence sales. The standard methodology was to select a random sample of licence holders, representing a known percentage (e.g., 5%) of total sales, and use a telephone interview to collect the information of interest. Subject to the assumption that this information is not significantly influenced either by licence holders who cannot be contacted (non-response bias), or who cannot accurately remember details such as when and where they fished (recall bias), results for the anglers in the sample can then be extrapolated to give a result applicable to the full population of licence holders.

In both surveys, the 12 month angling season was divided into six two-monthly segments, with respondents being contacted at the end of each period. This interval was chosen based on previous FGNZ studies, which indicated that recall bias became significant only after a recall period of three months or more (e.g., Barker 1991). Respondents were asked whether or not they had fished over the previous two months, and – if so – which rivers and lakes they had fished, and the number of days they had spent on each. Both surveys were conducted simultaneously in all twelve FGNZ Regions, and the data for each Region pooled into a single national database.

The measure of angling effort provided by the surveys is the angler-day, defined as one angler fishing on one day irrespective of the number of hours spent fishing. By summing results across all Regions, over the full 12 month angling season, the survey provides usage estimates for essentially all New Zealand angling waters. Standard errors for most waters are relatively broad (typically ±20% - 50%), but are to be interpreted in the context of usage estimates which vary by a factor of more than ten thousand between the most heavily fished waters (e.g., over 50 000 days for the Mataura River) to single figures for the most remote headwater streams.

2.3. Rivers database

An essential component of the NAS database is a lookup table listing all lakes and rivers fished by licence holders responding to the survey. This table assigns each river[3] a unique five digit ID number, and an NZMS260 map reference representing either the river mouth (for those flowing directly to the sea), or its confluence with a larger river (for inland tributaries). We also assigned a secondary NZMS260 map reference to

[3] In the subsequent discussion we refer only to rivers, as this study was not concerned with lake fisheries. However, all of the database procedures described apply equally well to lake fisheries.

represent the angling centroid, i.e., the point most closely representing the centre of angling activity, based on advice received from FGNZ Regional managers. For most rivers this was assumed to be the same as for the river mouth or point of confluence, but for a few (e.g. the Clarence River) it was located further upstream, usually at some well-recognised local access point.

Twenty five rivers, mostly longer mainstem rivers where the fishery varied significantly in character between reaches, were subdivided into two or more sections. Angling centroids for each section were located in the same manner as for single-reach rivers, either at the section's downstream end, or (on the advice of FGNZ) at some other point further upstream.

2.4. Licence database

All persons wishing to fish for sports fish must purchase a freshwater fishing licence at least annually. Licences purchased from FGNZ are freely interchangeable between FGNZ Regions, and are priced without regard to angler origin: overseas anglers pay the same as New Zealand residents, and residents of each Region pay the same as non-residents. It is possible, therefore, for anglers to live in one Region, purchase a licence from a second Region, and fish in a third.

The NAS database included a table containing fishing licence records for the 2001/02 fishing season, for all twelve FGNZ Regions and (for adult whole-season licences only) for the Taupo Conservancy. For each licence, this table contained the issuing Region; the licence type (i.e. adult, junior, whole-season, part season etc.); the date of issue; and the home address of the licence holder. To preserve respondent's anonymity their address was identified only as to city, town, or locality, and did not include details (such as a street address) which would allow individuals to be identified. Overseas anglers were identified by country of origin only. The only significant gap in the licence database was for the Otago Region, where addresses for the first two-monthly survey period, and for part-season licence holders in all periods, were unavailable.

From the pooled licence records for New Zealand residents who purchased a licence in 2001/02, we compiled a list of all addresses which could be matched with the New Zealand Geographic Place Names Database, maintained by Land Information New Zealand (LINZ)[4]. Of over 89 000 New Zealand resident addresses contained in the NAS database, all but 37 corresponded to an existing Metropolis, Urban Satellite, Town, Locality, or Populated Place as defined in the LINZ database, and could thus be

[4] http://www.linz.govt.nz/rcs/linz/pub/web/root/core/Placenames/searchplacenames/index.jsp

assigned an NZMS260 map reference. Addresses corresponding to urban satellites of Auckland, Christchurch, and Dunedin (e.g., Howick, Halswell, Green Island) were inconsistently recorded, and were therefore pooled under the corresponding metropolis. However, licence records for the Wellington Region included postal codes, so we took advantage of these to subdivide greater Wellington into Wellington City (postal codes 6001 – 6005); Porirua (code 6006); upper Hutt (code 6007); and Lower Hutt (codes 6008, 6009).

The final licence database included just over 750 distinct New Zealand locations. To facilitate analysis of Regional trends, all locations were matched against the corresponding FGNZ Region. We also introduced a second level of groupings at sub-Regional scale, generally corresponding to recognised Territorial Authorities, so as to allow for further analysis of geographical trends within each Region.

2.5. Distance measures

Using the NAS database tables of river names and locations, licence sales and place names, and the rivers fished by each survey respondent, standard query techniques were used to generate a table containing one record for every river fished by each respondent. We then used the NZMS260 map references for the river, and for the respondent's home address, to calculate the straight line distance between the angler's home and each river they had fished, which we interpreted as a simple measure of travel distance. In practice, this measure is clearly no more than a rough approximation, since neither the point where the angler fished, nor their actual home address, necessarily coincide with the map references used. In addition, their travel path will only rarely be a straight line, so that the calculated distance will tend to be conservative. For the purposes of this study, we assumed that most such inaccuracies were small compared to the maximum travel distance recorded (1300 km), and did not compromise our basic aim of characterising variation in travel distance between individual rivers.

Exploratory analysis of the complete travel distance data set suggested that the data were highly skewed (Fig. 2a), with the mean distance (83 km) nearly double the median (43 km). By contrast, log transformed distances were approximately normally distributed (Fig. 2b), with a back-transformed mean (39.0 km) only slightly less than the median (43.0 km). We therefore used log transformed data for all calculations of mean travel distance.

A further adjustment to estimates of mean travel distance was required to compensate for variations in the percentage of licence holders sampled between Regions, licence type, and two monthly survey period. For example, Regions with relatively few licence sales (e.g. West Coast, Taranaki) were sampled more intensively than larger regions (e.g., North Canterbury, Eastern), and adult whole season licences were sampled more intensively than junior or part-season licences. The procedure adopted was to weight each response in inverse proportion to the corresponding sampling fraction, so that responses from Regions with a low sampling fraction were given more weight than those with a high sampling fraction. For most rivers this adjustment had little effect on the estimated mean travel distance, although there was a tendency for the weighted estimates to be slightly less than the unweighted estimates. All results presented in this report are for weighted distances unless otherwise stated.

