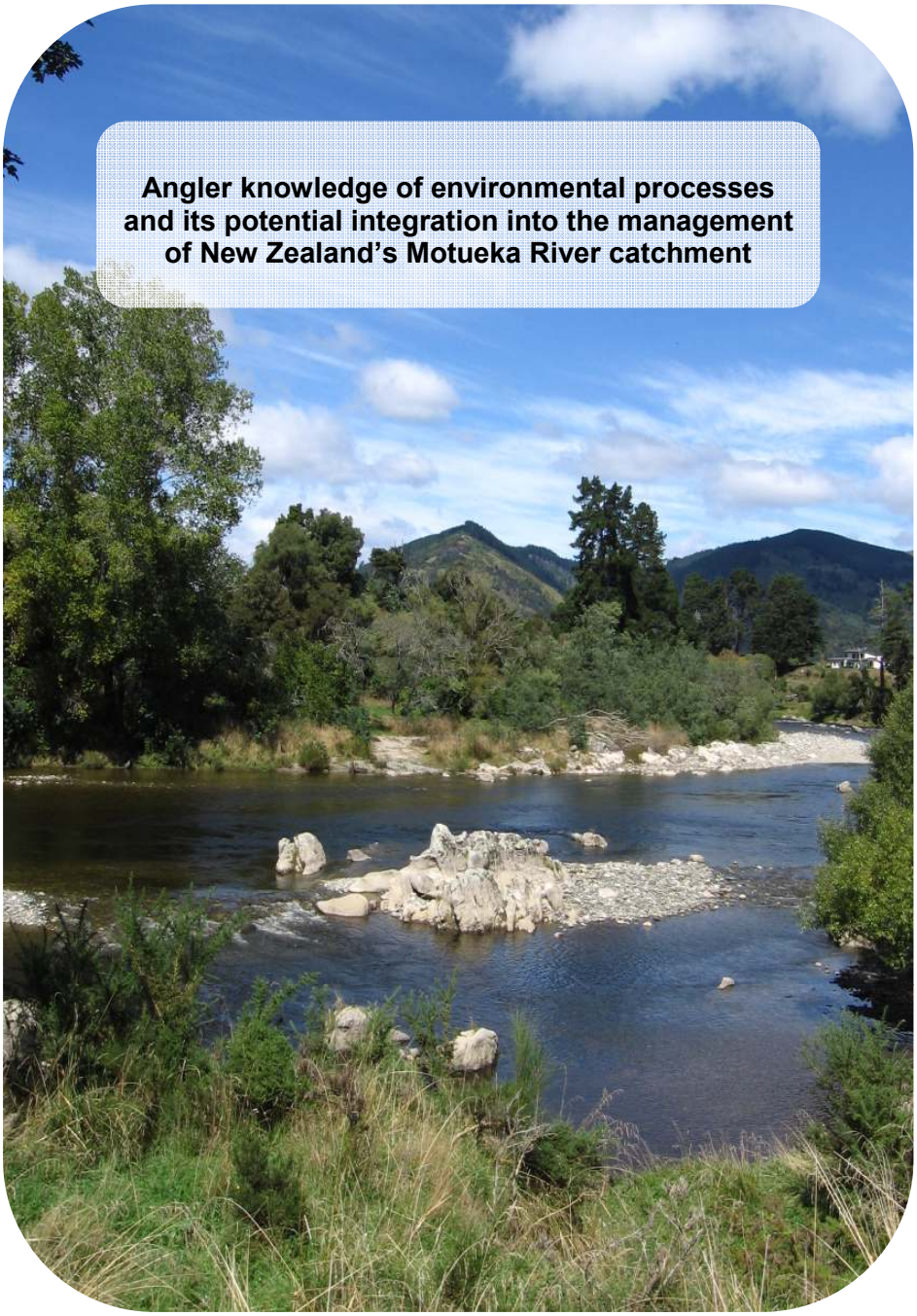
A thesis submitted to the Department of Environmental Sciences and Policy of
Central European University in part fulfilment of the
Degree of Master of Science



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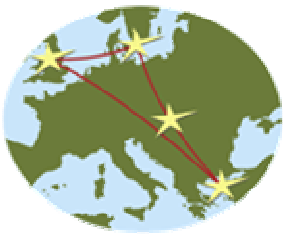
May, 2009

Budapest

Erasmus Mundus Masters Course in Environmental Sciences, Policy and Management

MESPOM



This thesis is submitted in fulfillment of the Master of Science degree awarded as a result of successful completion of the Erasmus Mundus Masters course in Environmental Sciences, Policy and Management (MESPOM) jointly operated by the University of the Aegean (Greece), Central European University (Hungary), Lund University (Sweden) and the University of Manchester (United Kingdom).

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No portion of the work referred to in this thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

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THE CENTRAL EUROPEAN UNIVERSITY

ABSTRACT OF THESIS submitted by:
Anne-Claire LOFTUS
for the degree of Master of Science and entitled:
Angler knowledge of environmental processes and its potential integration into the management of New Zealand's Motueka River catchment

Month and Year of submission: May, 2009.

New Zealand's Motueka River catchment is home to a renowned brown trout fishery. Trout numbers in parts of the river declined in the mid-1990, and have only slowly recovered; the precise reasons for this decline are unknown. Sedimentation has been identified as a potential cause, but scientific research is hampered by the lack of historical records of sediment events. This study examined through interviews the local knowledge of environmental processes held by long-terms anglers, and sought to determine the extent to which it could be integrated into the catchment's management.

The interview results did not yield a straightforward explanation for the reduction in trout numbers. Observations and opinions varied widely amongst anglers, but some overall trends that may be useful for further research were identified. Angler knowledge was found to present characteristics which made it highly suitable for integration into management, provided it is gathered in a timely fashion rather than as part of a historical analysis. Indeed, many of the deficiencies identified with angler knowledge in this study could be remedied through modified research methods.

Keywords: New Zealand, Motueka River catchment, catchment management, local knowledge, anglers, brown trout, Fishermen's Ecological Knowledge (FEK), knowledge integration, sediment

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Acknowledgements

The choice of New Zealand as a location for my thesis research was motivated by the deep attachment I formed to the country and its people, following a year spent there working on organic farms and traveling. I hope this thesis can positively contribute to the management of the country's unique environment.

Although the names of the interviewed anglers are not revealed, their contribution to the research process is highly valued and appreciated, as are those of the other interviewees.

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Rachel, "thesis buddy" and provider of sound advice and criticism, merci! Thanks also to Dad and Jessica for the help, and to Daniel for your patience.

To Lydia

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Abbreviation	Stands for
ICM	Integrated Catchment Management
NIWA	National Institute of Water and Atmospheric Research
FGNZ	Fish and Game New Zealand
DOC	Department of Conservation
TDC	Tasman District Council
RMA	Resource Management Act

1. Introduction

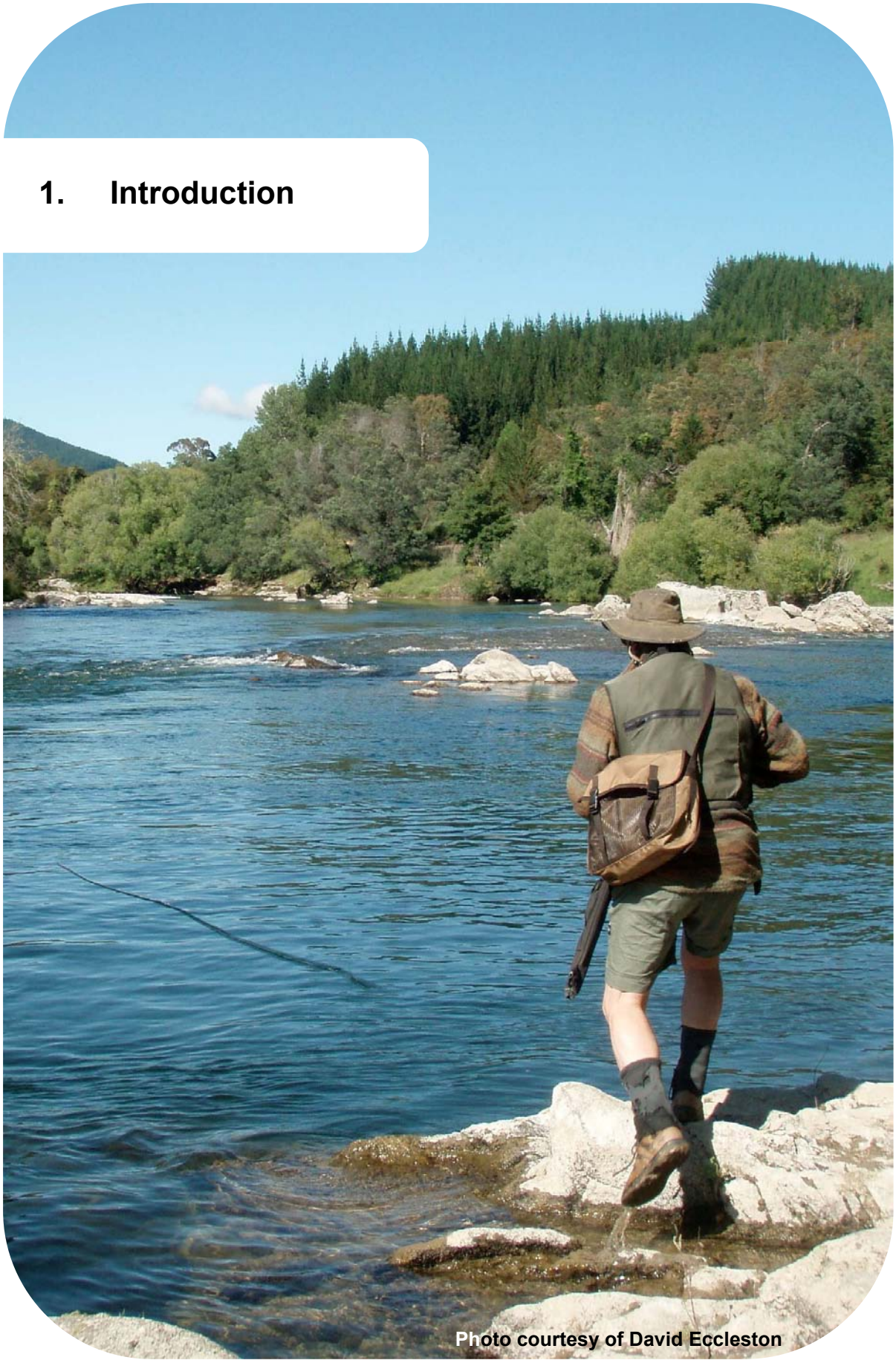


Photo courtesy of David Eccleston

1.1 Background

The depletion of fish stocks is but one example of an unresolved environmental crisis. According to the FAO, approximately half of all monitored fish stocks are fully exploited, while over a quarter of stocks are overexploited, depleted or recovering from depletion (FAO 2009). Against this backdrop of fish population reductions, two related developments have occurred in fisheries research. First, researchers have pointed to the failure of scientific knowledge to address these problems (Baird and Flaherty 2005; Bergmann *et al.* 2004; Close and Hall 2006; Mackinson and Nøttestad 1998; Mathooko 2005; Murray *et al.* 2006; Murray *et al.* 2008), and, second, other types of knowledge have as a result of this failure been identified as complementary or even alternative solutions for improved fisheries management. One alternative to scientific knowledge which has been proposed is making use of the knowledge possessed by a group which interacts with fisheries on a regular basis, and can be thought to have a stake in helping to maintain viable fish populations – fishermen themselves. This conceptual development in fisheries research is symptomatic of a resurgence of interest in wider local knowledge, which covers a number of different natural resource management areas.

For a number of natural resources, data gaps are a key problem for the conception and implementation of management measures, which rely on knowledge of environmental processes and conditions in order to formulate responses to existing or potential threats. This uncertainty is particularly prevalent in the domain of wildlife management (Gilchrist *et al.* 2005), of which wild fish species are a part, because of the difficulty in estimating stocks (Baker 1995).

Both concerns regarding fish stocks and the existence of data gaps and uncertainties are something that marine and freshwater fisheries have in common, and research on fishermen's knowledge as a way to address these problems covers both types of fisheries. However, most research on fishermen's knowledge focuses on commercial or subsistence fishermen, with little emphasis given to the ecological knowledge held by recreational fishermen such as anglers. New Zealand's Motueka River catchment, home of an important brown trout fishery, is an ideal test case for research on angler knowledge, not least because of the amount of uncertainty surrounding the fishery dynamics and their interactions with the catchment as a whole.

The initial impetus for this study came out of a need by the Motueka Integrated Catchment Management (ICM) Programme to gain a better understanding of both the causes and consequences of sediment generation in the Motueka catchment, which are not fully understood. In the mid-1990s, brown trout numbers suffered a decline in at least one section of the Motueka, as estimated by drift dive surveys. Although the exact causes of the decline are not known to science, the impact of sediment is among the hypotheses that have been put forward (Basher 2003). Given that the ICM Programme began monitoring sediment in 2005, there is a large data gap prior to this period, where the location, timing and duration of sediment events are poorly understood (Basher pers. comm.). As regular users of the Motueka River and its tributaries, it was hypothesized that anglers who have

fished in the catchment over a long period of time might have important insights about such sediment events, as well as observations about their possible effects on the trout fishery. The thematic scope of the investigation was subsequently widened to encompass other environmental processes affecting the catchment and its trout fishery. In addition to the perceived need for this specific research as part of the goals of the ICM Programme, it is hoped the results will also provide some useful learning points for the integration of local knowledge within catchment management.

1.2 Research problem

The research problem emerges at two levels, both global and local.

- **Global scale**

Studies on the knowledge held by commercial and subsistence fishermen form an important component of research on local knowledge; however, the knowledge of environmental processes held by recreational fishermen has not been the subject of as much academic investigation. Moreover, although catch information provided by sport fishermen is regularly used as part of fish population surveys (Butler *et al.* 2009; Cooke *et al.* 2000; Kerr 2007; Margenau *et al.* 2008; Mosindy and Duffy 2007; Pollock *et al.* 1994; Willms and Green 2007), or as part of studies on recreation (Ditton *et al.* 2002), systematic efforts to understand what knowledge local fishermen may hold about environmental processes affecting rivers and catchments are less common (Cooke *et al.* 2000). Furthermore, while the general consensus is that local knowledge has inherent value – for fishermen's knowledge and local knowledge as a whole – views on how valuable this knowledge can be for environmental management and on how it can be integrated within it are much less unified.

- **Local scale**

At Motueka catchment level, scientific research on the manifestations of sedimentation in the area, its causes, and its potential effect on the trout fishery has been hampered by a lack of available historical records. The role of other environmental processes in affecting the fishery is also unclear. In parallel, the Motueka ICM Programme has identified local knowledge as a potentially useful contributor to management decisions, and considers community and stakeholder involvement as one of its key goals (Bowden *et al.* 2004).

This thesis attempts to address both of these themes, contributing to the global body of research on recreational fisheries by conducting a catchment-scale case study gathering the knowledge of environmental processes held by long-term anglers in the Motueka catchment, and evaluating the ways in which this knowledge could be integrated into the catchment's management.

1.3 Research question

In order to address the research problem identified above, this thesis will seek to answer the following research question:

How can local angler knowledge be valued and used for Motueka River catchment management?

Contained within the research question are a number of key terms, out of which emerge sub-questions, which the four objectives of the thesis seek to answer in turn:

- **"Knowledge": what knowledge do anglers hold?**

The first objective of the thesis is to determine what knowledge local anglers possess regarding the Motueka trout fishery and environmental processes in the catchment as a whole; the breadth and depth of angler knowledge will play a large part in determining to what extent it can be used for catchment management. This objective is addressed in section 5 of the thesis.

- **"Valued": is angler knowledge valuable?**

The second objective of the thesis is to find out how valid and valuable the knowledge anglers hold is, in terms of its potential use for management purposes. Although important to assess, this objective is arguably the most difficult to meet, given the many possible interpretations of what constitutes value. Section 5 of the thesis is given over to assessing the validity of angler knowledge, and the question of value is discussed in section 6.

- **"Used": can angler knowledge be used, and if so, how?**

The third objective is to determine the extent to which angler knowledge can be made use of, in general terms – this is linked to the second objective (valuing knowledge), and is also considered in section 6.

- **"Management": can angler knowledge be used for catchment management, and if so, how?**

The fourth and final objective of the thesis is linked to the third, in that it aims to establish the usability of angler knowledge, but is distinct from it because it relates not to general usability, but rather to specific use of knowledge for catchment management purposes. This objective is addressed in section 6 of the thesis.

1.4 Scope

The scope of the thesis is defined thematically, temporally, geographically, and also by the subjects of the study:

- **Thematic scope**

The thesis focuses on recreational trout fishermen, as well as on fishing guides, as a subset of that group. However, reference is also made to studies of small-scale commercial and/or subsistence fishermen as part of the review of literature, given the close link between the two types of fishermen. As will be elaborated upon in the methodology section, the semi-structured nature of the interviews conducted meant that although fishermen were asked about specific environmental processes such as sediment events, trout population dynamics and invertebrate communities, information about a number of other issues was also generated as part of spontaneous comments during interviews.

- **Temporal scope**

Although the long history of academic study of local knowledge could have warranted reference to studies dating back to the middle of the 20th century, this thesis chose to focus rather on more current interpretations (1995-present) of the promise of and challenges to local knowledge integration. Given the thesis' focus on knowledge of environmental processes accumulated throughout lifetimes of angler interaction with the catchment, the study of the Motueka catchment reaches back into the second half of the 20th century.