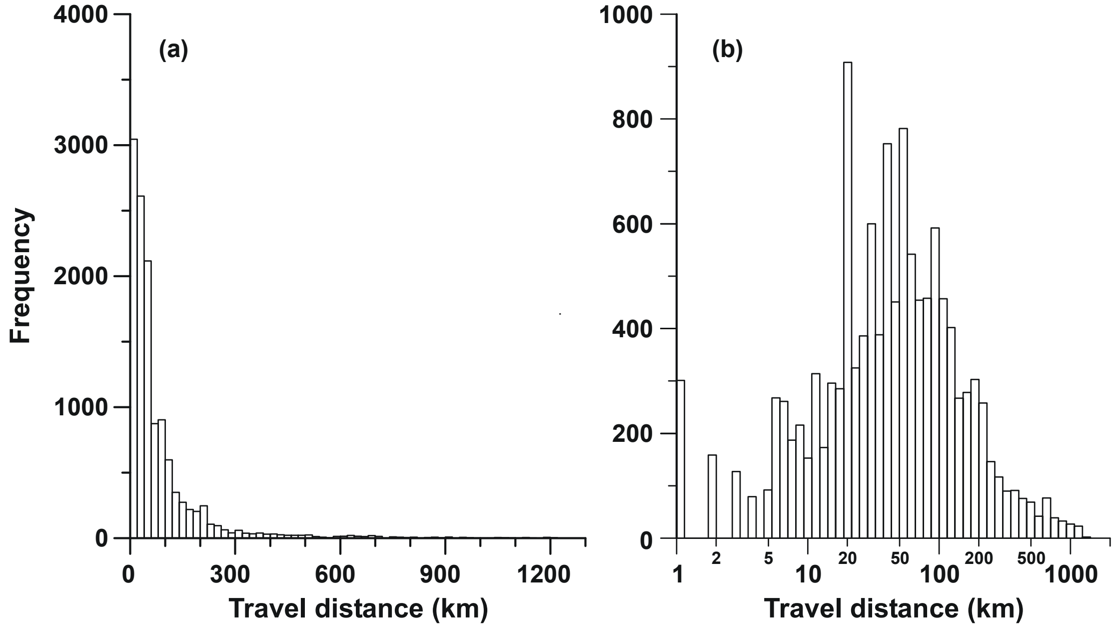

Figure 2: Distribution of raw travel distances for all rivers fished by respondents to the 2001/02 NAS, plotted on a linear scale (a), and a logarithmic scale (b).

2.6. Other datasets

To provide an additional dimension to our analysis, we re-examined data collected during the 1979/80 National Angling Survey (Teirney et al. 1982, Teirney & Richardson 1992). The unique feature of this survey was that, as well as identifying which rivers they had fished, anglers were asked to provide a rating (on a 1-5 scale) for the overall importance of each river as an angling amenity, and for seven attributes which a pilot survey had identified as potentially characterising different types of fishery. These attributes were: distance from home, area of fishable water, ease of access, scenic beauty, peace and solitude, catch rate, and size of fish.

After merging the 1979/80 data with the 2001/02 data, we compiled a workfile of 175 rivers for which at least ten responses were obtained in each survey, from which we calculated total annual usage and weighted mean travel distance (from the 2001/02 data), and means for overall importance and the seven attributes (from the 1979/80 data). We expressed the 1979/80 means on the same 1-5 scale used by the survey respondents, so that each attribute was assigned a rating from 1 (low) to 5 (high). We then inspected scatter plots of the relationships between travel distance, annual usage, and mean rankings for each attribute, to better understand how these attributes (as assessed in about 1980) were related to travel distance.

3. Results

3.1. Data set

The final NAS database included records for 24 944 respondents, of whom 12 976 had fished at least one lake or river. Collectively, these respondents provided 13 244 records of river fishing, on 616 distinct rivers. Of these, 12 503 records (94.4%) included sufficient data to allow travel distance to be estimated. We used these records to compile a working file of 87 rivers for which estimated annual usage exceeded 1000 angler-days, and at least ten responses provided usable data on travel distance. Sample sizes ranged from 11 to 556 and averaged 105, with annual usage ranging from 1.0 to 52.9 thousand angler-days, and mean travel distance from 3 to 147 km (Table 1).

3.2. Travel distance

Inspection of the raw data for individual rivers confirmed that, in general, travel distances were highly skewed towards local anglers (Fig. 3). For most rivers the distribution of travel distance was unimodal, and for several of these (e.g., the Ashburton, Hutt, Opihi, Tutaekuri) the mode lay within the 0-20 km range. Bimodal or polymodal distributions occurred in a few cases, such as the Clutha (where there were distinct modes representing local anglers fishing the upper Clutha (20-40 km), Dunedin anglers fishing the lower Clutha (60-80 km), and Dunedin anglers fishing the upper Clutha (140-160 km)); the Rangitata (where two modes, at 20-40 km and 100-120 km, represented anglers from Timaru/Ashburton, and Christchurch, respectively); and the Rangitaiki (where a secondary mode at 220-240 km represented anglers from greater Auckland). More generally, however, the most representative pattern (e.g., the Hurunui, Mohaka, Rangitikei, and Tukituki) was a broad mode in the 0-100 km range, with a few larger values making up a long but well-defined tail.

Table 1: The full data set of 87 river fisheries used in this study, showing: the number of respondents who provided usable data on travel distance (N); the estimated annual effort (thousands of angler days, ± one standard error); and three measures of mean travel distance based on unweighted raw data, unweighted log-transformed data, and weighted log-transformed data.

				Mean travel distance (km)		
FGNZ Region	River	N	Days ± 1 SE	raw, unweighted	log transform, unweighted	log transform, weighted
Auck/Waikato	Waikato R	123	7.1 ± 1.4	83	59	43
	Mangatutu Stm	45	1.1 ± 0.2	63	44	39
	Ohinemuri R	71	2.6 ± 0.5	68	46	43
	Waihou R	93	3.0 ± 0.5	71	48	44
	Waipa R	38	1.6 ± 0.4	85	58	42
	Whanganui R	44	1.9 ± 0.4	128	64	83
	Whakapapa R	30	1.0 ± 0.3	115	71	82
Eastern	Kaituna R	28	1.6 ± 0.8	63	38	36
	Motu R	25	1.4 ± 0.4	70	47	44
	Ngamuwahine R	11	1.0 ± 0.4	47	28	27
	Ngongotaha Stm	123	17.8 ± 2.9	43	16	13
	Ohau Channel	24	2.2 ± 1.0	93	50	43
	Ruakituri R	41	1.4 ± 0.3	129	102	91
	Tarawera R	52	4.2 ± 0.9	71	38	32
	Utuhina Stm	32	4.3 ± 1.3	14	3	3
	Waioeka R	22	1.5 ± 0.5	112	100	106
	Waiteti Stm	28	3.1 ± 1.1	36	15	15
	Whakatane R	21	1.4 ± 0.5	50	8	6
	Rangitaiki R	98	13.3 ± 3.5	110	69	47
	Hamurana Stm	18	1.5 ± 0.8	67	31	26
	Awahou Stm	15	1.4 ± 0.6	76	32	32
Taranaki	Waingongoro R	73	1.0 ± 0.2	24	16	16
Hawkes Bay	Mohaka R	259	7.0 ± 0.7	94	66	68
	Ngaruroro R	180	6.2 ± 0.7	46	18	18
	Tukipo R	21	1.1 ± 0.3	55	49	49
	Tukituki R	401	17.2 ± 1.5	47	25	25
	Tutaekuri R	158	6.7 ± 0.8	30	12	12
	Waipawa R	53	2.1 ± 0.4	53	35	36
Wellington	Hutt R	133	6.3 ± 0.8	48	12	12
	Manawatu R	274	13.8 ± 1.3	32	13	12
	Mangatainoka R	43	1.7 ± 0.3	39	24	22
	Rangitikei R	212	5.9 ± 0.7	68	50	47
	Ruamahanga R	162	6.8 ± 0.8	49	39	38
Nelson/Marlb	Buller R	204	4.3 ± 0.5	120	54	69
	Maruia R	58	1.8 ± 0.9	138	112	113
	Motueka R	248	6.3 ± 0.7	97	58	67
	Pelorus R	85	1.6 ± 0.3	73	39	44
	Takaka R	45	1.1 ± 0.2	119	36	64
	Wairau R	325	8.3 ± 0.9	103	86	90
West Coast	Arnold R	76	1.4 ± 0.2	62	30	41
	Grey R	207	6.0 ± 0.7	51	7	13
	Hokitika R	41	1.1 ± 0.3	39	16	17

FGNZ Region	River	N	Days ± 1 SE	Mean travel distance (km) raw, unweighted	log transform, unweighted	log transform, weighted
	Inangahua R	48	1.1 ± 0.2	104	41	57
	Taramakau R	49	1.7 ± 0.3	52	38	43
N Canterbury	Ashley R	75	3.5 ± 0.7	33	27	26
	Hurunui R	185	8.2 ± 1.0	110	89	85
	Kaiapoi R	33	1.8 ± 0.5	30	12	11
	Rakaia R	333	21.5 ± 2.0	70	51	50
	Selwyn R	48	2.1 ± 0.5	27	25	28
	Waiau R	42	2.1 ± 0.4	125	110	101
	Waimakariri R	556	48.9 ± 4.3	36	22	21
Central South I	Ahuriri R	55	2.9 ± 0.6	194	122	119
	Ashburton R	76	5.5 ± 1.1	35	22	22
	Hakataramea R	28	1.6 ± 0.4	107	80	80
	Ohau Canal	72	5.4 ± 2.1	204	131	133
	Opihi R	175	13.4 ± 1.7	38	18	18
	Opuha R	25	1.3 ± 0.4	141	91	87
	Orari R	40	2.3 ± 0.6	51	27	27
	Rangitata R	174	12.7 ± 1.9	87	55	58
	Tekapo R	106	4.9 ± 0.7	173	138	147
	Tekapo Canal	162	7.7 ± 0.9	145	118	115
	Twizel R	31	1.3 ± 0.3	166	120	131
	Waitaki R	374	26.6 ± 2.6	100	54	53
Otago	Hawea R	47	5.0 ± 1.3	168	70	57
	Hunter R	21	1.6 ± 0.6	178	125	117
	Kawarau R	18	1.7 ± 0.8	169	35	22
	Clutha R	234	36.7 ± 4.1	144	77	65
	Makarora R	26	1.5 ± 0.4	212	124	100
	Manuherikia R	28	5.6 ± 2.1	101	63	56
	Pomahaka R	58	6.0 ± 1.4	91	39	35
	Shotover R	11	1.1 ± 0.5	164	104	65
	Taieri R	166	19.1 ± 2.6	72	37	33
	Tokomairiro R	20	4.1 ± 1.7	41	4	6
	Waipahi R	17	1.8 ± 0.5	46	34	37
Southland	Aparima R	124	6.7 ± 1.0	27	24	25
	Eglinton R	27	1.0 ± 0.4	263	162	134
	Hamilton Burn	14	1.0 ± 0.4	48	42	37
	Makarewa R	30	1.9 ± 0.6	9	8	8
	Mararoa R	62	3.0 ± 0.6	119	84	78
	Mataura R	552	52.9 ± 3.9	76	34	34
	Mimihau Stm	27	1.5 ± 0.5	62	23	20
	Mokoreta R	24	1.2 ± 0.3	30	20	19
	Oreti R	296	20.6 ± 2.1	57	15	14
	Upukerora R	23	1.2 ± 0.4	138	60	50
	Waiau R	263	14.6 ± 1.5	118	65	62
	Waikaia R	86	6.9 ± 1.2	85	50	40
	Waikaka Stm	17	1.8 ± 0.7	14	3	3