- **Geographical scope**

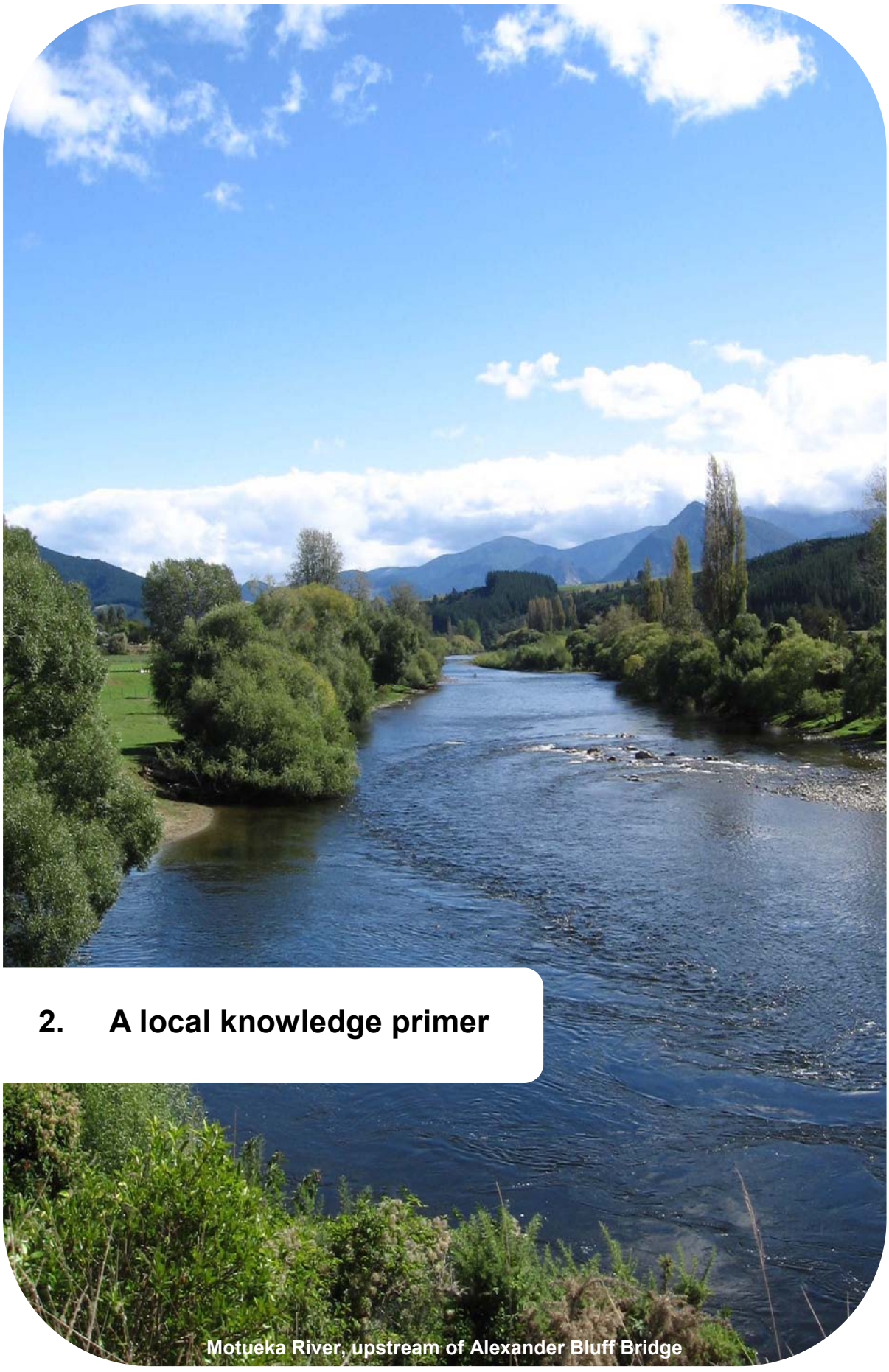
Although the case study of local angler knowledge is confined to the 2180 km^2 area of the Motueka River catchment in New Zealand, the literature regarding knowledge integration spans the globe. It is also hoped that the conclusions of the thesis will have applications for the study of local knowledge integration beyond the Motueka catchment.

- **Study subjects**

The main focus of the thesis is on a sample of long-term anglers who fish the Motueka River and its tributaries; in addition, persons involved in the management of the Motueka catchment and its trout fishery are also part of the study.

1.5 Structure of thesis

The remainder of the thesis is divided into 6 sections. Section 2 explains the methodology of the study, from archival research through to analysis of results. Section 3 contains the review of literature pertaining to local knowledge integration, with a particular focus on research relating to fishermen's knowledge; it also provides the conceptual framework underlying the thesis. Section 4 provides an introduction to the Motueka catchment and its anglers, as well as explaining the most relevant aspects relating to trout biology and sedimentation, which are useful for the understanding of later discussions. Section 5 presents the results of the angler interviews, and also attempts to apply a validation process to these results. Section 6 discusses the implications of the angler knowledge presented in the previous section, particularly in terms of catchment management. Finally, section 7 concludes the thesis by outlining some possible avenues for further research.



2. A local knowledge primer

Motueka River, upstream of Alexander Bluff Bridge

The literature on local knowledge and resource management is extensive, it being the subject of academic enquiry since at least the 1950s (Dove *et al.* 2007) and spanning a diverse range of disciplines, from anthropology through to fisheries research. Given the breadth of information available, it is not feasible to provide an in-depth review of all the literature. Instead, this section first provides a glimpse into local knowledge and resource management discourse, and subsequently delves deeper into the aspects of the debate most relevant for this thesis, namely fishermen's knowledge and its capture and integration into management.

2.1 Getting started

Before looking into the more detailed aspects pertaining to the use of fishermen's knowledge within environmental management, it is worth stepping back and reviewing the basics of local knowledge: the different terms used to refer to it, and the history and reasoning behind the increasing levels of interest in its use.

2.1.1 Defining local knowledge

A variety of terms have been used in connection with local knowledge; table 2.1 attempts to pull together and define these terms.

Table 2.1. Some definitions of terms describing local knowledge

Term	Definitions	Variants
Traditional knowledge	▪ "Multiple bodies of knowledge accumulated through many generations of close interactions between people and the natural world" (Drew 2005) ▪ "Primarily used to refer to "eco-friendly" traditional knowledge that small populations, typically employing simple technology, use when relating to their natural environment" (Knudsen 2008) ▪ ''A cumulative body of knowledge and beliefs, handed down through generations by cultural transmission, about the relationship of living beings (including human beings) with one another and with their environment'' (Berkes 1993 in Mathooko 2005) ▪ "An integrated system of information, knowledge, and belief, transmitted through generations on the relationship between local community and environment; this knowledge is cumulative and dynamic, and it is based on adaptive experience" (Schafer and Reis 2008)	Traditional Ecological Knowledge (TEK), Folk science
Indigenous knowledge	▪ "Indigenous knowledge (IK) is local knowledge – knowledge that is unique to a given culture or society. IK contrasts with the international knowledge system generated by universities, research institutions and private firms (Warren 1991)" in (Agrawal 1995)	Indigenous Technical Knowledge (ITK), Indigenous Ecological Knowledge (IEK), Ethnoscience
Citizen science	▪ "Deliberation on the pressing issues of concern to those affected by the decisions at issue" (Fischer 2000) ▪ "The public now engage critically with the scientific perspectives of expert institutions, either through funding or orchestrating their own scientific investigations, or through lobbying to transform research questions" (Leach and Fairhead 2002)	Public participation
Local knowledge	▪ "Knowledge pertaining to a local context or setting, including empirical knowledge of specific characteristics, circumstances, events, and relationships, as well as the normative understandings of their meaning" (Fischer 2000) ▪ "Informal, popular, or folk knowledge that can be contrasted to formal or specialized knowledge that defines scientific, professional, and intellectual elites" (Brush 1996)" in (Fischer 2000) ▪ "What is variously termed "traditional," "indigenous," or "local" ecological knowledge" (Davis and Wagner 2003) ▪ "Knowledge and activities of local resource harvesters" (Close and Hall 2006)	Local Ecological Knowledge (LEK), People's knowledge

The concept of indigenous knowledge is one that emerged from anthropological research upon contact with non-western cultures; however, the validity of the idea of there still being wholly 'indigenous' people is itself criticized, given the increasingly blurred boundaries between western and non-western cultures (Agrawal 1995; Dove *et al.* 2007). In the literature, there is a strong emphasis on the cultural situatedness of indigenous knowledge (Siebers 2004), though some also highlight its ties to the physical location where it has evolved (Strang 2004).

Traditional knowledge is in some ways similar to indigenous knowledge, though it does widen the scope beyond non-western cultures. The concept is firmly rooted in time, and does not allow for the changes which affect all types of knowledge as a result of interactions with other people and places (Ingold 2000; Sillitoe 2002). As with indigenous knowledge, the concept of traditional knowledge is impoverished by the increasing exchanges taking place throughout the world, which make the idea of a 'pure' and uninfluenced source of knowledge untenable (Agrawal 1995).

Although some terms have been narrowed down to describe knowledge relating to a specific resource, for example Fishermen's Ecological Knowledge (FEK), the additional value provided by some other terms is unclear. If approached from Ingold's (2000) situated knowledge perspective (a concept which will be reviewed in greater detail in section 2.5.1) the umbrella term 'local knowledge' is the most valuable, as other concepts highlighting the indigenous or traditional origin of knowledge appear to marginalize the spatial component which Ingold favors (Strang 2004). Figure 2.1 illustrates where the different types of knowledge fit in the situated knowledge spectrum of space, time and culture.

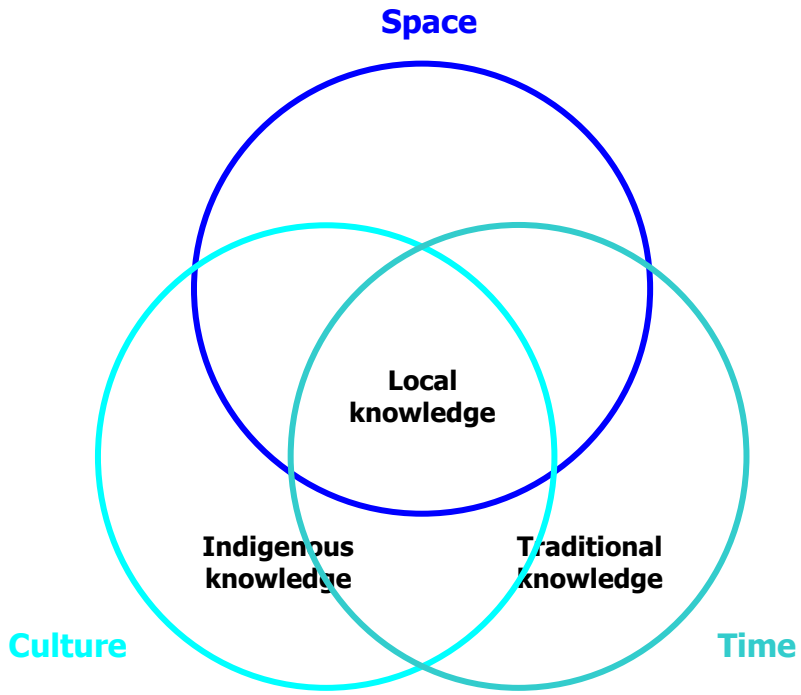


Fig. 2.1. Distribution of different local knowledge types in a situated knowledge spectrum

If a wider interpretation of situated knowledge is taken, as it is in this thesis – where knowledge is taken to be situated in space, time and culture – then many of the terms taken individually have merit, as they may for example stress the inter-generational transmission of knowledge (as with Traditional Ecological Knowledge). However, the term 'local knowledge' satisfactorily encompasses all of the different types of situated knowledge, and should be used not only because it is the most holistic, but also in the interest of simplicity and clarity. Indeed, some feel the multiplicity of terms is indicative of a lack of cohesion within research being undertaken on the subject (Nadasdy 1999; Sillitoe 2002).

Although the term Fishermen's Ecological Knowledge (FEK) will be used in the review of literature, the rest of the thesis will also refer to 'local knowledge'.

2.1.2 The resurgence of local knowledge

Increasing academic interest in local knowledge as an alternative to outsider knowledge can essentially be traced back to the 1950s (Dove *et al.* 2007), with the rise of ethnoecology or ethnobiology, defined as "the study of how people of all, and of any, cultural tradition interpret, conceptualize, represent, cope with, utilize, and generally manage their knowledge of those domains of environmental experience which encompass living organisms" (Ellen 2006). Although the initial focus of such research centered more on a cataloguing approach in relation to 'primitive' peoples (Ellen 2006), it subsequently moved to a more analytical and comparative approach, and has in some ways merged with the public participation and environmental justice agendas, which see citizens as experts in their own right (Fischer 2000). This growing interest is in many ways linked to the increased awareness of the deficiencies of scientific knowledge in explaining and solving environmental problems. For Agrawal (1995), it is also linked with the shift from all-encompassing to more locally-specific development theories. With the increasing recognition of non-expert, traditional, indigenous or local knowledge as being valuable, a growing body of research centers on the integration of said knowledge into natural resource management. According to Leach and Fairhead (2002), two parallel discourses have formed, one focusing on indigenous knowledge within developing countries, and the other on citizen science in more industrialized countries. For the authors, the concept of citizen science has emerged recently in the West as an alternative to science and in response to its perceived deficiencies, while that of indigenous knowledge has older roots in anthropological research, and emphasizes the strong social component of knowledge, mainly in research on rural areas in developing countries. This section examines the main resources on which this research focuses and lists the main justifications for increased use of local knowledge.

The study of local knowledge started within anthropology, but now involves several academic disciplines, such as international development and conservation, and spans a number of research areas, such as fisheries, agroecology, and forestry research. According to Ellen (2007), the larger proportion of the field research component in research on forests has lead to a greater degree of incorporation of local knowledge than in other disciplines. For Silver and Campbell (2005), fisheries research has been slower in taking up the idea of the importance of local knowledge, for a number of reasons.

"The Taylorist distinction between production and consumption of knowledge is increasingly questioned" (Siebers 2004)

Several arguments are put forward in advocating the greater use of local knowledge. One category of arguments relates to increasing the validity of scientific research, by supplementing it in the areas where it is deficient, namely local relevance of research (Fischer 2000; Sable *et al.* 2007; Williams and Bax 2007). In the case of fisheries, replacement of traditional or local knowledge by centrally

generated data has lead to a lack of locally relevant policies, on which problems like overfishing can partially be blamed (Fischer 2000). Lack of local relevance is particularly prominent in development studies, where examples of projects failing because of their failure to incorporate local knowledge abound; calls by donor agencies and researchers to break the top-down expert driven transmission of knowledge are increasing (Agrawal 1995; Siebers 2004).

This point relates to another argument put forward, promoting the benefits brought about by increasing the participatory and collaborative nature of scientific research. Local empowerment is seen as a means of increasing the quality of the outputs of scientific research, through participation in both formulation and implementation (Fischer 2000; Mackinson and Nøttestad 1998; Marzano 2007; Sillitoe 2002, 2007; Stanley and Rice 2007). Fischer (2000) sees local involvement in environmental management as vital given the local origin of many environmental problems.

A further category sees local knowledge as an essential component of scientific research; a good example of this is pharmaceutical research, where local indigenous knowledge of the medicinal properties of local flora and fauna is key to the development of new compounds (Sillitoe 2007). Often, local knowledge is also put forward as a first investigative step, which may save both time and money, by supplanting the need to conduct scientific research, or at least enabling a focus of research on certain priority areas (Sillitoe *et al.* 2004).

Research and incorporation of local knowledge varies not only in terms of academic disciplines and reasoning for its use, but also in the extent to which it is incorporated into decision making. Canada is considered to be a leader in terms of this incorporation, seeking to give an equal role to both indigenous and western science perspectives (Sable *et al.* 2007). Canadian research is used as an example in describing knowledge integration, in section 2.4.1.

2.1.3 Local knowledge in the research process

Very little recent research supports the wholesale substitution of scientific research by local knowledge; rather, local knowledge is seen as a supplementary source of knowledge, to be tapped before, during or after scientific research has been undertaken, or sometimes at all stages (Fischer 2000; Gilchrist *et al.* 2005; Sillitoe 2007). A number of researchers have questioned the current use of local knowledge within the research process, seeing as mistaken the trend of largely using holders of local knowledge as data collectors, rather than as an integral part of the entire research process (Fischer 2000; Stanley and Rice 2007; Williams and Bax 2007).

For Stanley and Rice (2007), fishermen are as skilled as scientists in the domain of experimentation, on which much of their experience relies; an acoustic study of widow rockfish in Canada is mentioned, in which fishermen were involved not only in formulating the research problem, but also in the selection of study sites and timings, as well as the analysis of results. Moreover, involvement of local

knowledge holders in all stages of the research process is likely to increase the degree of confidence in the research, as well as in any potential policy outputs from this research.

An example of local knowledge sought outside of the data collection step comes from south-eastern Australia, which was designated as a test case as part of Australia's Oceans Policy, a policy which takes a regional marine planning perspective. Because of the paucity of data regarding the region, local fishermen were recruited to help with ecological mapping (Williams and Bax 2007). The fishermen were used not only as data collectors, with the aid of vessels' track-plotters, but also as data interpreters, by being asked to give their opinion of the seabed habitats, something which they would assess for example by gauging the degree of wear on fishing gear (Williams and Bax 2007).

2.1.4 Focusing on fishermen's knowledge

As this thesis focuses on anglers, it is most useful to review the literature pertaining to fishermen's knowledge: how it can be captured and incorporated into management, and what the limitations to its use are. The following thematic literature review will therefore primarily focus on literature pertaining to fishermen's knowledge, though relevant examples from other disciplines will also be used where appropriate. Given that research on fishermen's knowledge has a high degree of commonality with research on other domains of local knowledge, it is felt the main themes identified within this review of literature also have a wider application. Much of the material provided in this section is taken from a previous paper written on the subject of fishermen's knowledge (Loftus 2009).

2.2 Local knowledge capture

The first step in any study on local knowledge involves capturing or gathering this knowledge, for subsequent analysis or integration into management. Several possible methods for doing so have been described in the literature; the limitations relating to local knowledge capture are also outlined.

2.2.1 Techniques

Several research methods have been adapted for the purpose of capturing local knowledge; two of these are Geographical Information Systems (GIS) and interviews.

The spatial component of local knowledge means it lends itself particularly well to systematization using GIS. Although not limited to fisheries (Sillitoe *et al.* 2004), the spatial conceptualization of fish stocks and fishing zones in fishermen's minds means GIS can be used to clarify and record their observations (Anuchiracheeva *et al.* 2003; Close and Hall 2006; Hall and Close 2007; Schafer and Reis 2008). In using GIS, the general format of research is to ask fishermen during interviews or workshops to position information on various topics – such as migration routes or fishing areas – on printed maps, and to subsequently digitize this information using GIS software. This approach can for example help identify overlapping fishing areas which may be at higher risk of overfishing (Hall and Close 2007). A novel approach, used by Schafer and Reis (2008), is to accompany fishermen around

the boundaries of their fishing areas, and record the coordinates using GPS technology. While this can be a rather time-consuming process, it does remove the potential for error associated with asking artisanal fishermen to utilize and understand maps (Close and Hall 2006).

A number of interview techniques have been devised to attempt to capture the richness of FEK while accounting for the fact that it may not come in the same format as scientific data. For example, some researchers use color photographs of various fish species when going through questionnaires and interviews with fishermen (Silvano *et al.* 2006; Silvano and Valbo-Jorgensen 2008; Valbo-Jørgensen and Poulsen 2000). This is particularly important in places where several names exist for the same species, or where on the contrary one name is attributed to an entire fish family. Another example is the use of timelines (recording yearly or daily trends) made by the fishermen themselves, in order to adequately capture the length and breadth of their knowledge (Píriz 2004). Given the fact that FEK is deeply embedded in practice, some researchers believe active participation in the fishermen's work is the best way to gain an understanding of their informal knowledge and practices, which are probably not recorded in writing (Knudsen 2008).