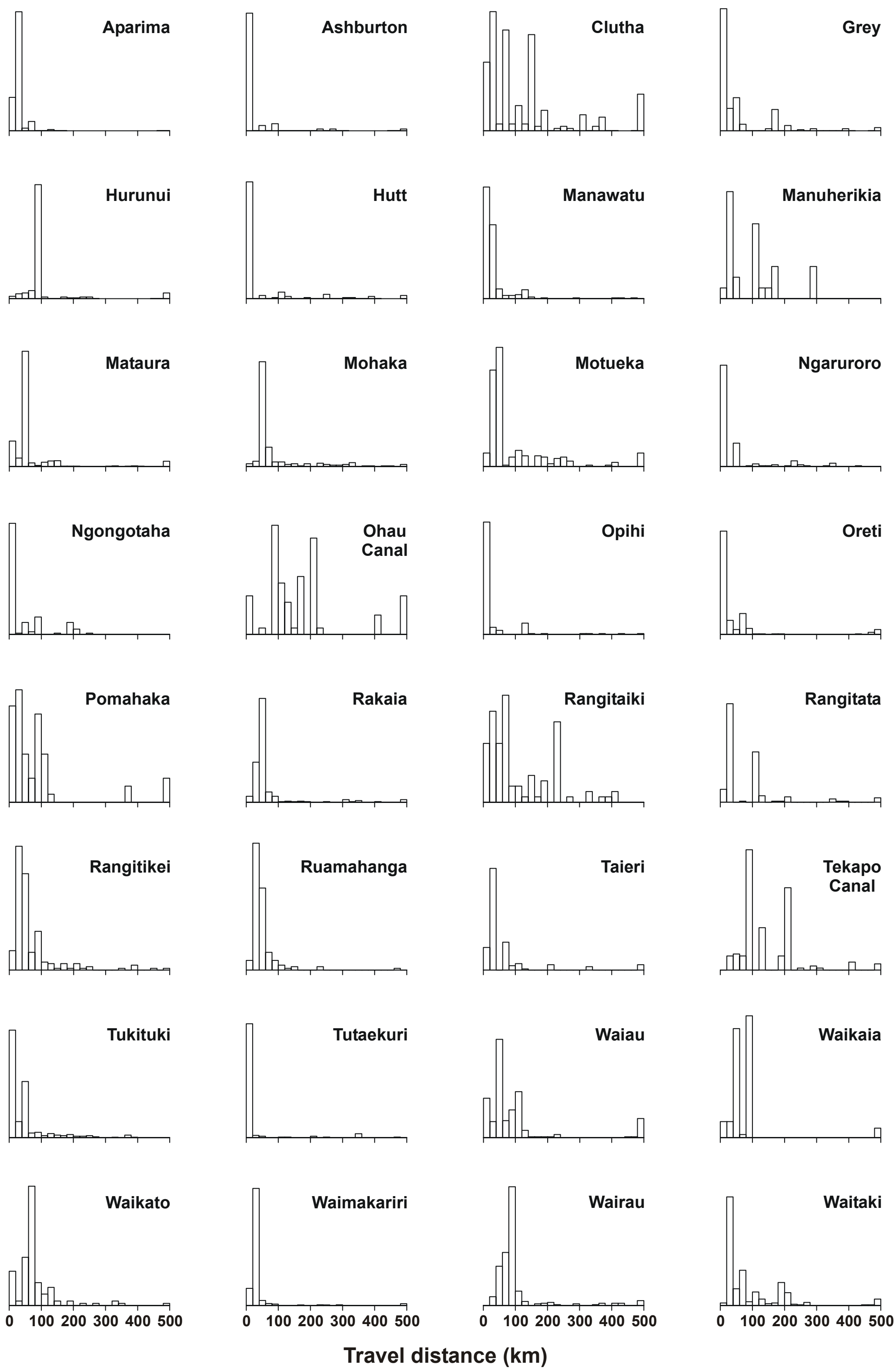

Figure 3: **Distribution of raw travel distances for 32 selected rivers fished by respondents to the 2001/02 NAS. All figures are plotted on the same horizontal scale, with distances over 500 km pooled into a single bin.**

3.3. Travel distance vs. usage

Examination of the relationship between total usage and mean travel distance (Fig. 4) confirmed that our results are consistent with the conceptual model of Fig. 1. Rivers with high annual usage (e.g. the Mataura and Waimakariri) were characterised by a low mean travel distance, and the most remote rivers (e.g., the Eglinton, Hunter, and Ahuriri) were much more lightly used. More importantly, there was a distinct trend for the data to be bounded by a line running diagonally from upper left to lower right, consistent with the importance contours in Fig. 1. Many rivers fell well below this line (Fig. 4b), representing fisheries (such as the Ashley, Kaiapoi, Mimihau, and Waingongoro) which are important for local anglers but attract very few individuals from further afield. By contrast, the upper right quadrant of Fig. 4a, representing remote rivers which sustained high levels of usage, was empty: no river with an annual usage over 8 500 angler-days had a mean travel distance of more than 65 km.

Further inspection of Fig. 4 confirms that rivers lying on or near the upper diagonal include many which have been previously identified by FGNZ as of particular importance. In the high use bracket (i.e., over 10 000 angler-days annually), the Mataura, Rakaia, and Rangitata have all been the subject of applications for a Water Conservation Order (WCO), and another three (the Waimakariri, Waitaki, and Clutha) were identified as nationally important by Teirney *et al*. (1982). In the 5000 – 10 000 angler-days per year bracket are another two rivers (the Mohaka and Motueka) for which FGNZ has sought WCOs, and the Hurunui (which was considered nationally important by Teirney et al. 1982). With an estimated annual usage of 4 300 angler-days in 2001/02, the Buller River (which was granted a WCO in 2001) also lies well towards the upper diagonal. Among other rivers attracting less than 5 000 angler-days annually, the Ahuriri was granted a WCO in 1990, the Maruia was included in the Buller River WCO, and a further five were considered by Teirney et al. (1982) to be either nationally important (the Eglinton, Hunter, and Ruakituri), or possibly nationally important[5] (the Whanganui and Mararoa). Four more rivers in the “possibly important” category identified by Teirney et al. (1982), the Taieri, Tukituki, Opihi, and Oreti, all lie to the lower right of Fig. 4a, but are generally further below the diagonal than their nationally important counterparts.

Three rivers which feature prominently in Fig. 4 are the Tekapo River, and the Tekapo and Ohau Canals. All three fisheries sustain considerable angling effort (4 900, 7 700, and 5 400 angler-days, respectively), despite being three of the most remote rivers included in this analysis (with mean travel distances of 147 km, 115 km, and 133 km,

[5] but for which the data available at the time were insufficient to make a more definitive judgement.

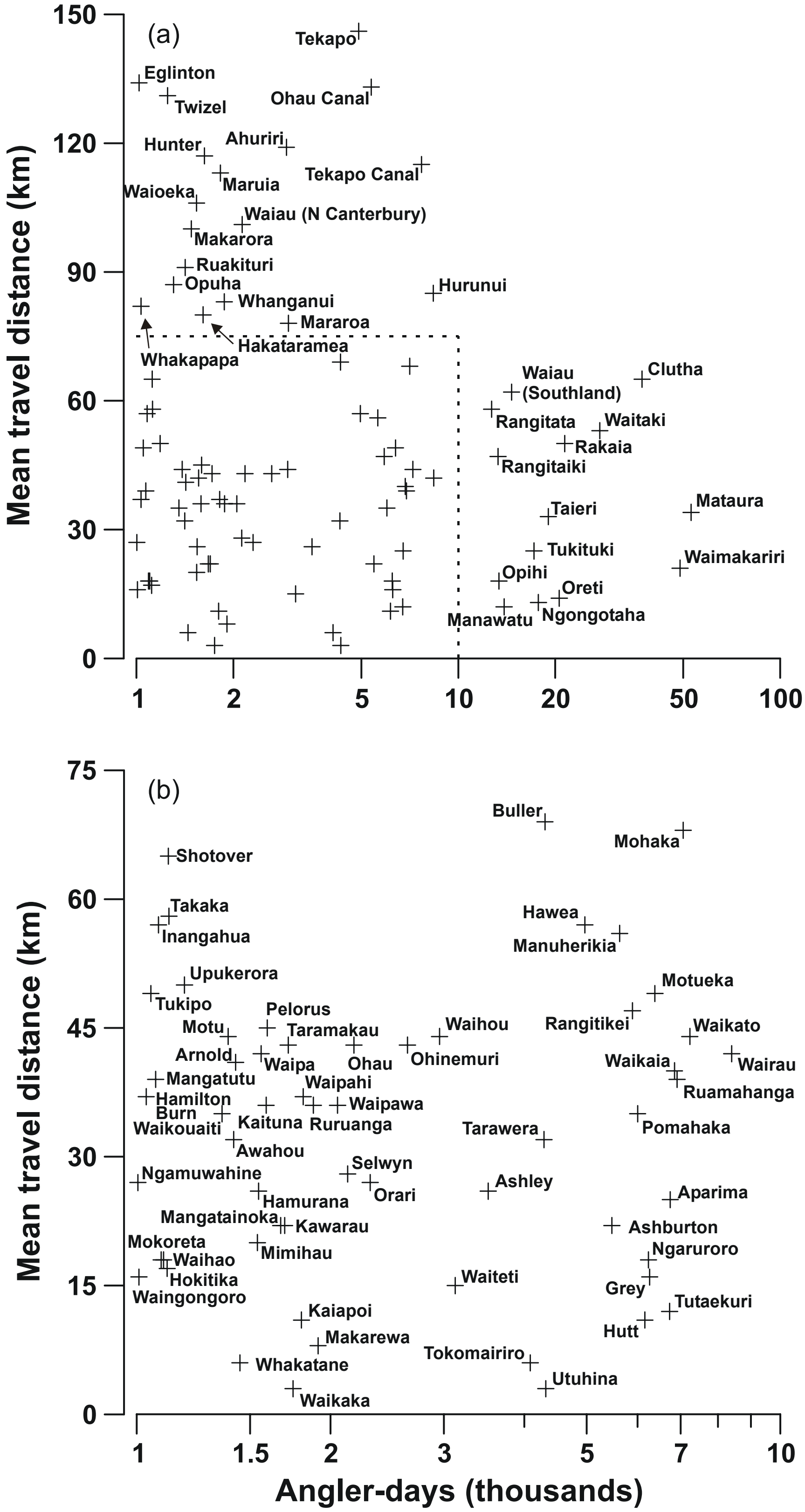

Figure 4: **Usage (annual effort in angler-days) vs. mean travel distance plot for 87 river fisheries sustaining at least 1000 angler-days in 2001/02. The area lying within the dashed square in (a) is shown, enlarged, in (b).**

respectively). The relatively high usage for the Tekapo River is consistent with the reputation of the lower reaches (below the Grays River and Mary Burn confluence) as a high quality back country fishery. However, the two canal fisheries are something of an anomaly, in that the fishing opportunities they provide are substantially boosted by commercial salmon farming operations. These farms appear to sustain significant populations of trophy-sized trout, which take advantage of food pellets drifting downstream from the farm pens, and also allow anglers to catch moderate numbers of salmon through the presence of farm escapees. In addition, the canals are flanked by good quality sealed roads which allow unrestricted access to virtually their entire length. A detailed analysis of travel distances associated with lake fisheries was beyond the scope of this study, although preliminary inspection of the data suggests that the canal fisheries may be closer in character to some lake fisheries, such as Lakes Benmore, Dunstan, and the upper Clutha lakes, in that they provide a large area of fishable water which does not require extensive local knowledge to be fished successfully.

3.4. A case study: Central South Island

Although the results shown in Fig. 4 suggest that, when considered in relation to total angling effort, mean travel distance provides a useful index of the importance of a fishery, it remains a relatively blunt instrument. To illustrate this, we conducted a more detailed analysis of four rivers within the Central South Island Region: the Ashburton, Opihi, Tekapo, and Waitaki. For each river, we identified all the respondents who had fished there, and tabulated them by home FGNZ Region, sub-region, and home town (Table 2).

This analysis, although qualitative, vividly illustrates how the extra level of detail available from the survey raw data helps to characterise each river in terms of its local, regional, and national significance. Collectively the four rivers suggest a spectrum. The Ashburton River was fished almost exclusively by local anglers, from Ashburton and the surrounding district, and could almost be the defining example of a fishery of local importance. The Opihi River was fished mostly by anglers from Timaru and the surrounding area, but also attracted anglers from Christchurch (130 km away), suggesting its importance is mostly local but that it is also of value to anglers from the wider mid to North Canterbury region. The Tekapo River is remarkable in that it attracted more respondents from outside the Central South Island Region than from inside. It was also popular with anglers from Christchurch and Dunedin, and derived 8% of its use (in terms of number of respondents) from anglers living in Southland, Nelson/Marlborough and the West Coast, and the North Island. This suggests it is clearly of at least regional importance, and should probably be considered as

Table 2: **The number of NAS respondents fishing four selected Central South Island rivers in 2001/02, grouped by FGNZ Region of residence (Home Region), and (for the Central South Island Region only) by sub-region (see text for further details), and home town. Mean travel distance (km) and estimated annual effort in angler-days (a-d) is also shown for each river.**

			River Fishery			
Home Region	**Sub-region**	**Town**	**Ashburton 22 km 5 500 a-d**	**Opihi 18 km 13 400 a-d**	**Tekapo 146 km 4 900 a-d**	**Waitaki 53 km 27 600 a-d**
Northland						1
Auckland/Waikato					1	5
Eastern						3
Hawkes Bay				1	1	
Wellington			1	1	1	1
Nelson/Marlborough				1	2	2
West Coast					2	
North Canterbury			5	15	44	57
Central South Island	Ashburton	Rakaia				2
		Methven	1			
		Ashburton	66	1	1	5
		Mount Somers	1			
	Timaru	Geraldine		8	5	5
		Temuka		38	7	3
		Pleasant Point		8		1
		Timaru		94	18	50
		Pareora				5
		Saint Andrews		1		
		Waimate		2		47
	Mackenzie	Fairlie		2	1	
		Lake Tekapo			2	1
		Twizel			3	1
		Omarama			2	1
		Otematata			1	1
		Kurow				13
	North Otago	Oamaru			1	134
		Ngapara				2
		Herbert				1
		Hampden				2
Otago			2	1	12	35
Southland				2	1	8
Total respondents			76	175	105	386

nationally important. The Waitaki River, arguably one of the most highly valued river fisheries in New Zealand, and regarded by FGNZ as nationally important (see Teirney et al. 1982), attracts anglers from throughout the country.

3.5. Synthesis with the 1979/80 NAS

Comparison of weighted mean travel distance (for the 2001/02 data) with mean ratings for "distance from home" (for the 1979/80 data) showed that the two measures were highly correlated (r = 0.705; Fig 5a). Four of the remaining six attributes (scenic beauty, peace and solitude, catch rate, and size of fish) were also positively correlated with travel distance, although less strongly so ($0.269 \leq r \leq 0.507$; Figs 5e-5h), and one (ease of access) was negatively correlated with travel distance (r = -0.447; Fig. 5d). However, overall importance was only weakly correlated with travel distance (r = 0.249; Fig. 5b).