2.2.2 Limitations

The fact that levels of knowledge may not be equally distributed among members of a community or resource user group and the perceived sensitivity of some forms of knowledge are two of the main limitations relating to local knowledge capture.

When utilizing FEK, it is important to keep in mind that it may not be distributed equally amongst all members of a fishing community; this is in accordance with Ingold's (2000) hypothesis of knowledge accumulation as increased with the distance traveled over a lifetime. For example, one study found that fishermen using larger equipment possessed less FEK than those using smaller equipment (Wilson *et al.* 2006); differences can also be due to differences in age and/or diversity of fishing areas utilized. This has important implications for research design; if the 'wrong' fishermen are chosen to participate in, for example, in-depth interviews, this may skew the data output (Close and Hall 2006; Davis and Wagner 2003; Drew 2005; Murray *et al.* 2006; Murray *et al.* 2008; Silvano *et al.* 2006; Silver and Campbell 2005; Wilson *et al.* 2006). In order to avoid these pitfalls, it is important to select fishermen carefully; this can be done by choosing those with the longest experience in the field (Silvano *et al.* 2006), or by using a systematic methodology to determine who the most knowledgeable fishermen are – such as using a system of peer referencing and aggregation of results in a rank-ordered list (Davis and Wagner 2003). Davis and Wagner's paper (2003) is highly critical of current ethnobiological research on FEK, in terms of the methods used to select participants and informants.

The knowledge held by fishermen undertaking fishing activities of a commercial nature is subject to some particular considerations; these fishermen may feel their knowledge is of commercial value and hence should remain confidential (Close and Hall 2006; Drew 2005; Maurstad 2002), and may also feel that any use of their knowledge in the interest of environmental management is likely to lead to

more restrictive regulations, and is therefore not in their commercial interest to engage in (Silver and Campbell 2005; Williams and Bax 2007). This may affect the quantity and veracity of responses received; the same is true if fishermen have a negative perception of conservation in general (Silver and Campbell 2005). In the south-eastern Australia case mentioned previously, although the majority of fishermen viewed the initiative as positive, because it allowed for greater involvement of fishermen in the formulation of relevant policies, some fishermen were more cautious, conscious of the potential for the initiative to backfire against them. Indeed, if the effort to catalogue ecological diversity was to reveal a high level of biodiversity, this may mean closure to fishermen of a highly productive area (Williams and Bax 2007). Research should be designed in order to assure the confidentiality of any information given – particularly if the results are to be publicized – if researchers want to ensure they get correct and complete data from fishermen.

2.3 Local knowledge analysis

Following its collection, local knowledge usually undergoes a stage of analysis, either through GIS software, databases or the use of modeling. Available methods of analysis are subject to some limitations, which are also outlined in this section.

2.3.1 Methods

The use of GIS also allows for the storage of non-map information, in linked databases, text files or photographs (Hall and Close 2007; Harmsworth 1998); this approach is particularly valuable, as it captures the varied nature of local knowledge. The relatively low cost involved in obtaining local information through interviews and subsequently inputting this into GIS software is one of the main advantages of this method; however, according to Sillitoe *et al.* (2004), overcoming the disadvantages of this method using more in-depth analysis would require much higher expenditure.

The data obtained from interviews is often entered into databases and statistically analyzed (Baird and Flaherty 2005), as would be done in a classic scientific survey.

Modeling is another tool which has been proposed to make FEK useable. For example, one piece of research uses data from interviews and sampling and analyses it according to an optimum foraging model (Begossi 2008). Another is based on a consensus model, and seeks to compare responses from different groups of fishermen using factor analysis (Wilson *et al.* 2006). Recognizing the deficiencies of attempting to fit FEK into mathematical models, some researchers have used an expert system model, a concept borrowed from artificial intelligence, to better use FEK (Grant and Berkes 2007; Mackinson and Nøttestad 1998). This model sees fishermen as adaptive experts, who use the sum of their knowledge to guide them through decision-making processes.

2.3.2 Limitations

- **Validity of local knowledge**

Notwithstanding similar criticism which can be directed at scientific knowledge, FEK is not always correct or complete; this has repercussions on the quality of the data output. According to some studies, fishermen may lack knowledge about certain aspects of fish biology such as reproduction, diet, fish densities, and changes in fish stocks (Baird and Flaherty 2005; Begossi 2008; Bergmann *et al.* 2004; Mathooko 2005; Silvano *et al.* 2006; Silvano and Valbo-Jorgensen 2008; Wilson *et al.* 2006). For example, fishermen on the Mekong River have a poor understanding of the location of spawning grounds; while this can be explained by the high turbidity of the river, it does reveal one of the limitations of the use of FEK (Valbo-Jørgensen and Poulsen 2000). In a related point, some aspects of fish biology may take place outside of the sphere in which the fishermen's knowledge is situated. For example, fishermen in Brazil do not have extensive knowledge on the reproduction of pelagic fish, simply because it takes place at sea, beyond the reach of their vessels (Silvano *et al.* 2006). A solution applied on the Mekong River was to aggregate multiple local surveys in order to obtain a complete picture of fish migration along the river (Valbo-Jørgensen and Poulsen 2000).

Although Fischer (2000) uses this argument in relation to agroecology and not fisheries management, the conclusions he draws have a wider application. For him, the limitations of local knowledge use relate not to detailed issues, but rather to the larger issue of systematization and incorporation of local knowledge using scientific methods and structures. Indeed, he feels the methods used by researchers fail to properly incorporate the true nature and purpose of local knowledge, and hence its overall significance is not adequately captured, as it would be if research was conducted from within the social system being studied (Fischer 2000). This idea returns to Ingold's (2000) view of situated knowledge as rooted in practice and technique.

- **Format of local knowledge**

The most oft-cited limitation to the use of FEK is the fact that it comes in different formats, and is thus neither easily made compatible with existing scientific structures, nor easily communicated to others in a fishery management setting (Agrawal 2002; Anuchiracheeva *et al.* 2003; Baird and Flaherty 2005; Close and Hall 2006; Davis and Wagner 2003; Drew 2005; Mackinson and Nøttestad 1998; Píriz 2004; Schafer and Reis 2008; Varjopuroa *et al.* 2008; Wilson *et al.* 2006). Fishermen's knowledge is often locally-specific and unsystematic; it is therefore difficult to draw wider conclusions from it, which is usually the aim of fisheries management (Schafer and Reis 2008).

Integration of local knowledge often entails its repackaging into existing means of analysis, such as databases, models, or geographical software. However, such analytical tools often have pre-existing requirements in terms of the type of data and information which can be inputted into them – requirements which local knowledge may not necessarily be able to meet. As a result, some local knowledge must sometimes be discarded, regardless of its value or relevance; this can happen in

relation to GIS packages (Ellen 2007), modeling software (Mackinson and Nøttestad 1998) or databases (Baird and Flaherty 2005). For example, data relating to factors which local fishermen on the Mekong River believed to be important to the success of particular fish species' survival rates were discarded from a study because they populated only sparsely the data matrices established by the research project (Baird and Flaherty 2005).

2.4 Local knowledge integration

Knowledge integration contains two main steps: obtaining the knowledge, followed by incorporating it into decision making; for Nazarea (1999), research on incorporation of local knowledge into decision making is lacking in ethnoecology, which has on the whole focused more on describing and classifying indigenous knowledge than on using it in a more applied way. A key consideration pertaining to the second step relates to the nature of the knowledge in question, and its potential relevance to policy and management. According to Fischer (2000), it is this deficiency in terms of relevance of knowledge which has excluded citizens and their knowledge from involvement in decision making processes, particularly in the technically-dominated environmental field.

Although integration into management is not the aim of all local knowledge collection – some being geared more towards archiving of knowledge for posterity (Agrawal 1995) – it is an important part of some local knowledge research. This section presents the specific case of Canada, given that section 2.5.2 gives a wider perspective of local knowledge integration. Local knowledge integration faces some limitations, which are outlined in this section. Finally, this section presents an overview of the differences in local knowledge research in developed and developing countries.

2.4.1 Local knowledge integration in Canada

Canadian policies towards local knowledge integration are both anticipatory and reactionary. Legislation provides for the use of indigenous knowledge within Environmental Impact Assessments, and "some northern communities […] have direct input into the research permitting process that then gives them some influence on the research process" (Brook and McLachlan 2005). Indigenous knowledge is also an integral part of the government's research efforts; for example, Environment Canada has been running since 1997 a project with the Innu Nation in Labrador in order to compile baseline ecological data (Sable *et al.* 2007). For Murray *et al.* (2006), efforts by the Canadian government to integrate fishermen's knowledge – for example in stock assessments and management regimes – were made in an effort to regain legitimacy, lost in the wake of the collapse of cod stocks.

2.4.2 Limitations

Local knowledge integration can be constrained by practical limitations, relating for example to existing legal frameworks or research capabilities; however, it is also subject to more fundamental conceptual limitations.

- **Subjectivity and local knowledge**

Since fishermen's knowledge is so intimately linked to their livelihoods, it could be regarded as a biased source of information. Surprisingly, few academic articles mention this potentially large bias as a limitation of their research (Mackinson and Nøttestad 1998; Silver and Campbell 2005; Wilson *et al.* 2006). Of these three articles, Silver and Campbell (2005) is the most detailed and outspoken on the topic; however, their work is cited in none of the 14 relevant articles (written after 2005) reviewed in this paper. It is possible that the limitation is overlooked because it affects the very core of the research done.

- **All knowledge as situated knowledge**

In their study of First Nation fishermen in Canada, Menzies and Butler (2007) write of the fishing techniques of the Gitxaała people, which are more effective in maintaining sustainable fish populations. However, though these techniques could be thought to constitute best practice for the management of salmon runs, the authors posit that they would probably not be successful if applied to another context. This site-specificity of the traditional techniques is in large part due to the fact that they are closely linked to the particular social relations of the Gitxaała people. For example, the techniques are guided by underlying principles of "need-based resource use" and "goal-oriented harvesting" (Menzies and Butler 2007), which lend more support to sustainability than mere technologies.

This example can be linked to a wider issue regarding the situated nature of fishermen's knowledge. Indeed, if FEK is accepted as being situated (in place, time and/or culture), then it is conceivable that this knowledge might be of limited applicability in a wider setting. Naturally, the concept of situated knowledge, according to Ingold (2000), applies just as much to science; this particular conceptual limitation to FEK need therefore not render it less valuable than scientific knowledge. A possible solution to this limitation could be to make the output of research on FEK as locally-specific as possible, i.e. without attempting to draw from it wider conclusions and weaken its relevance; this would imply re-tailoring fisheries management to take account of local variability.

2.4.3 Research in developing and developed countries

The biggest difference between research in fisheries in developing and developed countries is that the research in developing countries tends to focus on artisanal-style fisheries, which use more traditional techniques, while that in developed countries (apart from some examples focusing on the fishing methods of aboriginal communities) tends to focus on small-scale fisheries which use more modern techniques. While this may very well be a simple reflection of the reality on the ground, it has implication in terms of the research methods used; a good example is the use of GIS. Research using GIS to systematize FEK in developed countries uses detailed maps, such as nautical charts, as well as advanced technologies, such as interactive GIS platforms (Murray *et al.* 2008) and GPS (Bergmann *et al.* 2004). The results of this research are likely to have little replicability in developing countries, where use and understanding of these methods is likely to be very low; moreover, claims

that FEK is becoming increasingly compatible with scientific knowledge as use of technologies such as GPS spreads (Murray *et al.* 2008) cannot be extended worldwide. A number of authors see FEK as having particular value for tropical fisheries, because of their high biodiversity value, and also because of the dearth of research on fisheries in these areas which results from the complexities of conditions (Baird and Flaherty 2005; Johannes 1998; Silvano *et al.* 2006; Silvano and Valbo-Jorgensen 2008; Wilson *et al.* 2006).

In sum, there does not appear to be a profound gulf between research on fisheries in developed and developing countries. However, one does get the impression that research in developing countries often takes the view that FEK is 'better than no research at all' and should be the first step before scientific methods are used. On the other hand, research in developed countries sees FEK as an interesting addition to scientific knowledge, and an important component of public participation practice.

2.5 Conceptual framework

The conceptual framework for the thesis is contained within the key words of the research question, as illustrated in figure 2.2.

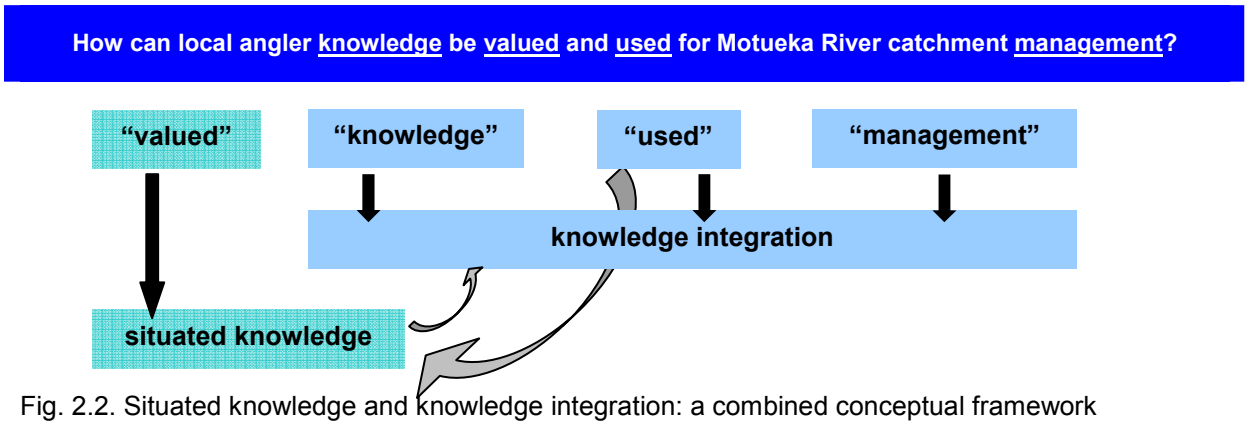


Fig. 2.2. Situated knowledge and knowledge integration: a combined conceptual framework

For the purposes of this thesis, the analysis process was divided into two distinct parts. The first sought to determine what knowledge anglers possess, and whether it was of intrinsic value, whereas the second part looked at the feasibility of using angler knowledge for Motueka River catchment management. In order to facilitate analysis, two separate conceptual frameworks were developed.

Even though knowledge integration is the main frame of reference for this thesis, the subject of the value of local knowledge is best separated and analyzed through a situated knowledge lens. Indeed, if the results of this analysis were to determine that angler knowledge is not readily usable for catchment management, this may be for reasons unrelated to the inherent value of this knowledge. By the same token, seeing knowledge as situated may place some limitations on the extent to which angler knowledge can be used.

Other conceptual frameworks could have been chosen for this analysis; one example is that of power and hegemonic discourse, concepts which are referred to by a number of authors (Agrawal 1995; Leach and Fairhead 2002). For example, Jackson (2008) sees an initiative promoting Māori management of local fisheries, taiāpure, as furthering the hegemony of non-indigenous institutions rather than leading to empowerment of New Zealand's Māori people, its ostensible aim. Given that the reflections on integration presented below take these concepts of power relations into account, the more all-encompassing conceptual framework of knowledge integration was privileged.

2.5.1 Situated knowledge

The concept of situated knowledge is one derived from Ingold's (2000) anthropological work, and one alluded to by others (Agrawal 2002; Bebbington 1994; Davis and Wagner 2003; Drew 2005; Fischer 2000; Gilchrist *et al.* 2005; Knudsen 2008; Lien 2007; Maurstad 2002; Murray *et al.* 2006; Murray *et al.* 2008; Píriz 2004; Strang 2004). Ingold sees knowledge as shaped by an individual's lifelong interactions within his or her environment, rather than transmitted genealogically at a single point in time, and also sees the situated or intuitive nature of knowledge as common for all humans. The concept of situated knowledge therefore has important implications for scientific knowledge, one of whose main aims is to disassociate itself from the cultural context in which it is produced. According to Ingold (2000) and others (Fischer 2000; Leach and Fairhead 2002; Stanley and Rice 2007), scientific knowledge, both in terms of the individuals and the institutions which produce it, is also subject to the influences of space, time and culture. Although determining the degree of situatedness of scientific knowledge is not the purpose of this study, this idea does have bearing on the evaluation of the relative value of local knowledge, and will be revisited.

"What one observes in the physical world depends in important ways on where one stands" (Fischer 2000)

If local knowledge is accepted as being situated in time, place and culture, this has necessary implications for its integration into management. Though Agrawal's (1995) critique of knowledge preservation is directed at indigenous knowledge researchers, its main arguments have application for wider sources of local knowledge. Indeed, he sees the main proposed method of preservation, namely storage in archives, as inherently at odds with the main characteristic of indigenous knowledge that gives it its value: its local specificity (Agrawal 1995). The situated knowledge concept gives rise to the idea of local knowledge integration being most valuable at the most site-specific scale of management, and decreasingly valuable and relevant as the management scale covers a larger and larger area, be it in terms of subject, geographical space, or time limit.

A further aspect of local knowledge is its rooting in practical action, rather than in theory and documentation. This facet of situated knowledge has important implications for its conceptualization and incorporation into wider contexts; its acquisition through time spent in a particular location and as part of a particular set of activities is quite different from the more temporary and observational role of

scientific research (Ingold 2000; Sillitoe 2007). The often tacit nature of local knowledge, as well as its general lack of documentation, is one of the biggest obstacles to its widespread use. For example, classification of forest types by the Nuaulu in Indonesia, as described by Ellen (2007), has evolved organically as a result of continual interaction with the forest itself. In response to the variability of the forest resource, the local classification is not only dynamic but also lacks harmonization amongst individuals, who may have varying but equally valid and extensive knowledge of forest types (Ellen 2007). This lack of singular and widely accepted classification may be more appropriate to the local forest dynamics, but is also a hurdle in its amalgamation and translation into appropriate policy tools.