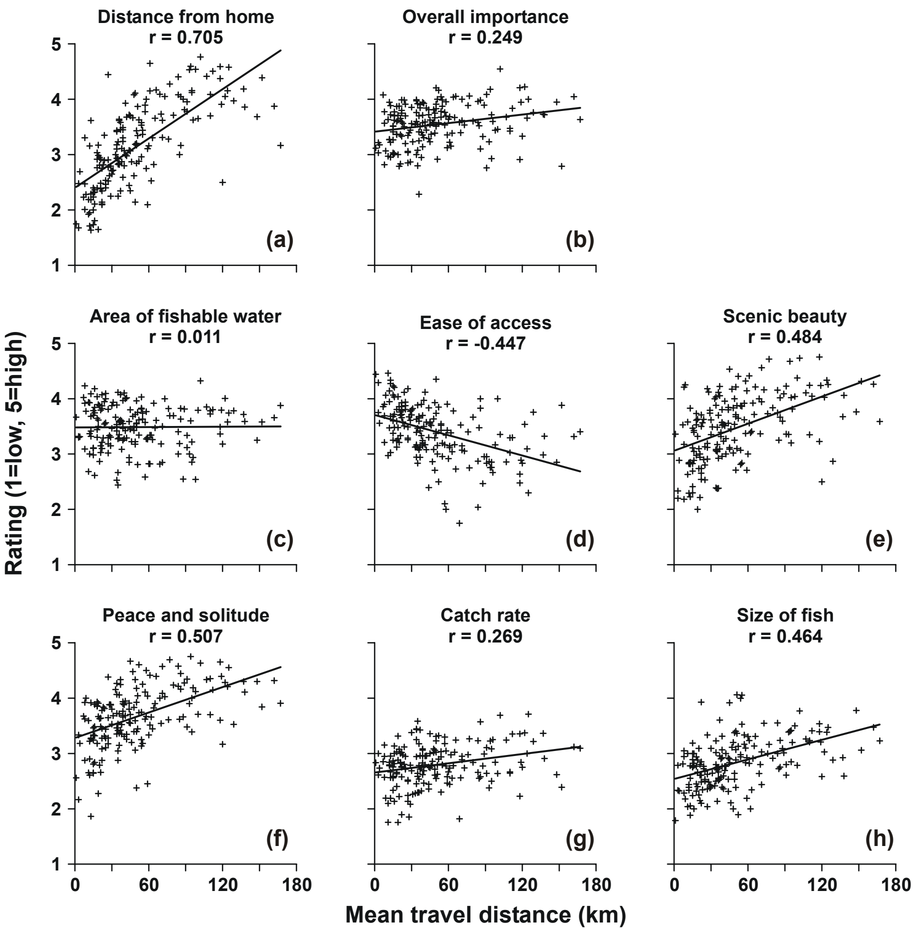

Figure 5: Scatterplots of weighted mean travel distance (from the 2001/02 National Angling survey) against mean rankings (on a 1-5 scale) for eight attributes assessed by respondents to the 1979/80 National Angling Survey

Overlaying the 1979/80 importance rankings onto the 2001/02 travel distance and usage data provided a further illustration of the complex relationships between these three measures (Fig. 6). This figure is an extension of Fig. 4, showing all rivers common to both surveys for which estimated annual usage exceeded 100 angler-days, and using colour coding to indicate the mean importance grade from the 1979/80 survey. Lowering the cut-off for annual usage to 100 angler-days roughly doubles the size of the dataset, albeit at the expense of increased uncertainty (up to ± 100%) in some usage estimates; our purpose in presenting this figure is to highlight general patterns rather than detail.

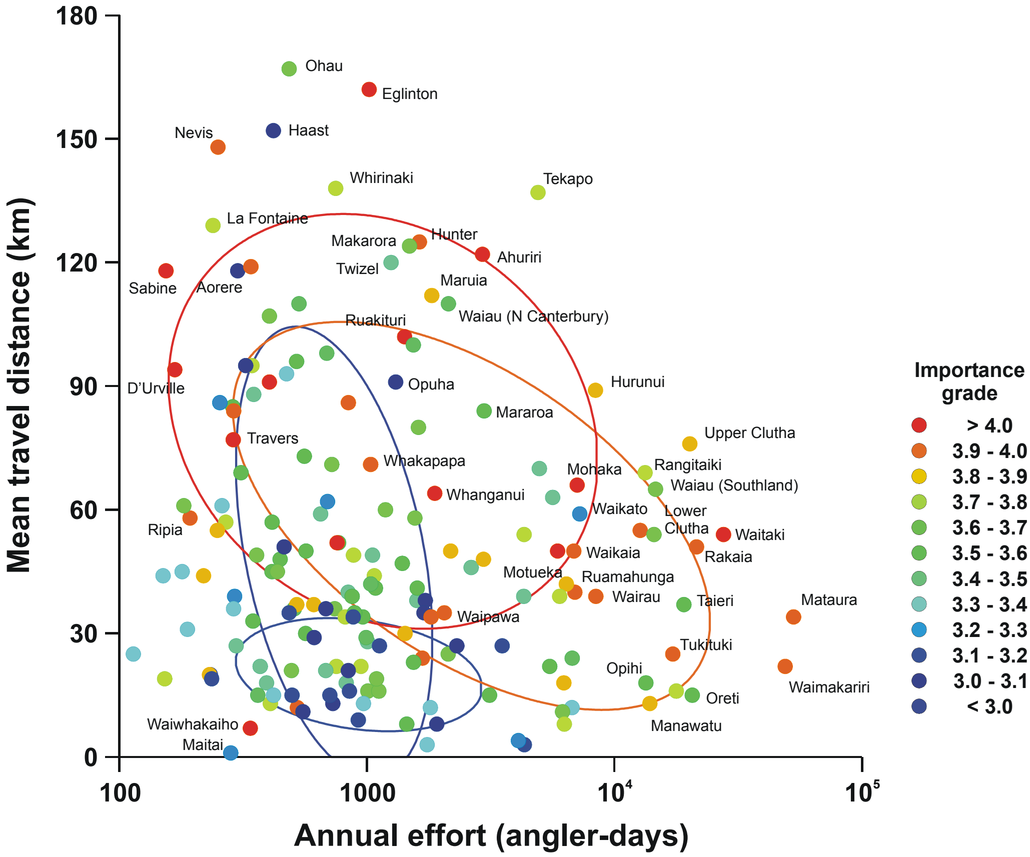

Figure 6: **Usage (annual effort in angler-days) vs. mean travel distance plot for 175 river fisheries sustaining at least 100 angler-days in 2001/02, and assessed by at least ten respondents to both the 1979/80 and 2001/02 National Angling Surveys. The colour coding shows the relative importance for each river in the 1979/80 Survey, shaded from deep blue (lowest importance) to red (highest importance). Bivariate normal ellipses enclosing 50% of the points are shown for the two most highly ranked groups of rivers (importance grade ≥ 3.9), and for the two lowest ranked groups (importance grade ≤ 3.1). Selected rivers are identified; space limitations preclude identifying all 175, although a comparison with Figure 4 will help to identify many of the unlabelled points.**

This analysis offers some support for our conceptual model, in that rivers with a similar importance ranking tend to band together along a common diagonal, and rivers ranked highly in 1979/80 tend to lie along a higher diagonal than those with a lower ranking. As noted earlier in this report, many rivers which have previously been identified as nationally important, such as the Mataura, Rakaia, Waitaki, Ahuriri, Hunter, and Mohaka, continue to feature prominently when their importance ranking is taken into account. However, the Figure also identifies some rivers which appeared to be valued relatively poorly by anglers, despite their prominent location in the Figure (e.g., the Haast and Waikato), and others (e.g., the Ripia, Waipawa, and Waiwhakaiho) which were highly valued despite being well below the upper diagonal.

Several of these anomalies can be readily explained. For example, the Haast River has a relatively high level of usage given its remote location, but its low importance ranking suggests this is largely due to its proximity to SH6, rather than the quality of the fishery. The Waiau River in Southland was rated comparatively poorly in 1979/80, and thus appears to be relatively highly used. However, Regional FGNZ staff consider that the fishery has improved greatly following implementation of a new minimum flow regime in 1996, based on instream flow modelling (Jowett 1993), and it appears that the 1979/80 data underestimate its current value. Similar comments probably apply to the Tekapo River, as noted in Section 3.3, and the Opuha River, where completion of the Opuha Dam (in 1996) has resulted in a more stable flow regime, with fewer periods of summer low flow, and a consequent improvement in the fishery. Conversely, the high value attributed to the Waiwhakaiho, despite its relatively low use given its proximity to Taranaki population centres such as New Plymouth and Inglewood, reflects its importance to local anglers. Taranaki anglers are largely dependent on the rivers of the Taranaki ring plain, which are popular with local residents but attract virtually no effort from other Regions. Given that the Waiwhakaiho is one of the top five Taranaki rivers in terms of annual effort, its high importance ranking is appropriate when the river is considered in its proper context.

Nevertheless, the extent to which rivers of both high and low importance (as assessed in 1979/80) are scattered across Figure 6 highlights the difficulty of identifying the most highly valued fisheries solely on the basis of total usage and mean travel distance. This point is reinforced by a direct comparison of the present measure of importance for each river with its mean importance grade from the 1979/80 survey (Fig. 7). To convert our usage vs. travel distance data into a measure equivalent to the 1979/80 data, i.e., a numerical index on a 1-5 scale, we defined a new variable Z by the relation $Z = \dfrac{D + 60\log(E)}{100}$, where D is the unweighted log transformed mean travel distance in km, as used in Table 1 and Figures 4 and 6, and E is the estimated annual effort in angler-days. The scaling factors of 60 and 100 ensure that, in the context of Figures 4a and 6, a *Z* score of 1 corresponds to the lower left corner, a score of three corresponds to the main upper left to lower right diagonal, and a score of 5 would correspond to the upper right corner. The *Z* scores so defined ranged from 1.48 (for the Maitai River) to 3.59 (for the Tekapo River). The high degree of scatter in Fig. 7, and the relatively weak correlation (r^2 = 0.138) between the two importance measures, suggests that each measure captures information about the true importance of each river which neither measure alone is capable of doing. Although our results are generally consistent with the conceptual model of Figure 1, in that – other things being equal – the most highly valued fisheries will lie near the upper diagonal, they also serve as reminder of the practical reality that other things are seldom equal.

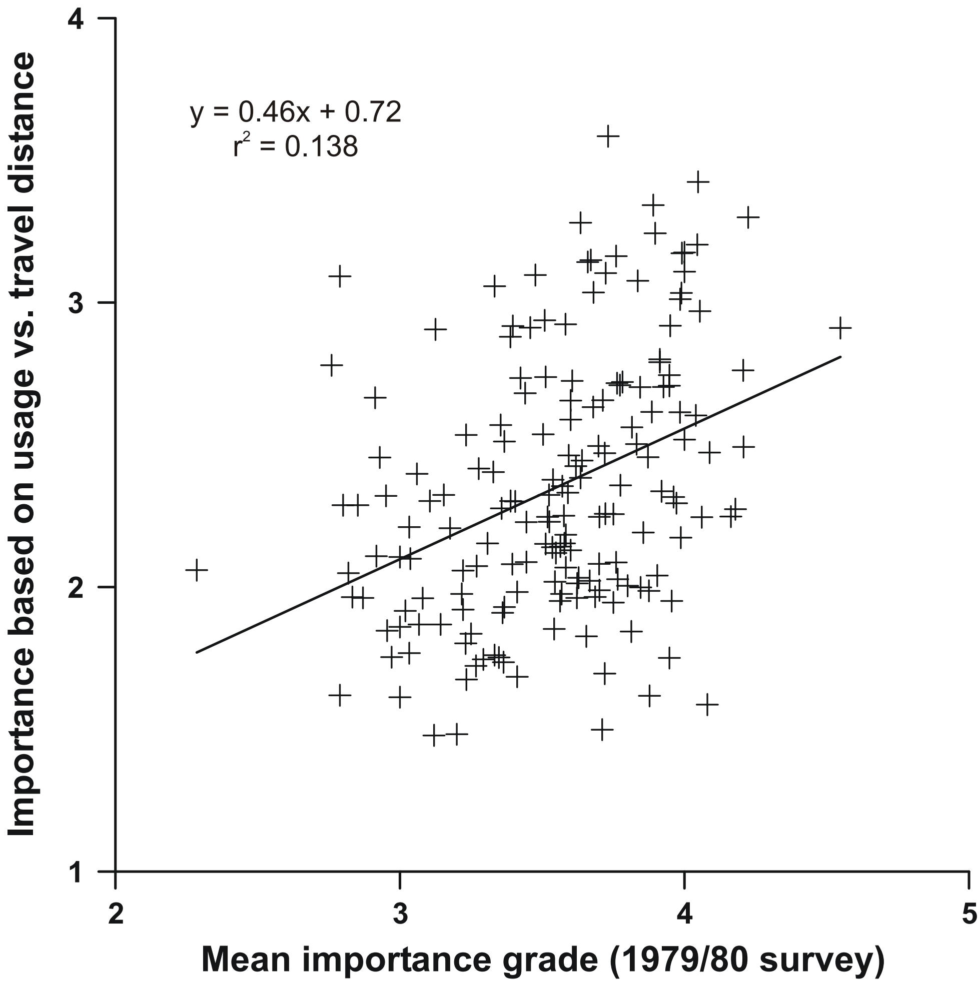

Figure 7: Alternative measures of importance for the same set of river fisheries as in Figure 6. The horizontal axis represents the mean importance grade from the 1979/80 survey, and the vertical axis represents the mean importance grade (or *Z* score) developed in the present study (see Section 3.5 for further details).

4. Discussion

4.1. Travel distance as an index of angler behaviour

The results of this study show that travel distance is a potentially useful index for assessing the value of individual river fisheries. When coupled with usage data, an estimate of mean travel distance allows any given river to be located on a spectrum ranging from intensively fished, highly accessible fisheries close to one or more large population centres, to remote back country fisheries which are lightly fished but highly valued. In addition, a measure of travel distance can help to identify the importance of any given fishery in a local, regional, or national context. There is a satisfying level of consistency between the rivers identified as important in terms of the use-distance spectrum developed here, and those which have already been identified by FGNZ as deserving of protection via a WCO. In a few instances (e.g., the Tekapo, Waiau, and Opuha), where current usage is much higher than would be expected from the 1979/80 importance scores, the discrepancy can be identified with a specific change in circumstances such as revised minimum flows. However, comparison with the results of the 1979/80 National Angling Survey also highlights the extent to which fishery values for individual rivers may depend on other attributes, many of which are difficult to quantify.