"People do it, they do not debate it" (Sillitoe 2007)

Ingold's view of situated knowledge as gained through a lifetime of interaction with the environment, as opposed to transmitted genealogically, is supported by evidence of expertise accumulated through practical activity, for example in the case of the anglers interviewed for the purposes of this study. However, there is also a body of evidence supporting the idea of hereditary transmission of knowledge, particularly in cultures where knowledge is transmitted orally and not recorded through other means. It is likely that there is a case to be made for both means of transmission; a good example is the knowledge of biodiversity within the Innu Nation in Canada. The knowledge is possessed by elders but in danger of being eroded, not only as they pass away without being able to transmit it to the younger generation (genealogical transmission), but also because the younger Innu lead different lifestyles with much less interaction with their environment (relational exchange of knowledge) (Ingold 2000; Sable *et al.* 2007). The multiplicity of possible means of knowledge transmission gives additional weight to the use of the term 'local knowledge', which eliminates the solely hereditary transmission implied in the term 'traditional knowledge' (Gilchrist *et al.* 2005).

Ingold's situated knowledge theory has a strong geographical focus; for him, knowledge of the environment is derived from spatially-situated practices (Ingold 2000). Although this view of knowledge is valuable, the concept of situated knowledge as applied in this study is widened beyond the spatial focus, to include culture and time as contexts upon which knowledge can be dependant. Placing local knowledge in a particular spatial, cultural and temporal context adds depth to the evaluation of its value and likelihood of incorporation into management.

2.5.2 Knowledge integration

Once local knowledge has been captured and recorded, a question arises: what next? The review of literature undertaken for this thesis supports the idea that the manner in which knowledge is integrated is largely driven by the initial aims of the research; two main aims put forward by researchers are the empowerment of knowledge holders, and the collection of data. Although the two aims are not necessarily contradictory, researchers appear to privilege one or the other.

The two predominant and opposite views on the subject are well illustrated by the exchanges of views between Gilchrist and Mallory (2007; 2005) and Brook and McLachlan (2005). The first group of researchers sees local knowledge as a data source like any other, which must be subjected to rigorous analysis in order to contribute to management in a meaningful way. The authors evaluated the local knowledge held by some indigenous persons about four species of migratory birds in Canada, and found that the levels of knowledge varied according to the species of bird under study and the individuals interviewed, and also that while some previously unknown data was obtained, in many instances the information was limited to large declines rather than precise population variations (Gilchrist *et al.* 2005). The second group of researchers takes the view that the inherent value of local knowledge is compromised by attempts to evaluate it based on comparisons with scientific knowledge, which they see as subject to its own set of biases and imperfections. For the authors, using scientific data as a validation tool merely perpetuates the power imbalance which they feel places local knowledge holders at a disadvantage (Brook and McLachlan 2005).

The fact that knowledge is held by people who are often marginalized in terms of decision making is a particularly strong feature of research on indigenous knowledge. The emphasis on power relations, and the perception of local knowledge integration as a tool for empowerment, is in that case particularly relevant; for some researchers, empowerment is the main aim (Brook and McLachlan 2005; Silver and Campbell 2005). According to Berkes (2004), the success of this approach is demonstrated by the increasing use of knowledge as a tool to further political and territorial aims in some regions. For some authors (Agrawal 1995; Leach and Fairhead 2002), the main focus of research on local knowledge should be on the power relationships, whether social or institutional, which underpin society. For Agrawal (1995), indigenous people would be better served by an acknowledgement of the asymmetries of power which bring about their marginalization. Leach and Fairhead (2002) demonstrate, through case studies of hunters in developing countries, that terms used to qualify different types of knowledge are actually better suited to characterize the relations between knowledge holders and resource managers. Although these authors focus on indigenous knowledge in developing countries, their work can be seen to have implications for the integration of local knowledge in general. Indeed, if the aim of local knowledge integration is to empower knowledge holders, and if one sees power as producing knowledge rather than the reverse (Agrawal 1995), then the ability of integration to facilitate empowerment will be limited. Notwithstanding discussions of power relations, research on local knowledge has the potential to achieve effects diametrically opposed to the original aim, and instead “further disenfranchise” (Silver and Campbell 2005) the knowledge holders, if the information they provide is either not used, or indeed used against their interest in decision-making.

The second main aim of local knowledge research is to gather data, in order to inform scientific research and/or management decisions. In this case, ‘moral’ considerations regarding the research participants are less prevalent, the emphasis being rather on the quantity and quality of the data output, as well as its usability for management purposes.

A third view of local knowledge research does not actually necessarily promote its integration into management. Indeed, it sees the mere fact of gathering knowledge and interacting with the fishermen as achieving a positive environmental outcome (Mackinson and Nøttestad 1998).

2.6 Summary

Research on local knowledge, despite over 50 years of history, is still subject to many debates and disagreements; this review has attempted to present some of the most important ones. The thesis takes the view that the concept of local knowledge is the most useful and inclusive, and that it is most closely related to the framework of situated knowledge which is put forward.

Despite the shortcomings of local knowledge, the consensus nevertheless appears to be that using it leads to a positive end sum. In gathering knowledge, accepting the trade-off between reliability and cost seems to be a key point for many researchers, in that the benefits of obtaining local knowledge relatively cheaply and easily outweigh the possible loss of objectivity and thoroughness. Analysis of local knowledge mostly centers on the question of how best to integrate qualitative data into quantitative analysis. The extent and type of integration of local knowledge into management is largely driven by the initial aims behind the capture of said knowledge.

Within studies of local knowledge, research broadly revolves either around indigenous and traditional knowledge within developing countries, or around citizen science in developed countries. A similar dichotomy exists within research on fishermen's knowledge, where a large body of work is given over to research on traditional fishing methods in developing countries, which includes many of the challenges particular to the study of indigenous knowledge. The work that is done on fishermen's knowledge in developed countries mostly focuses on commercial fishermen and their knowledge of fish population characteristics; this thesis instead focuses on the knowledge possessed by recreational fishermen.

3. Methodology

Signs - Water Conservation Order and Didymo warning

This section describes the formulation of the research question underpinning the thesis, and outlines the different elements of the research design, namely archival research, data collection and data analysis. Finally, the main limitations to the research are described.

3.1 Fishermen's knowledge – preliminary study

The research undertaken in this thesis is a continuation of the work carried out for the Applied Research in Preventative Environmental Approaches (ARPEA) course at the IIIEE (Loftus 2009). This paper focused on the use of fishermen's knowledge for fisheries management. The scope of the paper was limited to small-scale fisheries in freshwater and coastal areas, providing commercial and/or nutritional benefit to fishermen, and did not include recreational fisheries. It helped to identify the main sources of academic research on the use of fishermen's knowledge, as well as the main tools which have been proposed for the use of this knowledge, but also highlighted a need for further research, to which this thesis endeavors to respond.

3.2 Research design

The overall thesis design was divided into three phases: initial archival research, fieldwork (interviews), and results analysis. The research question and objectives were determined prior to the start of the interview stage, which enabled the formulation of key objectives which the interviews aimed to meet. In addition to relevant archival research carried out by Loftus (2009), the review of literature was also part of a continuous learning process throughout the fieldwork period. The fieldwork was conducted in New Zealand, as part of an internship at Landcare Research, from February to April 2009. Although the three parts of the research design were quite distinct in purpose, the approach to research actually followed a circular Plan-Do-Check-Act pattern rather than a linear one (figure 3.1), emphasizing flexibility and incorporation of lessons learned. This process took place not only between the different stages of research, but also within them. For example, as will be developed later, a pilot interview was conducted for the purposes of verifying the suitability of the questionnaire design, and led to minor modifications being made. Also, as part of the analysis of fieldwork results, the interview validation process partly involved a review of statements based on existing literature.

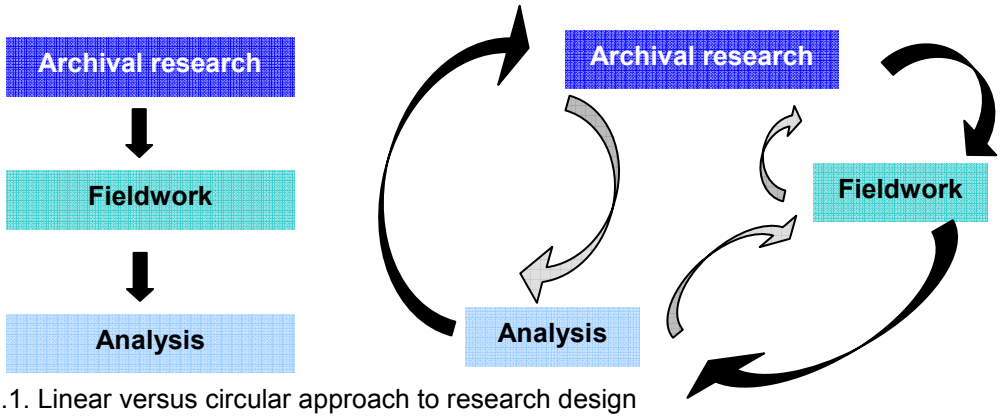


Fig. 3.1. Linear versus circular approach to research design

3.3 Data collection

3.3.1 Archival research

The first step of data collection involved archival research, covering a number of different sources, as well as a variety of themes. The conceptual framework of the thesis determined the main themes of the archival research, the results of which are presented in the review of literature in section 2.

3.3.2 Interviews

3.3.2.1 Selection of participants

Selection of interview participants was primarily based on an existing list of experienced anglers who participated in a 2000-2001 National Institute of Water and Atmospheric Research (NIWA) survey. The survey was commissioned by Fish and Game New Zealand (FGNZ) and collected angler perceptions of the state of New Zealand's lowland rivers and their associated trout fisheries. The selection method for the original NIWA survey was not random, but instead consisted of anglers who responded to a notice in a FGNZ magazine, were personally known to FGNZ staff, or were identified by local angling clubs (Jellyman *et al.* 2003). Data from survey respondents was screened to select anglers with over 10 years of experience (Jellyman *et al*. 2003).

Twenty angler names were initially provided to Landcare Research by NIWA; two additional names of anglers personally known to FGNZ, were subsequently provided. Of the anglers, three left the Motueka River catchment area, and three passed away. One angler was away from the region during the fieldwork period, and was substituted by a peer-recommended angler, bringing the total number of anglers interviewed to sixteen.

Both this study and the NIWA survey sought to contact the most experienced anglers in the region, as opposed to the largest possible number of anglers. The lack of randomized sampling in both studies is justified by the need to obtain information covering a long historical period, from anglers who frequently use the catchment. Lack of representativeness is therefore not seen as an issue; however, it must be noted that the discussion of results only represents the views of a subset of Motueka anglers – the section on limitations covers this topic in more detail. Indeed, the anglers interviewed for this study are likely to be very different from the average angler in the region, who holds a fishing license but may only go fishing a few times per year (Deans pers. comm.).

In addition to the anglers, a number of persons involved with catchment and natural resource management were also interviewed: two persons working at Tasman District Council, the unitary authority with responsibility for the Motueka catchment, one person from Nelson/Marlborough Fish and Game, and one person from Landcare Research. The aim of these interviews was to understand if and how angler knowledge can be used for catchment management. As the angler interviews formed the bulk of the work undertaken for this thesis, most of the sections under 3.3.2 are dedicated to explaining their methodology – a separate section, 3.3.2.8, provides more detail on the management-oriented interviews.

3.3.2.2 Questionnaire design

The objectives of the interview process were established prior to the questionnaire, correspond to the general objectives of the thesis in general, and were essential to establish in advance in order to facilitate the analysis of results.

- To determine what knowledge the anglers possess. This involved determining the breadth of fishing experience, as well as asking questions relating to sedimentation and other environmental processes.
- To determine the characteristics of the knowledge that may play a part in determining to what extent it can be integrated in catchment management. This included asking questions on how knowledge is recorded, as well as questions pertaining to social interaction amongst anglers.

In order to ensure all questions asked in the interviews were relevant, a question-by-objective matrix (Pollock, Jones, and Brown 1994) was constructed.

The angler interview questionnaire (appendix 1) fits a semi-structured in-depth approach (Bryman 2001). For example, a number of questions were designed to obtain information about location, timing, and severity of sediment events. Also, interviewees were asked to complete a separate sheet regarding their opinion of management measures (appendix 2). However, in addition to this specific information, interviewees were encouraged to provide any additional information or anecdotes about their personal experiences relating to the catchment. In many cases, the information gleaned from these unstructured comments proved to be equally valuable for the research.

Anglers were asked to bring their fishing diary (if they keep one) to the interviews, in the hope of obtaining some dated observations regarding sedimentation and other events.

The sequence of questions was laid out to maximize interview output; the first two sections contain general questions about the angler's personal fishing experience and ways of recording knowledge, helping to put interviewees at ease. In contrast, the more challenging and opinion-filled questions are located towards the end of the questionnaire – to be asked when interviewees had hopefully become comfortable with the fact of being recorded and the interview process itself.

3.3.2.3 Visual materials

In recognition of the strong visual component involved in fishing, the questionnaire sought both to use and obtain visual materials to support the information extracted from anglers. Anglers were asked if they used any visual means of recording events during fishing trips, such as photographs. The aim of this question was not only to try and obtain useful supporting materials – e.g. photographs showing sedimentation in a reach of the river – but also to get a sense of how fishermen approached environmental issues, for example if they took photographs of what they defined as environmental damage in the river.

In addition, interviewees were asked to identify from a series of photographs the severity of the sediment events which they encountered (figure 3.2). This visual support was established in an effort to facilitate comparisons, as different persons may have different opinions regarding what constitutes slight, moderate and severe sedimentation. This scale was modeled on the format used by Landcare Research in its annual assessment of sediment levels (figure 3.3) where researchers note both the dominant substrate particle size (large pebbles or boulders, etc…) as well as the percentage within the defined area covered by fine sediment, defined as ≤ 2 mm.

Fig. 3.2. Scale of sedimentation severity used in interviews

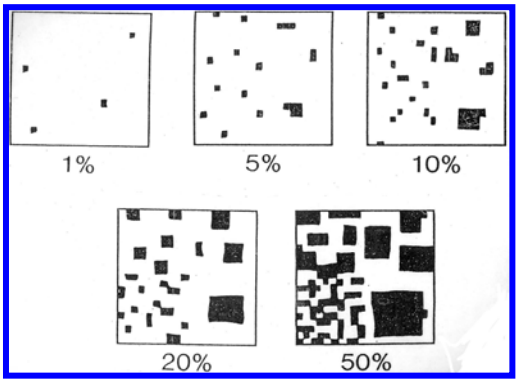


Fig. 3.3. Scale of sedimentation used by Landcare Research

Finally, a map showing the main bridges within the Motueka catchment was used during the interviews (figure 3.4), not only to aid with identification of the areas predominantly fished, but also to ensure clarity of communication between interviewers and interviewees.

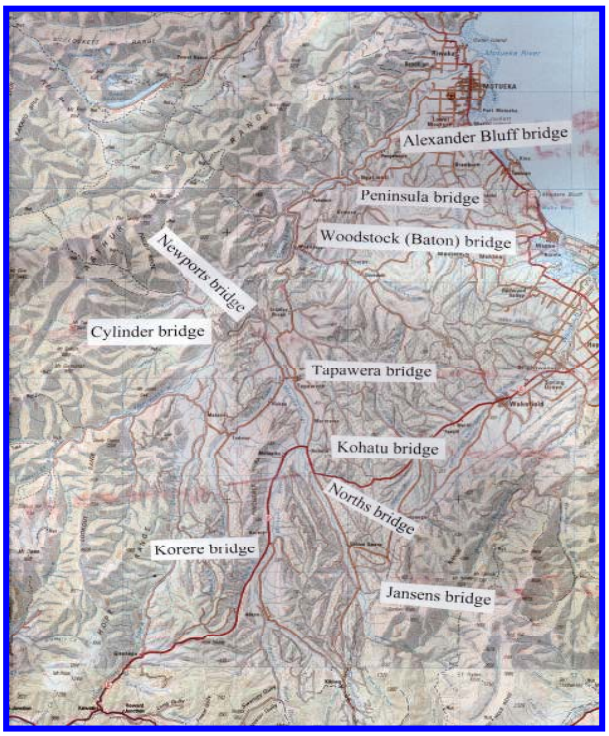


Fig. 3.4 Motueka catchment map, including main bridges

3.3.2.4 Questionnaire modification – pilot interview

As mentioned previously, the questionnaire design benefited from the continuous improvement approach followed throughout the research: a pilot interview was conducted to refine the questionnaire, and ensure its appropriateness for the target group. A number of useful lessons were drawn from this pilot interview, supporting the argument for use of local knowledge in research design. For example, the map used for the identification of sediment event locations was modified to show the names of the bridges in the catchment, and not merely the names of the tributaries of the Motueka River. Indeed, the pilot interviewee informed us that anglers primarily located themselves according to the access points to the river, something which was subsequently verified in the interviews. Also, a question regarding the use of vehicles during fishing trips was added, as it became apparent that anglers' perceptions of a river might vary according to the time spent and distance covered in a particular reach of the river. A question regarding angler observations of changes in abundance of trout food was also added, after the pilot interviewee revealed himself and other anglers he knew had observed a similar trend in invertebrate populations. Finally, the word "fine sediment" was supplemented by the word "sand" in order to cover the full spectrum of particle sizes which fishermen might be observing, or might consider as sediment.

3.3.2.5 Interview procedure

Anglers were initially contacted by letter in April 2008, and subsequently contacted again in January 2009, and informed of the study aims. The anglers were then contacted by telephone to arrange precise interview times.

At the start of the interviews, the interviewees were (i) informed of the main aims of the project, (ii) explained the structure of the interview, (iii) assured confidentiality, and (iv) asked to reconfirm that they agreed to the recording of the interview. At the end of the interviews, interviewees were thanked for their participation in the study, asked if they wished to see a copy of the transcript of their interview, as well as to receive a copy of the thesis itself. Interviews took between 50 and 130 minutes (mean= 90 min), and were conducted mainly in the homes of the interviewees. The interviews were recorded using iTalk and Olympus WS-210S technology, and both a Senior Scientist at Landcare Research and myself were present at the interviews.

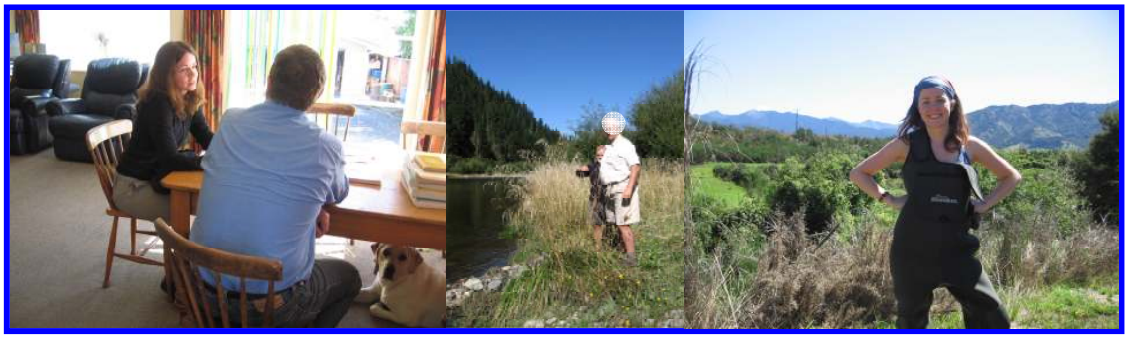


Fig. 3.5. An angler interview, and spending some time getting to know the Motueka catchment

3.3.2.6 Post-interview work

All interviews were fully transcribed, and interviewees were asked if they wanted a copy of the interview transcript for verification. Eleven interviewees asked for such a copy, and six subsequently sent comments, usually minor additions as well as place and person name clarifications where necessary. This respondent validation (Bryman 2001) was useful not only to add a layer of verification and to provide the opportunity to obtain additional information, but also as a means to involve respondents further with the research project, by partially illustrating how the knowledge they have shared will be used. This was also done by asking respondents whether they wanted to receive a copy of the thesis, which fifteen anglers requested. The thesis will also be made available on the Landcare Research ICM website.

3.3.2.7 Ethical considerations

Interviewees were ensured confidentiality prior to the start of the interviews. First and foremost, the promise of confidentiality was made in recognition of the sensitive nature of some of the solicited information. Indeed, interviewees were asked not only for personal data such as date of birth, employment and level of education, but also to provide information about their favored fishing locations, as well as opinions regarding current fishery and environmental management measures. The main manifestations of this policy are the use of aliases for each interviewee, as well as the use of personal data in general terms only, given the links within the angler community.

As outlined by Maurstad (2002), fishermen's knowledge can hold important commercial value. Although commercial considerations would only apply in this instance to the several fishing guides

interviewed, anglers' knowledge of fish location and behavior can be seen as valuable to them in other ways. Indeed, their enjoyment of the recreational sport of fishing can depend for example on their ability to catch fish, as well as on the ability to spend time alone in a particular place, either of which might be jeopardized by an increase in the number of encounters with other anglers. This study was designed in such a way as to prevent any potential negative impact of the research on respondents, and therefore avoided revealing for example the precise areas in which interviewees concentrate their fishing effort.

Another associated reason for ensuring confidentiality was to maximize the amount of information gathered during interviews; anglers may for example not have wished to specify where they fish the most if they thought this information might be made publicly available, but this information was important in order to determine what breadth of knowledge an angler may have of a particular reach of the river. Interestingly, nearly all interviewees expressed indifference when informed that the interviews would be confidential, suggesting that their opinions were either already well known or that they would be happy to reveal them.

As a way of ensuring that the interview design met general ethical requirements for social research involving human participants, I applied to receive approval under Landcare Research's Social Ethics approval process. This process involves a peer review of the entire interview process, starting from the purpose of the study and the selection of participants, and going through to the intellectual property considerations as well as provisions for the future use of interview data. Although this process is not obligatory for the undertaking of social research at Landcare Research, I felt not only that the project would benefit from the added legitimacy awarded by a peer-reviewed process, but also that the methodology of the interview process would become more rigorous as a result. Approval for the project was received on the 26th of February 2009.

3.3.2.8 Management-oriented interviews

Interviews of persons involved with the management of the Motueka catchment were conducted in parallel with and subsequent to the angler interviews. As with the angler interviews, the sample chosen did not presume to be representative, but instead sought to provide an insight into the potential for the use of local knowledge in catchment management. Although these interviews did not follow a single set questionnaire, but were instead tailored to the specific roles of each interviewee, many of the other methodological elements were the same as for the angler interviews. However, unlike the angler interviews, these interviews were not treated as confidential, as none of the interviewees requested anonymity when asked at the start of the interview. These included the following:

- Water Quality Scientist, Tasman District Council
- Policy Planner, Tasman District Council
- Manager, Nelson/Marlborough region, Fish and Game New Zealand
- Senior Scientist, Landcare Research New Zealand

3.4 Data analysis

3.4.1 Validation of interview responses

Given the anecdotal nature of many of the responses elicited by the questionnaire, validity and reliability were particularly difficult to assess. Three main methods were used:

- Comparison of statements made during each interview to determine whether there were any inconsistencies within the story(ies) told by each angler.
- Cross-checking of information within the angler sample; this particular method was used as much to identify any outlying opinions as to determine validity. Indeed, the expression of a view contrary to all others was not necessarily seen as evidence of its falsehood, particularly given the small size of the angler sample.
- Triangulation with other sources of data: statements made were compared, where possible, to existing information on the subject, from both scientific and non-scientific sources. For example, angler hypotheses regarding possible drivers for variations in trout numbers were compared to existing scientific research, while recollections of sediment events were compared to written records published by the forerunner of FGNZ. The opinion of a leading salmonid scientist was also sought regarding some of the statements made.

For some of the types of information gathered in the interviews, only the first two methods of validation could be used, because of a lack of existing research on a given topic.

3.4.2 Analysis of interview responses

Some of the key words within the research question formed the basis of the analysis of interview results, by helping to set objectives for the research: to find out what knowledge anglers possess, and also to determine whether or not it is of value.

The analysis of interview results combined a number of methods, including univariate analysis such as frequency counts and measures of central tendency, and also using some methods proper to qualitative analysis, such as meaning condensation, clustering, scoring, categorization and integrating specific points into wider categories (Kvale 2009). This combination of methods is an eclectic form of analysis, and is particularly applicable in this study, where the different types of questions in the interviews require different means of analysis (Kvale 2009).

Answers to the specific interview questions were either entered directly or subjected to meaning condensation (Kvale 2009) – which essentially entails the compression of long statements into summarizing sentences – within an Excel table. Because of the semi-structured nature of the interviews, a great deal of information was obtained outside of the questionnaire framework; this was subsequently inserted where relevant, or led to the formulation of new categories. The main purpose of this condensation was to identify the main themes of the interviews, which were subsequently

interpreted and analyzed in more detail. Much of the analysis (section 5) focuses on grouping together comments made by anglers, rather than categorizing the anglers themselves; this approach was favored because it enabled the analysis to take into account multiple comments made by individual anglers in certain instances.

Section 7 of the interview questionnaire (appendix 1) consists of Likert scale questions, where respondents were asked to indicate to what extent they agreed or disagreed with certain fishery and environmental management measures. For these questions, the responses were given a score, with "strongly agree" equal to +2, "strongly disagree" equal to -2, and "undecided" equal to 0. The "don't know" responses were not included in the analysis, but are discussed separately in the text. In the analysis, mean scores ranging from -2 to +2 were calculated for the management measures as well as for each angler's opinion profile. The mean scores were compiled to compare the extent of respondents' satisfaction with current fishery and environmental management measures within the catchment.

The qualitative nature of this study made content analysis an appropriate means of analysis for the interview data (Kumar 2005). The main step of this method is the identification of the main themes contained within the interview results; the semi-structured nature of the interviews, where specific questions were asked, facilitated the identification of these themes. The method can include coding of responses, which is useful if the researcher intends to count the occurrences of a particular theme within each interview (Kumar 2005). This type of coding was not considered appropriate in this case, as a number of interviewees tended to reiterate the same points throughout the interview. Had such a coding system been used, it may have placed an undue impression of importance to a particular theme, whose recurrence within an interview may actually not reflect its importance, but rather the interviewee's communication style. Instead, for the appropriate interview sections (i.e. questions relating to the possible causes of sediment events, and of the decline in the fishery identified by some but not all of the fishermen) a ranking system was established, enabling the identification of the top areas of concern among fishermen; this type of coding is known as categorization (Kvale 2009). In order to establish a ranking of the most important causes of sedimentation as identified by each fisherman, each angler was given 1 point, to be distributed for each named cause. If only one cause was identified, it was scored as 1; if one major and one minor cause were named, they were scored 0.7 and 0.3 respectively. A few fishermen mentioned three causes, in which case the major cause was scored 0.7, and the minor causes were scored as 0.15. The same overall method was applied for analysis of the factors affecting trout numbers, although because the numbers of factors mentioned were often more plentiful, the scores given to each had to be modified. If an angler identified a major and a minor factor, the scores were 0.7 and 0.3 respectively, and if one major and two minor factors, 0.5 and 0.25 respectively. Some anglers mentioned a large number of potential factors, without attaching more importance to any specific one; in that case the point was divided equally. Finally, some flexibility was given to the scoring, for example if an angler indicated one factor was less important than another.

3.5 Research limitations

This research project is subject to a number of limitations, relating to both the collection and the analysis of data; these are outlined below, as are their potential consequences for the research.

3.5.1 Data collection limitations

3.5.1.1 Interview participants

The selection of participants for the angler interviews was not randomized; this matched the purpose of the survey, which was to obtain specific data from experienced fishermen. Moreover, given the paucity of data in FGNZ's regional database of licensed fishermen (Deans pers. comm.), obtaining and then screening a random sample of fishermen to find those who are both long-term fishermen and fish in the Motueka River and its tributaries would have been a prohibitively time-consuming task, incompatible with the timescale of this project.

Although the interviewees represent only a subset of Motueka catchment anglers, it is also worth giving some thought to the composition of the subset in question. Participants were selected in two main ways (as part of a previous survey): recommendation by others and self-nomination. Both methods are likely to have lead to the selection of individuals who are both highly active in the angling community as well as rather passionate about the fishery itself. The existence of experienced and knowledgeable anglers who may be more private in their interaction with the fishery – and therefore perhaps not well known to either FGNZ staff, angling clubs or other anglers – is likely. Indeed, during the interviews, a number of anglers recommended other experienced fishermen with long-term experience of the Motueka River, demonstrating that the angler sample was not an exhaustive list of expert anglers in the region.

Finally, given that interviewee names were obtained from a previous survey (Jellyman *et al.* 2003) for which the criteria for participation was a minimum of 10 years' fishing experience, it was expected that most anglers would have fished the Motueka catchment for an extended period of time. However, the fact that some had not proved to be a small limitation, as it affected only a few anglers, who were moreover able to provide valuable insights about the period during which they did fish the Motueka.

3.5.1.2 Fishing guides as a subset of the sample

At the outset of the study, it was known that three of the interviewees were professional trout fishing guides. However, it subsequently became clear that five additional interviewees were also undertaking or had undertaken remunerated guiding activities, either as a primary or a secondary source of income. While this was not felt to be inconsistent with the goal of obtaining information from long-term fishermen, it did add a layer of complexity to the analysis of the results; this subject will be revisited in section 6.

3.5.1.3 Questionnaire shortcomings

Although the questionnaire was designed in order to maximize the degree of response, it is likely that it suffered from some of the problems usually associated with questionnaires, such as possible misinterpretation of questions. An example of possible misinterpretation of the motivation behind a question was that relating to use of vehicles as part of a typical fishing trip. Anglers may have thought this question was related to the spread of the invasive algae *Didymosphenia geminata*, also known as 'Didymo', whose introduction into New Zealand and subsequent spread throughout many of the South Island's rivers has partly been blamed on anglers allegedly failing to adequately clean equipment upon exit of contaminated bodies of water (Kilroy 2004). Although nothing in the responses received indicated that this was the case, it is worth mentioning, particularly given the contentious nature of this topic.

The questionnaire design suffered from a number of deficiencies. For example, anglers identified a number of different types of sediment: sand (white, pale or brown), silt (muddy or fluffy) and gravel (pea gravel, shingle or pebbles). Although the sedimentation photographs (figure 3.3) used were useful to determine the extent of sedimentation (i.e. the percentage of the surface covered by sediment) it would also have been useful to bring photographic samples of different kinds of sediment in order to aid identification. Also, questions 19 and 20 proved to be repetitious, as the events concurrent to sedimentation episodes (such as particular storms or floods) were also identified as being their cause; indeed, question 19 was skipped for six of the last eight interviews.

Another deficiency is that after a few interviews it became clear that most fishermen held some strong views about the state of the Motueka fishery as a whole, and also had some observations about changes in the trout population size distribution, as well as the altered location of the fish. It could be argued that questions on these topics should have been added to the questionnaire (had they been known about prior to the start), though it is also possible that unprompted mention is more valuable because eliminates the bias of suggestion. Regarding the population size distribution, the first four interviewees did not mention it, but the following six did, unprompted. As this was emerging as an important theme, four out of the last five interviewees were asked if they had noticed a change (the fifth also mentioned it spontaneously). Of course, it is not possible to determine whether the interviewees would have mentioned it themselves, or indeed if those interviewees who did not speak of such a change did not notice one, or simply failed to mention it.

Finally, the management-related questions in section 7 proved to be confusing for respondents, who often made a distinction between their opinion of the management measure in principle and its practical application. Although the decision to keep the questions to a minimum was made after the pilot interview, in retrospect it became clear the analysis would actually have been enriched by formalizing such a distinction. Moreover, it became clear that interviewees answered question 25a – about the Water Conservation Order's provisions pertaining to the trout fishery – as if it was question

26a, which asked about the general provisions of the Order. As a result, the analysis contained in section 5 is restricted to that of question 25a.

Furthermore, it may be that certain answers were given to 'please' the interviewers, particularly given the stated purpose of the interviews to gather anglers' knowledge. For instance, some interviewees seemed reluctant to utilize the "don't know" option for the Likert scale questions in section 7 of the questionnaire, and instead answered "undecided" in some instances where they admitted incomplete knowledge of the subject at hand. Their responses were not altered for the purposes of the analysis, given that they did have some knowledge of the matter, and also in recognition that other anglers who may have expressed a more categorical opinion may not necessarily have had more complete knowledge.

3.5.2 Data analysis limitations

3.5.2.1 Validity of responses

Self-contradiction during interviews was first examined: although such inconsistencies placed doubt on the validity of the particular statements concerned, the degree to which specific instances of self-contradiction affected the validity of the interview as a whole remained unclear. Moreover, as touched upon previously, cross-checking of statements within the angler sample was a particularly difficult exercise, given the wide variety of opinions put forward by interviewees. Interestingly, while some general views were held by the majority of anglers within the sample, this did not necessarily give them greater weight; indeed, contradictory views held by a smaller number of anglers (in some cases only one) were sometimes more strongly supported by other sources of information. Finally, using scientific research to triangulate the data obtained was sometimes limited by the availability of research on particular topics, and also gave rise to a wider ethical question: is local knowledge only valid if it can be verified by science?

The individual limitations of the three validation methods used are evident; indeed, some authors believe complete interview validation to be impossible to achieve with currently available methods (Lummis 1998). Nonetheless, it is hoped that the combination of the three makes the final result more robust.

3.5.2.2 Biases of categorization and coding

Of the data analysis tools used, those of meaning condensation and categorization have the most potential for bias. Indeed, meaning condensation is automatically subject to the interpretation of the researcher, and may conflict with the original meaning expressed by interviewees. However, the likelihood of bias was minimized by regular cross-checking with the interview transcripts, to ensure interviewee statements were not overly simplified.

For categorization, identification of the most important causes of sediment events was based on an interpretation of angler comments, though in many instances the ranking was made clear by fishermen

themselves. This method may have lead to some misinterpretations of angler opinions. The factors identified by anglers as affecting trout numbers were in most cases given an equal weighting, though an effort was made to take into account the varying levels of importance given by some fishermen to the different factors they mention, where possible. This approach was heavily based on interpretation, and a more robust method would have been to ask fishermen directly to rank the factors they mention in order of importance, or perhaps to have two persons coding and then compare the results (Kvale 2009).

The interpretive nature of some of the analysis methods used leave room for bias, and the possible influence of preconceived notions or anticipated and desired results; however, it is hoped the methodical approach taken with the tabulation of the interview transcripts helped to avoid this.

3.5.2.3 Memory or recall?

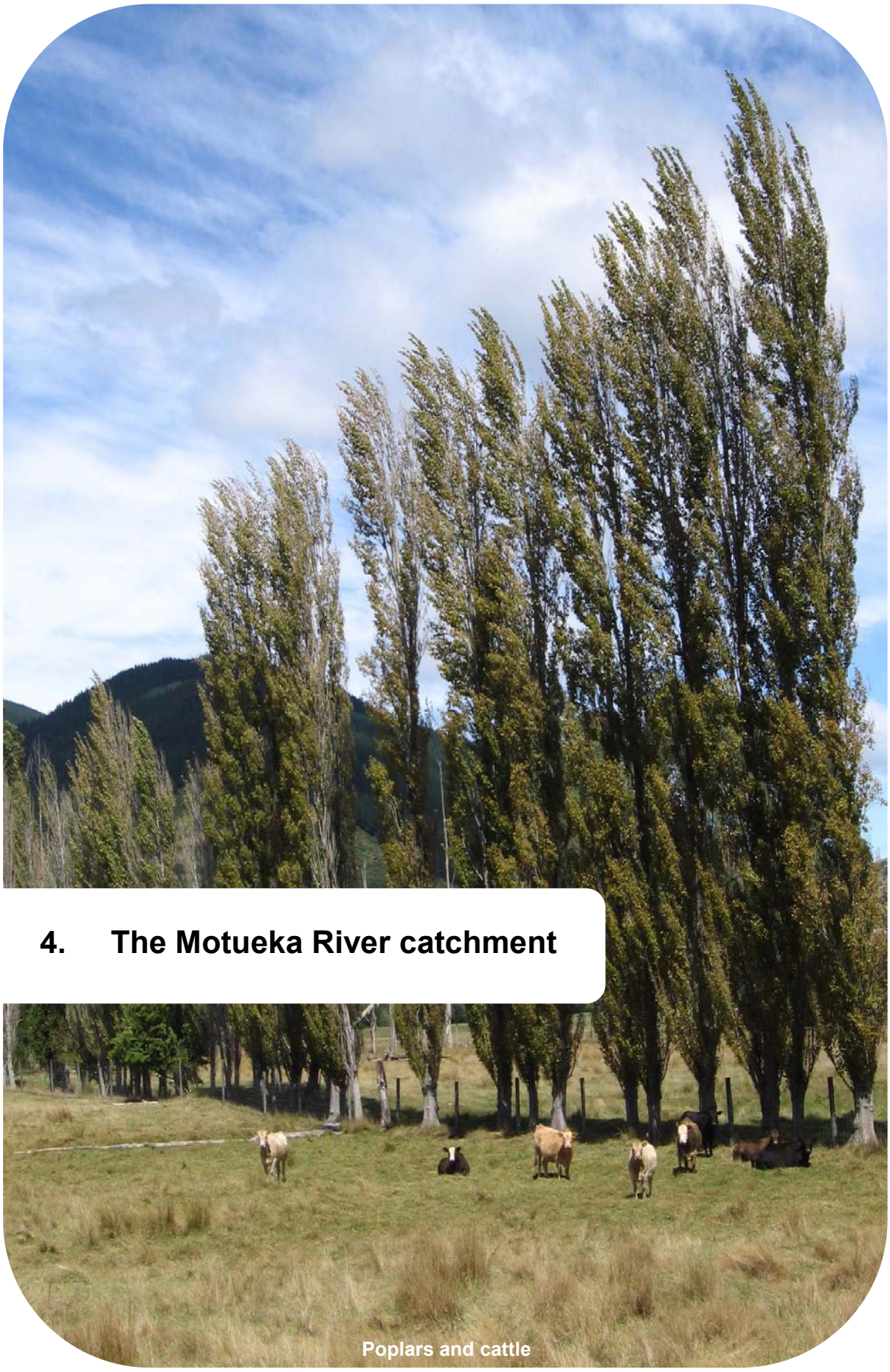
According to Lummis (1998), memory and recall are distinct processes, the former being colored by an individual's experiences and interactions, and the latter being a purer form of recollection. Although the questionnaire used did include questions evaluating the interviewee's level of interaction with the wider angling community, the degree to which statements were an individual's memory or recall was hard to establish.