Notwithstanding the substantial distances anglers are prepared to travel to reach some highly valued rivers, an important finding of the study is that river angling is primarily a local activity. The median travel distance was 43 km, and over three quarters of the responses (76.7%) were from anglers fishing within 100 km of home. River fisheries close to cities or large towns, such as the Waikato, Tukituki, Manawatu, Hutt, Wairau, Motueka, Waimakariri, Ashburton, Opihi, Taieri, Mataura, and Oreti, remain the backbone of New Zealand river angling: the twelve rivers just listed (with a median travel distance of 22 km) account for one third (37%) of the total river fishing effort recorded in the 2001/02 survey. By contrast, the exceptions – more distant but relatively high use fisheries such as the Clutha, Tekapo Canal, Waitaki, and Rangitaiki – tend to stand out when viewed in use-distance space.

A strength of this study is that essentially all New Zealand resident anglers were identified with respect to their home address, rather than just to the FGNZ district in which they purchased their licence. To the best of our knowledge, this is the first time FGNZ licence records have been collated in this manner. Since 27% of respondents either purchased their licence in a Region other than where they lived, or fished in a Region other than where they bought their licence, capturing this information is clearly essential if angling demographics are to be accurately measured.

4.2. Assumptions and limitations

The methodology developed in this study is simplistic, and represents no more than a first attempt to quantify travel distance in an objective and defensible way. As noted earlier, all distances are calculated "as the crow flies", and will therefore tend to underestimate the actual road distance involved. We did not investigate the possibility of using GIS datasets to refine these estimates, although – given a suitable GIS layer, containing information on New Zealand's roading network – this would be relatively simple to implement. However, our assumption that angling can be localised at a single point (except for large mainstem rivers such as the Manawatu, Rangitikei, Motueka, Buller, and Clutha, which were subdivided into multiple reaches; see Section 2.3) is also an oversimplification, which would remain even if straight line distance were replaced by road distance. Placing most angling centroids at the mouth of each river (or its confluence with a larger river) is somewhat arbitrary, although the effect this has on the estimated travel distance for individual anglers is significant only for those living close to the river. For anglers travelling more than 50-100 km the location of the centroid rapidly becomes virtually irrelevant: a Christchurch angler fishing the Waitaki River, for example, travels a straight line distance between 194 and 215 km irrespective of where they fished. There is potential for using the 1979/80 NAS database to refine centroid locations for some larger rivers, based on the number of anglers fishing the upper, middle, or lower reaches (Teirney et al. 1982, Teirney & Richardson 1992), but we did not explore this further.

Other, more subtle, assumptions are also involved. For example, we have implicitly assumed that all travel distances should be related to the angler's home address, and have thus made no allowance for anglers who fish several rivers during an extended trip from home. For example, with our present methodology, an Auckland angler holidaying in the upper Clutha region, and who fished rivers such as the Clutha, Hawea, and Hunter (and possibly several lakes as well) would generate travel distances of around 1000 km for every river, even though he or she made the full journey only once. This effect will tend to overestimate mean travel distance, although in practice the number of such individuals (and consequently any resulting error) is likely to be small.

The lack of data on overseas anglers is potentially a more serious source of error, particularly for rivers close to tourist centres such as Rotorua and Queenstown, or for others (such as the Karamea and upper Rangitikei) which have gained a reputation as trophy fisheries (Jellyman & Graynoth 1994). The absence of data for part-season licence holders in Otago is likely to have further affected some of our estimates, particularly in the upper Clutha and Southern Lakes region. The effect of these missing data is twofold, resulting in total usage and mean travel distance estimates which may be highly conservative. For example, over half of the anglers interviewed on the Greenstone and Caples during a recent FGNZ survey were from overseas, suggesting that for these rivers the 2001/02 Survey data may represent less than half the total usage.

More generally, the present methodology is necessarily restricted to rivers for which there were sufficient data to yield a reasonable estimate of both total usage, and mean travel distance. Many highly valued rivers, some of which (e.g., the Travers, Sabine, Greenstone, and Caples) have been identified as nationally important (Teirney et al. 1982), fell below our initial cut-off limit of 1000 days per year and more than 10 respondents, and so did not feature in our main analysis (although lowering the cut-off to 100 days per year, as in Figure 6, allowed some of these waters to be included). This limitation is a characteristic feature of random sample surveys such as the NAS, which are designed to collect information about as broad a range of fisheries as possible, rather than targeting any particular water. Because there are over 100 000 licence holders who are potentially in the sampling frame, many of the more remote river fisheries – even if they were to attract several hundred anglers per season – may be fished by only a small fraction of the licence holders who are actually interviewed.

5. Conclusions

When coupled with usage data, travel distance is a potentially useful index for assessing the value of individual river fisheries. In particular, our initial assumption – that travel distance reflects the effort anglers are prepared to make to reach a given fishery, and is thus an index of its angling value – appears to be validated by the extent to which our present results capture many of the rivers previously identified by FGNZ as worthy of protection. However, our results also suggest that other, less quantifiable attributes may need to be considered when assessing fishery values. The present analyses should be used to inform the process of identifying river fisheries of national priority, but not to dictate it.

The methodology developed in this study has considerable potential for improvement. Recalculating travel distances in terms of actual road distances, using GIS techniques, is one such possibility, and could ultimately be used to generate information on travel costs for inclusion in an economic model of the sports fishery. However, other problems with the present approach – such as the lack of data on travel distances for lightly used wilderness fisheries, and for overseas anglers – are less tractable, and may require new methodologies if they are to be fully resolved.

Although this study was motivated by the need for information on rivers of national priority, we have refrained from making any such identifications solely on the basis of the results in this report. On the contrary, we regard these results as only one of many potential indices, including characteristics such as angler satisfaction, species available, catch rates, and size of fish, which should also be taken into account when making such determinations.

Our finding that angling is primarily a local activity, often undertaken within 50 km of where anglers live, has significant management implications. Much of this angling takes place on waters which may be categorised as lowland rivers, and which several recent studies have shown are becoming increasingly degraded (Parkyn et al. 2002, Jellyman et al. 2003). This resource is of fundamental importance to many rural New Zealanders, particularly in the lower South Island where over one adult male out of every seven holds a whole-season fishing licence (Unwin et al. 2003).

The angling licence database compiled during the NAS, and the ability to link this database to the main NAS database of angler's responses, provides FGNZ with a new and – we believe – largely untapped resource on usage of New Zealand's freshwater angling resources. The present study illustrates one way in which these data can be used, but there are numerous other possibilities which remain to be investigated. For example, instead of interrogating the database to learn where the anglers who fish a particular river have come from, it would be possible to turn this question around and ask which fisheries are used by anglers from different regions and sub-regions. We would encourage FGNZ to continue to improve the quality of its fishing licence records, so that future studies can build on the present one.

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