"The memory of any particular even is refracted through layer upon layer of subsequent experience and through the influence of the dominant and/or local and specific ideology" (Lummis 1998)

Also, the degree to which the knowledge obtained from fishermen is purely local is nearly impossible to determine. Indeed, each individual's thoughts and opinions are continually formed by interactions with other individuals, organizations, and philosophies, and through exposure to different discourses (Long 1992). However, for the purposes of this study, the complete differentiation between internal and external knowledge is beyond the scope of the project.

3.6 Summary

The methodology of this thesis followed a number of steps: initial study, research design, archival research, selection of participants, questionnaire design, interviews, interview validation and analysis of results. The research steps followed a chronological pattern, but also benefited from a circular incorporation of lessons learned. Key to continuity within the research was the early establishment of the research question and its associated objectives, which helped for instance to guide the formulation of the questionnaire. The post-interview stages of validation and analysis of results followed an eclectic and common sense approach, rather than relying on a single method, not only because this approach fitted the format of the results best, but also in an effort to maximize the quality of the analysis.



4. The Motueka River catchment

Poplars and cattle

This thesis examines angler knowledge of environmental processes, including the effects of sediment events on trout, in the Motueka River catchment; in order to begin to address these issues, it is important to find out more about the catchment, the anglers who use it, and basic information regarding trout and sediment.

4.1 Setting the scene: the catchment and ICM Programme

This section presents the Motueka catchment and its main characteristics in terms of hydrology, geology, land use and management, as well as the ICM research programme.

4.1.1 The Motueka River catchment

4.1.1.1 The Motueka catchment: facts and figures

The Motueka catchment is located in the Tasman region of New Zealand, in the north-west corner of the country's South Island (figure 4.1). It drains an area of 2180 km^2, and flows into Tasman Bay, which is important both ecologically and economically, for its shellfish and fin fish (Basher 2003). The catchment is composed of the Motueka River, whose main stem is 110 km in length, as well as a number of tributaries. The most important tributary is the Wangapeka River, both in terms of water flow and area drained. The main tributaries of the Motueka River main stem are, in order of sub-catchment area (km^2): the Wangapeka, Upper Motueka, Motupiko, Baton, Tadmor, Dove, Stanley Brook, the Pokororo, Herring and Rocky, the Orinoco and Waiwhero, the Graham, and the Pearse (Basher 2003). Many of these tributaries will be referred to in the rest of the thesis.

Fig. 4.1. The Motueka catchment in New Zealand. Source: http://geography.about.com/library/blank/new.jpg

Precipitation is subject to seasonal variation, and rainfall levels vary within the catchment, with the western mountain ranges receiving much higher precipitation than the eastern side (Bowden *et al*. 2004); storms can be intense and localized, which has implications in terms of flooding and erosion. Large floods periodically occur in the catchment, and can be either localized in a specific catchment, or have a noticeable effect on the main stem of the Motueka River as well (Basher 2003).

The catchment is predominantly composed of mountains and hills, the headwaters originating in both the Red Hills and the Arthur Range; physiography exercises strong control over possible land uses in the catchment, with only 13.3% of the land classified as suitable for arable cropping (Basher 2003).

The geology underlying the catchment is complex, and is important in terms of the discussions around sedimentation in the river; it is addressed in more detail later.

4.1.1.2 Land use within the catchment

Land use within the Motueka River catchment is varied (figure 4.2), and makes for a wide variety of stakeholders with different and sometimes competing interests.

Fig. 4.2. Examples of land use in the Motueka catchment: forestry, sheep farming, apple growing, dairy farming and cultivation of hops

As is the case for most of New Zealand, the Motueka catchment has seen a change from almost complete native forest cover to mixed land use; two-thirds of the land has been cleared of native forest (Bowden *et al.* 2004). The catchment is mostly a combination of native forest (35%), planted exotic forests (25%), and pastoral grassland (19%) (Basher 2003). The remaining native forest within the catchment is mostly part of protected land managed by the Department of Conservation (DOC), in Kahurangi National Park and Mt Richmond Forest Park, and is used for both conservation and recreation.

Large areas of pine forest have been planted on steep and infertile land unsuited for pastoral farming, and occur in areas of the catchment underlain by both Moutere gravel and Separation Point granite. Radiata pine is the dominant type of exotic plantation tree, though there are also smaller areas of Douglas fir, and has a long history in the catchment, with some forests now into a third rotation – the average growth period being 25 years (Basher 2003). Forest plantations are largely in the hands of private companies, following the restructuring of forest ownership which has seen government-dominated ownership pass into largely foreign private ownership. The Tasman District Council has retained ownership over some plantations (Ministry of Agriculture and Forestry 2008).

Sheep farming and beef production dominate pastoral uses of the land, and there is a small but increasing proportion of dairy farming, particularly in some sub-catchments like that of the Sherry River (Basher 2003). Horticulture occupies a small (0.6%) part of the catchment area, and consists mainly of pipfruit like apples and kiwifruit, as well as berryfruit, hops and vegetables (Basher 2003).

Horticultural production is expanding, particularly in the area around Tapawera (Basher pers. comm.). Horticultural crops are irrigated using river or groundwater, as are pastures used to graze dairy cows.

The catchment is primarily rural, with urban areas composing only 0.18% of the catchment area; the population of the catchment is around 12000, and the main settlement is Motueka, with a population of 7000. Although the rural population density is low (2/km^2), the region has one of New Zealand's highest population growth rates (Bowden *et al.* 2004). The interaction of urban residents with the catchment is mainly in terms of recreation, including angling; the threat of flooding is of concern to urban residents (Basher pers. comm.).

4.1.1.3 Geology of the Motueka River catchment

The complex geology of the Motueka River catchment (figure 4.3) plays an important role in determining the type and extent of sedimentation occurring in the catchment. The eastern tributaries of the river are sourced hills underlain by Moutere gravels, younger alluvial sediments characterized by silt and clay-bound gravels. The western tributaries come out of hilly and mountainous terrain which is underlain by either Moutere gravels (for the Motupiko and Tadmor) or sedimentary and igneous rocks, which underlie the other western tributaries (Basher 2003). Of particular interest in the last category are the Separation Point granitic rocks of the west bank, which are highly erodible (Basher 2003). The underlying geology determines the characteristics of the sediment produced by different parts of the river, with gravel and granite sand coming out of the west bank tributaries, and silt and gravel entering via the eastern tributaries (Basher pers. comm.). An aerial survey undertaken by the ICM programme in 2002/03 found that landslides were the main source of sediment in the Wangapeka catchment, where the steep terrain prevents storage of sediment, and therefore means there is a high delivery ratio of sediment into streams (Basher *et al.* 2003). However, the ways in which sedimentation is distributed across the catchment are not well known, and estimates of sediment yield from different tributaries vary (Basher 2003).

Sedimentation can affect trout in the intragravel stage, by smothering redds and depriving eggs of oxygen. Moreover, sedimentation also affects trout indirectly, through its influence on invertebrates, the main source of food for trout. Sediment reduces the availability of suitable habitat for invertebrates by smothering rocks and gravel and filling in the spaces between them. Some of the possible causes of sedimentation, both natural and anthropogenic, will be returned to in section 5 of the thesis, with particular reference to the Motueka River catchment.

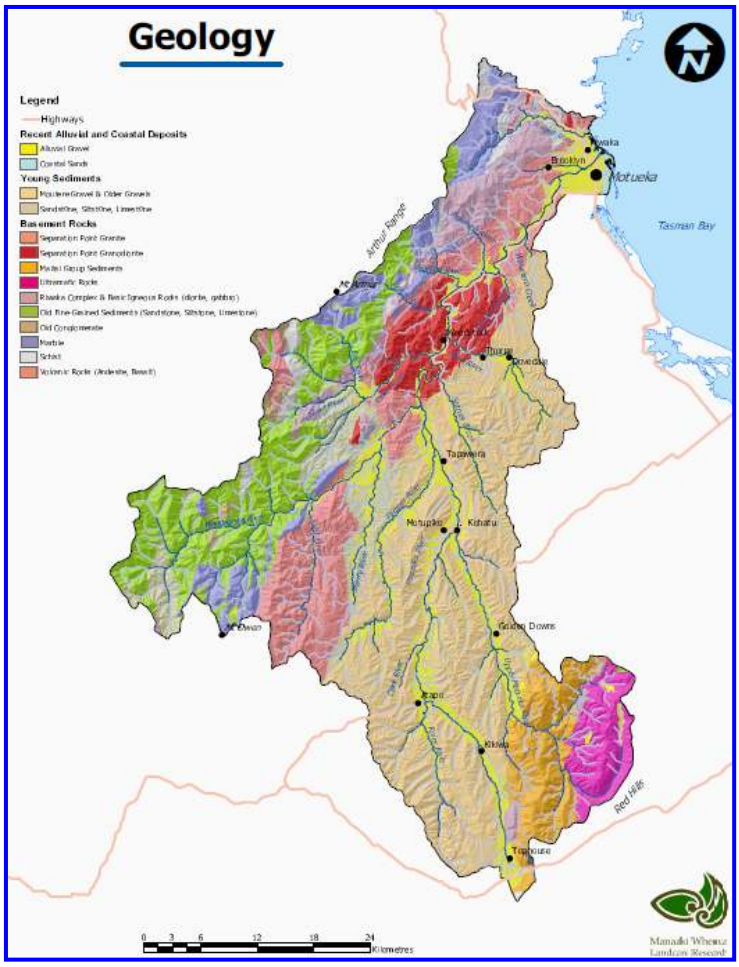


Fig. 4.3. Motueka catchment geology, with Separation Point granite rocks in dark and light pink. Source: Basher 2003

4.1.2 Management of the catchment

4.1.2.1 Management responsibilities within the catchment

Government agencies with a major role in water management in New Zealand are the Ministry for the Environment, the Department of Conservation (DOC), which manages approximately 28% of the country's land area, and regional councils. The Ministry for the Environment has a limited regulatory role, as a result of the decentralization of many environmental management responsibilities to regional bodies which the country has undergone (Memon 1997). The Resource Management Act (RMA) of 1991 established a hierarchy of environmental planning responsibilities and documents, with the view that decision-making should happen as close to the affected community as possible (Memon 1997). The RMA takes a sustainable resource management approach, for example taking into consideration biodiversity values, Māori cultural values, as well as the needs of future generations (Memon 1997).

- **Tasman District Council**

In New Zealand, regional councils and unitary authorities have responsibility for environmental management; there are 12 regional councils and 4 unitary authorities. The Tasman District Council

(TDC), which manages the Motueka River catchment, is a unitary authority, meaning that it has both the responsibilities of both a district council and a regional council, so that all resource management activities are covered by the council (Bowden *et al.* 2004). This dual role is thought to lead to occasional friction, when the actions of one part of the council are in conflict with the responsibilities of another. An example of this is gravel extraction for use in infrastructure and construction projects, which is part of the council's regional growth strategy, but can run up against its environmental protection role (Basher pers. comm.). The TDC's Tasman Resource Management Plan sets out activities which are permitted, and those which need to apply for resource consents; the resource consent process is sometimes open to limited or public notification, depending on the Council's assessment of the potential impact of the activity. The TDC is responsible for the management of water allocation and quality, as well as the management of land.

Although freshwater is more abundant in New Zealand than in most countries, seasonal and regional allocation varies, and conflicts over allocation of water amongst its many users are common (Memon 1997). The Tasman region is no exception, having both consumptive (mainly irrigation and forestry) and non-consumptive (recreation and conservation) uses of water. The RMA determines the TDC's responsibilities in terms of water quantity, including the control of abstractions, flow levels, and of land uses which influence it (Memon 1997). The Water Conservation Order described in the next section also prescribes management of water quantity, for example setting minimum flow levels, below which rationing is enforced, and also a flow sharing arrangement. The low flow regime prescribed by the Order was reached by negotiated settlement, and is the aspect of the Order which was of most concern in the community (Bowden *et al.* 2004). According to Memon (1997), the Tasman District's strong focus on researching how to allocate to meet competing demands for water is unusual in New Zealand regional bodies.

The TDC is responsible for the maintenance of water quality in the catchment's water bodies under the RMA, for both point and non-point discharges (Memon 1997), as well as under the more specific provisions of the Water Conservation Order. These specific provisions include controls on suspended solids and turbidity, controls on changes in the pH of water and reductions in dissolved oxygen levels, limits to undesirable biological growths caused by discharges, and the responsibility to ensure that aquatic organisms are fit for human consumption. Finally, the TDC must also ensure the river is suitable for contact recreation (i.e. contact without swallowing) by controlling contaminants and bacterial loads (Water Conservation (Motueka River) Order 2004). For Memon (1997), the ability of New Zealand regional councils to maintain water quality is hampered by the lack of punitive financial measures on polluters, by the emphasis on effects-based rules rather than on control of the effect-producing activities, and by the inherent difficulties in measuring and controlling non-point sources of pollution.

The TDC controls land management under the provisions of the RMA, including aspects relating to soil conservation and land drainage, and also the existing or potential effects of land use (Richmond *et al.* 2004).

- **Fish and Game New Zealand**

Fish and Game New Zealand (FGNZ) is responsible for the management of the Motueka River catchment's trout fishery. Acclimatisation Societies, first instituted to manage the introduction of plant and animal species into New Zealand and subsequently involved in the management of exotic fish and game, were reorganized and renamed in 1990 as Fish and Game New Zealand. The organization is financially independent from government, being funded through sales of fishing and game bird hunting licenses, but ultimately must meet with the approval of the Minister of Conservation with regards to its responsibilities under the Conservation Act (Hayes and Hill 2005). FGNZ is comprised of 12 local councils, composed of 12 councilors each; these councilors are elected by license holders. One councilor from each region sits on the national council in Wellington; the councils employ professional managers and fisheries officers (Hayes and Hill 2005).

Fish and Game New Zealand issue fishing regulations, both at a national level and specific to each region. The regulations cover allowable fishing methods, the length of the fishing season, the number of fish an angler can kill and take home (bag limit), and the species which can be fished (Fish and Game New Zealand N.d). There are some variations in the regulations according to each river. For example, in the Motueka River catchment, fishing with bait is allowed in the lower Motueka (downstream of Ngatimoti) only and the fishing season is from the 1st of October to the 30th of April (apart from the lower Motueka where fishing is open all year around). The bag limit is 2 fish in the lower Motueka and some of its tributaries, while it in other tributaries and in the middle and upper reaches 2 fish can be caught, but only one is allowed to exceed 500mm in length (Fish and Game New Zealand N.d).

As detailed above, resource consent applications under the RMA are sometimes notified, either to affected parties or to the public in general; once notification has been made, parties may send submissions, and the consent application goes through a hearing process. Fish and Game is heavily involved in the resource consent process; indeed, in 2008, the FGNZ managers in the Nelson/Marlborough region spent over half of their time involved in resource management issues such as submissions and hearings (Deans pers. comm.). An example of such involvement is the Wairau River in Marlborough, where FGNZ is involved in hearings concerning a proposed hydroelectricity plant (Deans pers. comm.).

- **Department of Conservation**

The Department of Conservation has direct responsibility over some lands within the catchment, such as Kahurangi National Park, and also has more general responsibilities relating to the conservation of wildlife, the preservation of native freshwater fisheries, the protection of recreational freshwater

fisheries, as well as all freshwater habitats within New Zealand (Richmond *et al.* 2004). Given the deleterious impact of trout on native fish species, the multiple responsibilities of DOC can be in conflict with each other.

4.1.2.2 The Motueka Water Conservation Order

Water Conservation Orders can be gazetted under the Resource Management Act for the purpose of recognizing and protecting the outstanding values of a particular water body, which can be for example scenic, recreational, cultural, or related to its value as a habitat or fishery. There are currently 16 such Orders in place in New Zealand, including one on the Motueka River (Ministry for the Environment N.d.). The limited number of applications for Water Conservation Orders can be explained by the lengthy and expensive procedure involved (Richmond *et al.* 2004). Applications can be made to the Minister for the Environment by any interested party, and can lead, if approved, to restrictions on uses of water, such as abstraction and discharge. Applications go through an approval process involving a special tribunal, the Environment Court and the Governor-General; if the order is made, all regional and district policies and plans must conform to its provisions (Ministry for the Environment N.d.). Water Conservation Orders were originally set up as a political concession for those concerned about central government's ability to modify rivers for infrastructure projects; however, despite the measure of protection they afford rivers, they do not offer permanent protection, being open for amendment and revocation (Memon 1997). Moreover, the Orders do not offer blanket protection for entire river systems; instead, an Order must specify the parts of the river in need of protection, as well the reason for their protection.

Concerned about growing threats to trout habitat, Fish and Game New Zealand lodged an application for a Water Conservation Order on the Motueka River in 1989, prompting a debate over the different interests of stakeholders regarding the management of the catchment's water resources; this debate was one of the factors leading up to the creation of the ICM programme (Bowden *et al.* 2004). The application was approved, and the Water Conservation Order was gazetted in 2004 (Water Conservation (Motueka River) Order 2004).

The Motueka River Water Conservation Order recognizes the outstanding recreational characteristics, fisheries and wildlife habitat features, scientific values, and wild and scenic characteristics present within the Motueka River catchment. In particular, certain reaches of the river are protected because of their brown trout fishery: the Wangapeka River and the main stem of the Motueka from the Wangapeka confluence downstream to approximately 7 km from the mouth of the Motueka. In addition, other reaches are protected for their contribution to the fishery in terms of flows and spawning grounds; this is the case for many of the tributaries, such as the Motupiko and Tadmor. There is a certain degree of overlap with the final category of reaches, those which must be kept in their natural state because of their features as Blue duck habitat or wild and scenic waters, and the importance of their karst landscape. The restrictions are set out in clauses, which apply to the different categories of reaches, and include restrictions on dam construction, on some alterations of river flows

and form (including fine sediment deposition) and on alterations of water quality, including turbidity and changes in acidity (Water Conservation (Motueka River) Order 2004).

4.1.2.3 Challenges facing the Motueka River catchment

Some key issues are of concern in the Motueka River catchment, and have been identified as needing further research. These are water allocation, with competition for limited water supplies within water-consumptive land uses, and between these and non-consumptive uses of water; sediment, its relationship with land use and influence on river ecology. Also water quality, which can deteriorate in the lower reaches of the river and in some tributaries because of the cumulative input of nutrients and bacteria. Finally, riparian management and possible negative trends affecting aquatic species, and interactions between the catchment and Tasman Bay (Basher 2003). Finally, presence of the invasive algae Didymo in parts of the catchment, and its possible spread to upstream reaches, is a cause for concern.

4.1.3 The Motueka River catchment ICM programme

4.1.3.1 The ICM partnership

The ICM programme is a research programme which was set up in 2000, in partnership between Landcare Research New Zealand and the Cawthron Institute, two research organizations, and the TDC, with contributions from other partners such as community stakeholders. The Cawthron Institute, is an independent and community-owned research centre based in Nelson and Marlborough, which provides research on a number of environmental issues, including coastal and freshwater ecosystems, aquaculture and invasive organisms (Cawthron Institute N.d.). Landcare Research New Zealand, formed in 1992, is a Crown Research Institute which operates as a company but receives most of its funding from government through a competitive funding system. Landcare Research has over 400 staff members spread over a number of sites throughout New Zealand, and provides research on a variety of topics relating to sustainable development and land-based natural resources (Landcare Research New Zealand 2008).

The ICM programme is primarily funded by the New Zealand Foundation for Research, Science & Technology, and takes an integrated perspective to the management of the catchment, researching social and economic issues as well as biophysical ones, and seeking to involve affected stakeholders in environmental management decisions (Bowden *et al*. 2004).

4.1.3.2 Areas of ICM activity

The ICM programme has five main areas of research: land, freshwater, coastal and marine areas, human dimensions, and integration and modeling. The information below is taken from the ICM programme website (Landcare Research New Zealand N.d.), which is used as a knowledge base for catchment stakeholders (Bowden *et al*. 2004).

- **Land**

The programme researches the effects of varying types of land use – and their changes over time – on ground and surface water. This includes researching the effects of forest harvesting and of gravel extraction, as well as the use of native vegetation for riparian management.

- **Freshwater**

Both water quantity and quality, and the causes and consequences of any change in these, are researched within the programme. The programme also studies freshwater ecology, including invertebrates and trout.

- **Coastal and marine**

The ICM programme is involved in research on the interactions between the catchment and Tasman Bay, including any consequences of land use on aquaculture in the Bay, and on marine ecosystems.

- **Social science and integration**

One of the main aims of the programme is to improve the two-way interaction between the catchment community and the science providers. The programme also operates in close cooperation with the four Māori tribes (or iwi) which have a relationship with the catchment.

- **Modeling**

Modeling is used extensively in the research programme, to assist with research into cumulative impacts and future trends within the catchment.

4.2 Trout

This section gives a general description of the trout's life cycle and outlines how this can be influenced by stream conditions and human activities. Also, the history and impacts of the trout in New Zealand are summarized, as are the main points regarding the Motueka River catchment's trout population.

4.2.1 Trout biology and life cycle

The brown trout, *Salmo trutta L.*, which originates from the North Atlantic, is part of the Salmonidae family, which also includes other species, such as the North Pacific salmon. Although there exist different types of trout within the salmonid family, the term "trout" will hereafter designate the brown trout, which is the only species found in the Motueka River.

The basic life cycle of the trout is illustrated in figure 4.4 below. Of most interest for the purpose of this study are the early stages of the life cycle, which take place in the stream or riverbed gravel; these are called the intragravel stages, and are of particular relevance for this study, as they are most influenced by sedimentation (Crisp 2000).

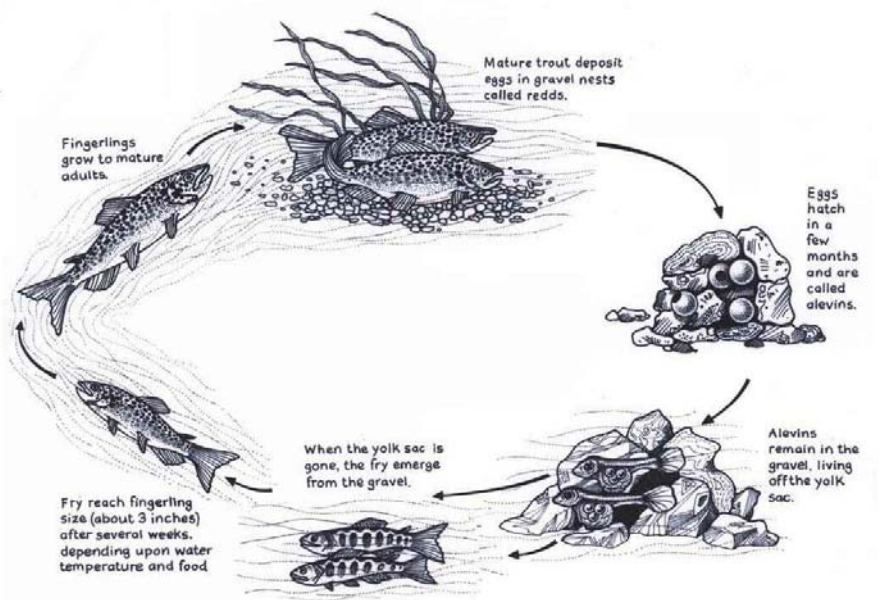


Fig. 4.4. Trout life cycle. Source: http://www.jetsettroutintheclassroomuk.org/Lifex.jpg

4.2.2 Relationship of the trout with its environment

A number of environmental factors affect trout habitat and success, namely food supply, water quality, water quantity, habitat and streambed gravel conditions. Because of their sensitivity to water quality, trout are a valuable bioindicator of stream health. Trout survival can be affected by pollutants, variations in the water's pH levels, as well as variations in temperature – trout are particularly susceptible to temperature variations in the intragravel stages (Crisp 2000). High temperatures are usually associated with low flow situations.

Water quantity also plays a role in trout egg survival, for example in the case of reduction of wetted area during low flows and subsequent exposure of redds to air, or in the case of sudden spates which can cause egg washout. In the intragravel stages, the quantity of gravel (and its interaction with water quality) obviously plays a paramount role. Gravel consists of two things: large particles, and fine material which is known as the "matrix"; it is the fine material which impacts incubation the most, as it regulates intragravel water flow (Crisp 2000). Increased silt deposition can alter the oxygen supply to the eggs, and affect growth and hatch rates; research has shown the increase of fine particle deposition causes premature emergence of fry, as well as a lowering of survival rates (Acornley and Sear 1999; Crisp 2000).

4.2.3 Effect of human activities on trout populations

Anthropogenic activities can alter stream environments in a number of ways; some of these are listed below (Crisp 2000), and visualized in figure 4.5.

- Variation in stream temperature. A good example is dams, which can increase or reduce water temperatures, depending on the location of the discharge point issuing from the temperature-stratified reservoir water.

- Increased sedimentation can occur because of upstream construction, extractive industries, forest felling and agricultural activities.
- Changes in oxygen levels are usually associated with increased nutrient input, from human or animal sewage or agricultural fertilizers.
- Addition of toxic substances can happen in urban, agricultural, industrial or forested areas.

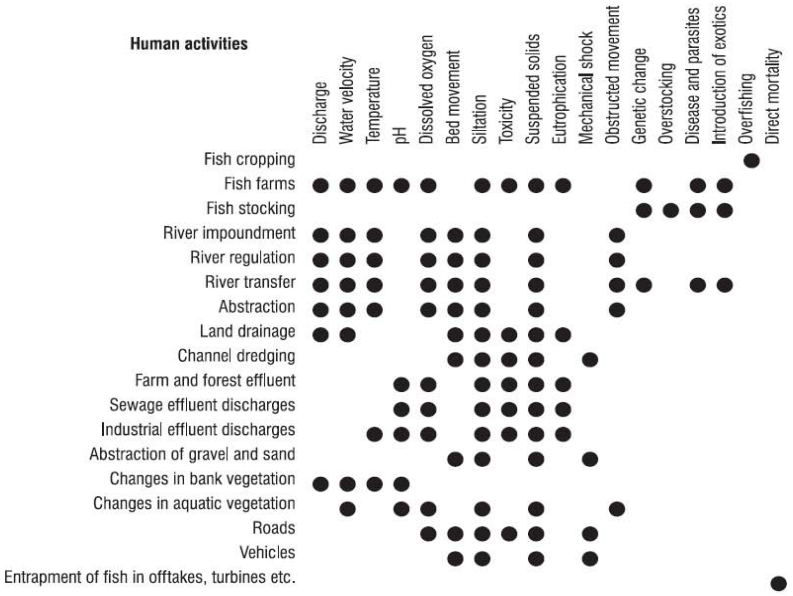


Fig. 4.5. Anthropogenic activities and corresponding impacts on salmonids. Source: Crisp 2000

4.2.4 Trout in New Zealand: an introduced species

Brown trout is not indigenous to New Zealand; it was introduced in the South Island starting from 1867, for sport fishing purposes, and can now be found in most of the country's rivers, as illustrated in figure 4.6 (Paulin *et al.* 1989; Townsend and Simon 2006).

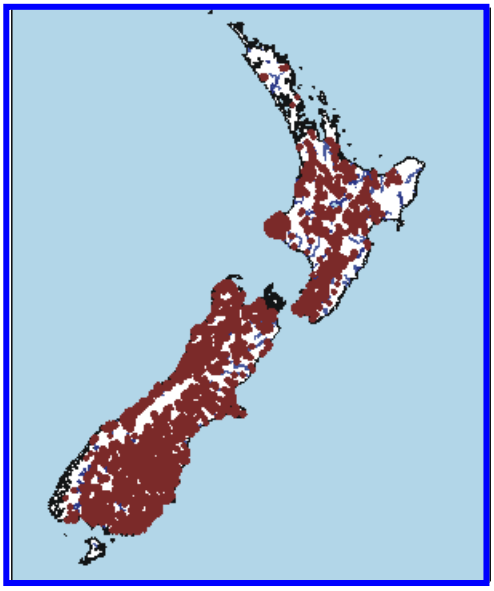


Fig. 4.6. New Zealand trout (in red). Source: http://www.niwa.cri.nz/rc/freshwater/fishatlas/species/brown_trout

Since the arrival of humans, starting with the Māori people and intensifying with the arrival of Europeans, many other species have been introduced to New Zealand. Some of these have imperiled indigenous ecosystems, and are subject to control and eradication campaigns; this is the case for grazers like deer, possums and goats, as well as predators such as weasels, stoats and ferrets. The impact of pests is compounded by the fact that they were introduced into ecosystems which evolved in isolation for millions of years, essentially devoid of the presence of land mammals, and therefore failed to develop the necessary adaptations to predation.

In comparison with these introduced land mammals, the negative impact of trout on ecosystems is less pronounced, or at least less visible; in addition, while the pests listed previously provide little income to the country, the trout is the centre of a lucrative sport fishing industry. Both factors explain the lack of any organized control measures for trout populations beyond fishing.

Trout impact on New Zealand's freshwater ecosystems in a number of ways. Research has shown that trout introduction has caused some local extinctions, as well as impacted on freshwater ecological organization (Townsend and Simon 2006). Trout affect the local environment through predation and competition. Trout tend to replace native fish and become the top predator; this predation – mainly on invertebrates – not only reduces the number of invertebrates, but also leads to changes in their behavior. For instance, mayfly nymphs undergo a diurnal shift in grazing patterns, in response to increased daytime risk of predation from trout. Trout predation on invertebrates also has a knock-on effect (or trophic cascade) on the rest of the food chain; indeed, as invertebrate numbers are reduced, the algae on which they graze becomes more abundant (Townsend 1996; Townsend and Simon 2006). Trout out-compete some native fish such as galaxiids, either through direct predation, competition for food sources, or by changing the behavior of their common prey (Townsend and Simon 2006). Trout are also known to have a deleterious effect on crayfish, a keystone species in New Zealand freshwater (Olsson 2003). In NIWA's 2008 Fish Risk Assessment of 21 alien freshwater fish species, the brown trout receives an overall risk score of 39, above the average score of 30.8 (Wilding and Rowe 2008).

The introduction of brown trout appears to have had an overall relatively less detrimental impact on New Zealand's ecosystems than other introduced species (Wilding and Rowe 2008). However, given the sometimes important impact of trout on a more local level, some advocate the creation of refuges for native fish, for example upstream of waterfalls which trout cannot pass (Townsend and Simon 2006).

4.2.5 Trout in the Motueka River catchment

Trout ova were first imported to the Nelson District in 1868, from Tasmania and Victoria, and released into the newly completed hatchery ponds in Nelson (Nelson Acclimatisation Society 1968). Liberations into the river system began the following year (Graynoth and Skrzynski 1974), and continued until the 1960s, after which the trout stocks have replenished themselves naturally (Basher 2003).

Trout are widespread and abundant throughout the catchment, though a reduction in trout numbers around the mid-1990s at the main measurement site (figure 4.7) and the subsequent slow recovery of the trout population has caused concern. Trout numbers are assessed by FGNZ using drift diving, a method which involves a line of divers drifting down a river and counting fish numbers in a given reach. Although drift-diving has been criticized for its lack of accuracy, it is still regarded as a useful way of measuring relative abundance as well as changes in trout populations over time (Young and Hayes 2001). The issue of a possible decline in the Motueka River catchment's trout population will be returned to in section 5 of the thesis.

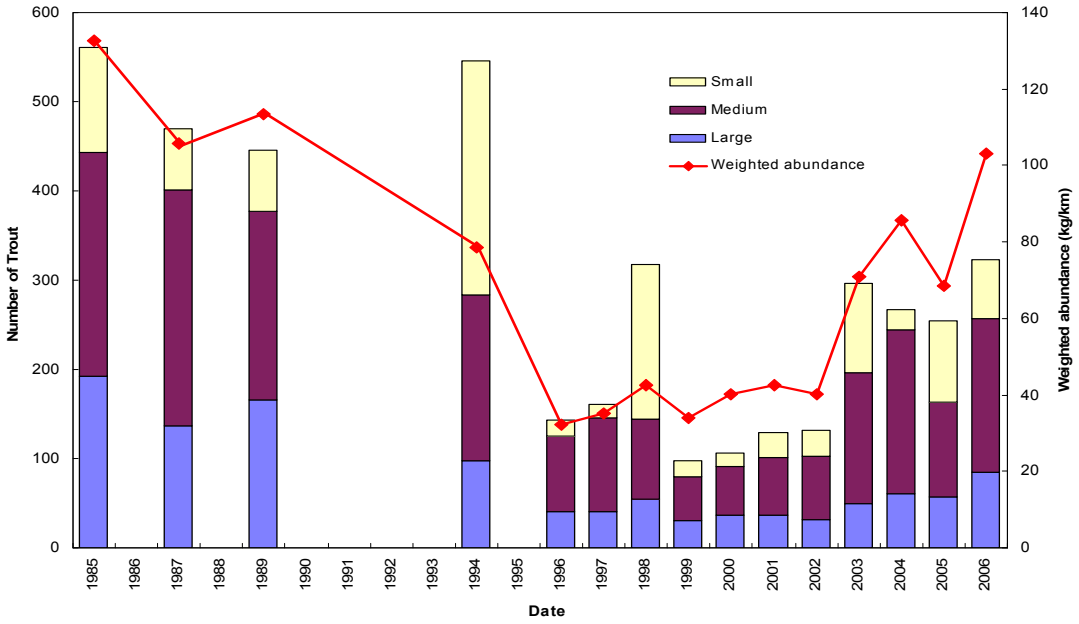


Fig. 4.7. Trends in trout population measured by drift dives at Woodstock 1985-2006. Source: Basher and Young 2006

4.3 Anglers in the Motueka River catchment

New Zealand is popular as a destination for trout fishermen; this is evidenced by the significant contribution the sport makes to the national economy (Hayes and Hill 2005); one estimate puts the value of the salmonid fishery at over NZ$ 800 million per year (Townsend and Simon 2006). The Motueka trout fishery is renowned both nationally and internationally; figure 4.8 shows examples of the importance of this recreational activity in the catchment, for instance accommodation catering specifically for anglers.

Fig. 4.8. Evidence of the importance of trout in the Nelson/Tasman region

In a 1984 survey of New Zealand anglers, the Motueka was found to be the most important river in the Nelson district in terms of angling use and frequency of visits, particularly from the Wangapeka confluence downstream, which was prized for ease of access and the extent of fishable water. These two factors were also prized in the Wangapeka itself, which was also noted for its scenic and solitude values (Richardson *et al.* 1984). Fishing use has declined over the last 15 years in the Nelson/Marlborough region, while use of the Motueka River has significantly declined over the last 10 years approximately; this decline is attributed to angler perceptions of a decline in the fishery, as well as the advent of Didymo in the river (Deans pers. comm.).

Recent figures on the socio-economic characteristics of anglers in the region could not be obtained, though a 1974 study found that these varied markedly from the socio-economic characteristics of the wider district population (Toynbee 1974). As for the nationality of anglers, in New Zealand 5% of licenses are sold to non-resident anglers, while they constitute 12.5% of the angling use of water bodies (in terms of time), meaning they get “good value for money” (Deans pers. comm.). Moreover, the cost of a license is the same for resident and non-resident anglers, which is unusual from a worldwide perspective. The Nelson/Marlborough region has the highest proportion of non-resident anglers out of the 12 FGNZ regions (Deans pers. comm.).

Although some anglers, including some interviewed for the purposes of this study, still kill and eat trout, the ethic of catch-and-release is now widespread throughout New Zealand, after first being introduced to the country by American tourist anglers and foreign fishing literature (Hayes and Hill 2005). A study of anglers on backcountry waters (headwater fisheries) in two regions found that 92% of trout caught were released, with the proportion being higher for non-resident anglers (97%) than for resident anglers (80%) (Walrond and Hayes 1999). In lowland rivers, on which most of the angling use is concentrated, catch-and-release rates are unlikely to be as high (Deans pers. comm.).

Having provided an overview of the catchment, its trout fishery, and its anglers, the thesis will now present the results of the angler interviews conducted in the Motueka River catchment.

5. Angler knowledge: interview results & interpretation

Post-harvest forestry in the Motueka catchment

The following section attempts to analyze the angler interview data, by laying out the main characteristics of the angler sample, summarizing the main findings of the interviews, and placing a validation 'filter' on the results of the interview. Section 5 addresses two of the main objectives of the thesis: to find out what knowledge anglers possess, and to what extent it is of value for catchment management.

5.1 Description of the angler sample

Although the bulk of the interviews consisted of questions relating to environmental processes and management measures, information on other relevant topics was also gathered. This information helps to paint a picture of the angler sample, including the extent of their experience within the catchment under study, the ways in which they capture and retain information, their opinions of management measures affecting the catchment, and also their degree of interaction with the wider angling community.

5.1.1 Angler sample profile

5.1.1.1 Place of residence

Most (62.5%) of the 16 anglers interviewed live in the largest city in the Nelson/Marlborough region, Nelson, and its satellite city Richmond; three anglers (18.7%) live in towns located within the Motueka catchment itself, while a further three live in towns located within 150 km of the catchment.

5.1.1.2 Age and employment status

The average age of interviewees is 66, with anglers ranging from 42 to 84 years of age; all are male. The majority (69%) of anglers are either retired or semi-retired, while 31% are currently employed. Of the employed anglers, 4 out of 5 are fishing guides; the fully or partially retired anglers have held a wide variety of professions, from teacher to farmer, and from plumber to shop manager.

5.1.2 Experience and interaction with the Motueka catchment

5.1.2.1 Duration of interaction

The angler sample holds a cumulative 573 years of fishing experience on the Motueka (min= 7, max= 71, mean= 36). Six of the anglers have been fishing the Motueka since they began fishing; the catchment is therefore associated with their formative years of fishing. Only three anglers have fished the Motueka for less than 30 years: two had lived in the area and subsequently moved to another city, while the third only moved to the Motueka region relatively recently. In terms of angler-days, which is the conventional means of measuring time spent on the river, irrespective of whether an entire day was spent on the river or not (Deans, pers. comm.), the interviewees have spent a total of between approximately 9,000 and 19,000 days fishing the catchment. The wide range is explained by the fact that most interviewees express themselves in general terms, such as: '10 to 20 times per year' or '2 to 3 times per week'. The average number of days fished per year per angler is 25, which, given the

fishing season lasts 6 months in most of the catchment, represents approximately one fishing trip per week. However, in practice, there is a wide variation amongst anglers, some spending as little as 6 days per year fishing the catchment, and others fishing it for over 50 days per year. Though recent figures were not available for comparison, a 1974 study found that anglers in the region fished on average 12.6 days per season over a period of several years (Graynoth and Skrzynski 1974); this shows the difference in river use between the interviewees and average anglers.

A number of considerations determine the duration of a fishing trip. For the professional fishing guides within the sample, full 8 hour days on the river are commonplace, while other anglers are either constrained by time available, or deem a 3 to 5 hour fishing trip to be sufficient. Only one angler placed the catch of his bag limit (the maximum number of fish an angler is allowed to take home per day) as the boundary for the duration of a fishing trip.

When asked what ideal weather conditions they look for during a fishing trip, fine weather (i.e. no clouds) was cited by 81%, and lack of wind by 75% of fishermen. In particular, downstream wind was cited as detrimental to fishing, because of the difficulties it causes for fly fishing. One angler was as content with an overcast day as a fine one, while another specifically looked to fish after heavy rain. Most of the anglers currently employed as fishing guides mentioned not being able to choose weather conditions ideal for fishing, because of advanced bookings made by clients. The employed anglers, of which the fishing guides are a subset, are subject to constraints which limit the influence of weather conditions on the time they spend fishing. However, this is not the case for the majority of the anglers, who are either retired or semi-retired, and are therefore likely to maintain a constant average fishing regime, except for long periods of unfavorable weather.

5.1.2.2 Breadth of interaction

As part of the interview, anglers were asked to indicate the areas of the catchment they fish or fished the most; the aim of this question was to understand their fishing patterns and as a result the extent of the knowledge which they might have about certain areas as opposed to others. For example, someone who fishes exclusively in one spot will have a different impression compared to someone who fishes as often but in different areas. Within the angler sample, approximately half fish quite a large number of areas, alternating fishing spots, while the other half has a more or less extensive favored area, which they fish exclusively. Only one of these anglers mentioned having one small specific spot, which he chooses not to reveal to others, in order to minimize the disturbance from other fishermen; the others prefer certain areas, but they are larger (for example, one particular tributary). Only one angler from the sample prefers to fish in a different place every time he goes out.

Table 5.1 provides an insight into the areas most frequented by fishermen, which are the middle sections of the Motueka River as well as the Wangapeka tributary; the main stem has been arbitrarily divided into four sections. Given the very general nature of the areas named, this information does not compromise ethical requirements.

Table 5.1. Areas fished by anglers

Anglers #	Area fished
1	Upper Motueka
7	Upper middle Motueka
10	Lower middle Motueka
4	Lower Motueka
10	Wangapeka (tributary)
5	Baton (tributary)
4	Motupiko (tributary)
2	Pearse (tributary)
1	Rolling (tributary)
1	Tadmor (tributary)

Asking fishermen why they choose to fish in the areas they do is important in order to ascertain what they see as the most important features of the fishery. Figure 5.1 illustrates the top reason cited by each fisherman, which are in order of importance quality of fishing (numbers, size and condition of fish), ease of access (to the river), and convenience (location close to home). This question is not applicable to one angler, who likes to fish a different part of the river every time. Secondary reasons were also cited by fishermen, such as scenic value and lack of other anglers. For fishing guides, who must take into account not only the fishing capability but also the mobility of their clients, ease of access is a key factor, which explains why the middle and lower Motueka is an important fishery for them.

Location of fishing, and therefore most in-depth knowledge of a particular area, is unlikely to change if fishermen respond to two of the determinants of location: convenience and ease of access. However, for the fishermen who choose fishing spots in response to the numbers and size of fish, favored location of fishing can vary through time. For example, one angler used to fish the entire Motueka River, including its upper reaches, but now concentrates the majority of his fishing in the middle and lower parts of the river, in response to a perceived deterioration of the fishing in the upper reaches starting in the mid-90s. While not necessarily impacting on the value of this particular angler's observations, this example does illustrate the potential for varying degrees of angler familiarity with certain parts of the catchment in response to different factors. The implications of this in terms of use of angler knowledge are important.

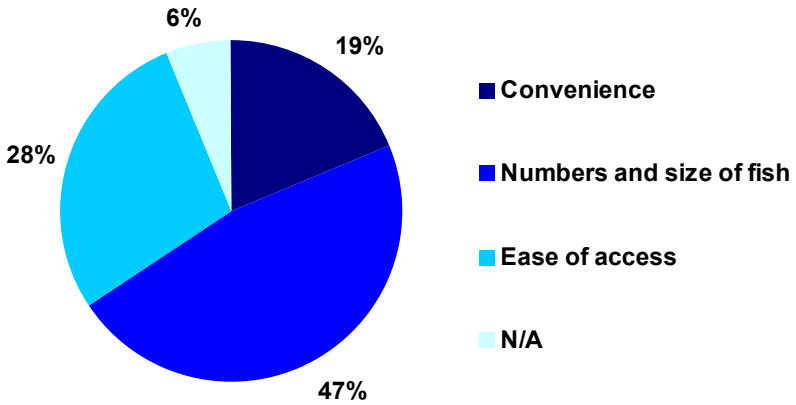


Fig. 5.1. Main determinants of choice of fishing location

As an additional means of determining the area of the catchment covered by the anglers, interviewees were asked whether they parked their car and fished from one spot for the whole day, or instead fished from a number of spots throughout the day, moving by car between spots. Thirty-eight percent of fishermen fish only one beat of the river per day, only parking once, while 13% use both tactics, depending on the day or the river fished. Fifty percent fish a number of spots during one fishing trip, making one to five stops per trip (mean= 2.6). Three of these eight fishermen used to fish from one spot only, but have had to change their fishing patterns to accommodate either personal injuries, the decreasing mobility of their ageing clients (in the case of fishing guides), or, in one case, for the decrease in the number of fish in the river. Though the results proved to be inconclusive in this case (given the impossibility of determining whether anglers who hopped from place to place during each trip have 'better' knowledge than those who do not), it may be that if applied to a larger sample in a different manner this question could yield more interesting results.

5.1.2.3 Fishing guides: a special case?

Half of the angler sample are or have been fishing guides; the implications of this profession on the extent of an angler's interaction with the fishery are examined in this section.

Of the eight anglers with guiding experience, four have been fishing guides in the past, for between 5 and 15 years (mean=11). For two of these anglers, guiding was a secondary occupation, while it was the sole means of earning income for the other two. Presumably, these anglers spent more time than normally on the river during their guiding period. This probably means they have a better knowledge of the river during this time; however, because these anglers gave an indication of the number of days fished per year at present, and not during the guiding period, it is not possible to use their results for comparison purposes. It is possible, however, to compare the results of the anglers currently guiding with those of the non-presently guiding anglers, in terms of the time spent on the Motueka River.

The four anglers who are currently employed as guides do so on a primarily full-time basis (though some supplement their income through various means); they have been guiding for between 19 and 30 years (mean=25). Three of the guides have recently reduced their frequency of fishing in the Motueka catchment, for a number of reasons: two because of a general reduction in the number of days spent guiding per year, and one because he moved further away from the catchment and also saw it as suffering from increased fishing pressure. On average, the non-guide anglers spent 23 days per year on the river over an average of 36 years of fishing the Motueka, while the guides spent an average of 32 days per year on the river over an average of 35 years of fishing. If taking into account the recent decrease in guiding activity on the Motueka for some of the guides, the results change slightly: during their 'peak' guiding years, they spent on average 46 days per year on the river, while they currently spend on average 16 days per year guiding on the Motueka. However, given that the decrease in activity for some of the guides is quite recent, it is safe to state that overall they have spent more days on the river than non-guide anglers.

With regards to the geographical distribution of the fishing effort among guides as opposed to non-guide anglers, there is no discernible difference: both guides and non-guides appear to fish mostly the middle sections of the Motueka, as well as the Wangapeka tributary.

Overall, this review of the fishing experience of the interviewees in the Motueka catchment has revealed that there are quite wide variations between interviewees. Some have both wide spatial and temporal experience, while others have had shorter-term experience in more limited parts of the catchment. However, these differences do not necessarily correspond to the degree of recollection of events in the catchment; indeed, as illustrated next, the extent to which fishermen record events in written form appears to play an important role.

5.1.3 Information captured by fishermen

5.1.3.1 Fishing diaries

Nearly 70% of the angler sample keeps or has at some point kept a fishing diary (figure 5.2).

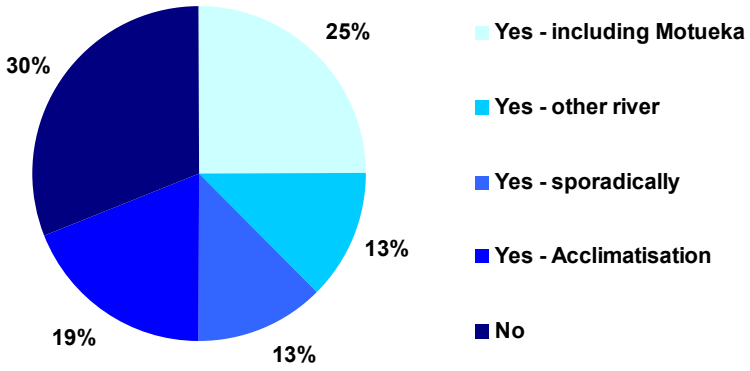


Fig. 5.2. Angler diary records: existence and type

Only four anglers regularly keep a diary which includes coverage of the Motueka River and its tributaries; another regularly keeps a diary, but it does not include information on the Motueka. Two more anglers sporadically keep fishing diaries, and three have kept them in the past, as part of Acclimatisation Society (the precursor of FGNZ) diary schemes. All of these anglers were asked questions regarding the type of information recorded in the diaries (table 5.2), as well as their reasons for keeping such records of information.

Table 5.2. Summary of the main types of information recorded in angler diaries

Angler:	R	D	M	A	T	O	X	N	P	U	S	Total
Basic information												
Date	√	√							√	√		4
River/lake fished	√	√				√			√	√		5
Location in river/lake	√	√				√			√	√		5
Time spent (hours)	√	√					√		√			4
Catching fish												
Fishing method used						√				√		2
Number of fish seen					√			√	√			3
Number of fish attempted									√			1
Number of fish caught or hooked	√	√		√	√	√	√	√	√	√	√	10
Number of fish landed								√	√			2
Number of fish killed		√								√	√	3
Species of fish caught		√										1
Sex of fish caught		√										1
Weight of fish caught		√	√	√			√					4
Length of fish caught		√	√			√	√					4
Condition of fish	√											1
Stomach contents of fish			√									1
Factors which may influence success												
Presence of other anglers									√			1
Weather conditions	√	√						√	√	√		5
Fish behavior	√											1
River flow	√	√					√	√	√	√		6
If river rising							√					1
If river falling							√					1
Water clarity								√	√			2
Water temperature		√							√			2
Species and numbers of insects							√					1
Visible insect hatches									√			1
Sediment levels							√					1

Three types of information are recorded by one or more anglers: basic information, different aspects relating to the catching of fish, and factors which may influence fishing success. Although they did not mention it in the interview, it is likely that more of the diarists record basic information such as date and river fished. Three types of diarists can be distinguished: basic, intermediate and detailed diarists.

Basic diarists do not record anything other than information relating to fish catch, and even then it is mostly limited to number of fish caught, weight and length. Five of the diarists in this sample fit in this category; three had participated in diary schemes organized by the Acclimatisation Societies, for one of them dating back to the 1950s.

Intermediate diarists also record some information relating to fish catch (again, mainly number of fish caught), but in addition they also make some notes relating to other factors, primarily weather conditions and river flow. Three of the diarists fit this profile: one only fills a diary in sporadically, while the others record this information for each fishing trip.

The final type of diarist is the detailed diarist, who records an abundance of information, particularly relating to factors which may influence success. Interestingly, while there are some commonalities (weather conditions, river flow and water temperature) in the information they record, some of it is unique to each angler, one recording the presence of other anglers as well as visible insect hatches, and another whether the river is rising or falling, for example. All three of the detailed diarists in the sample currently keep a diary, and record the information for each fishing trip. As a note, all anglers who record river flows mentioned using the Tasman District Council's online river flow data as a source of information on the cubic meter per second flow of the river. Figures 5.3 and 5.4 show two examples of diary entries from anglers; in figure 5.3, the notes read "river just a tad high – saw about 8 and landed a good one".

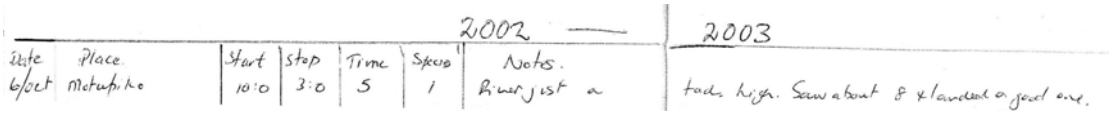


Fig. 5.3. Angler diary entry from the Motupiko River, October 2002

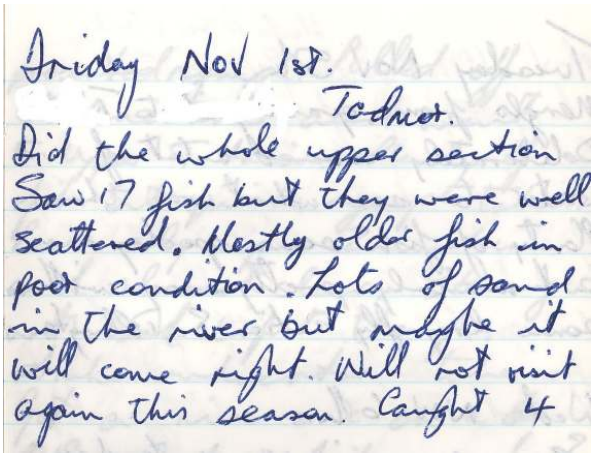


Fig. 5.4. Angler diary entry from the Tadmor River, November 1996

Figure 5.4 is an example of a diary entry which comments on habitat; it reads "lots of sand in the river but maybe it will come right". One of the main findings relating to fishing diaries is that information relating to habitat is recorded by diarists less frequently; of 11 current or past diarists, only two record such information on a regular basis. One notes any high incidence of periphyton, while the other makes observation regarding the degree of sedimentation in the location fished. Noting information relating to insect life is also infrequent; two diarists record either visible insect hatches, or species and numbers of insects found under stones in the river – a third used to note such information in his examination of stomach contents. Information on insect life is particularly prized by some fly fishermen, as it can help them determine the main source of food for trout, and subsequently tie up an imitation of this main source in order to increase the chance of fishing success.

Diarists were also asked why they chose to keep fishing diaries. Three anglers filled in diaries because they were asked to as part of Acclimatisation Society schemes – one of them felt a particular

responsibility to provide high quality data (as an experienced fisherman) to compensate for the average data provided by most participants; another angler does so as part of a FGNZ diary scheme targeted on the neighboring Wairau River. One angler became a diarist for a number of reasons: to gather data needed for his fishing guiding operation, out of personal interest and for scientific purposes – encouraged by a scientist friend of his to do so. Finally, two anglers do so for personal interest only: one to help understand the fishery in general and reasons for success or lack thereof, and to use as a guide if he goes there again on the same day. The other diarist has a personal interest in statistics, but also periodically looks back at the information he has recorded; the fact that he provides data from these diaries to FGNZ is incidental, and not a motivation for recording the information in the first place.

"You sort of learn more by going back to exactly the same place the next day, not because you necessarily think you're going to catch fish but… is there some pattern to this or is it just a random day?"

In sum, although obtaining diary records regarding things like sediment events would have been beneficial, particularly in terms of interview validation, very little such information was available. In any case, the original purpose of asking questions relating to fishing diaries was actually to better understand the ways in which anglers conceptualize and present information relating to the catchment.

5.1.3.2 Other records of fishing trips

Anglers were asked whether or not they keep other records of their fishing trips, beyond fishing diaries. The majority (75%) of fishermen take photographs during their fishing trips, in most cases of anglers catching or holding fish, and of the river and catchment scenery in general. Half of those anglers said they sometimes take photographs of things which they feel might be damaging the fishery, such as sediment from forestry practices, gold mining effluents, machinery working in the riverbed, or evidence of unsustainable dairy farming practices. Only one of these anglers was able to locate examples of such photographs (figure 5.5).

Fig. 5.5. Evidence of forestry damage as photographed by an angler: sediment and road slip

Though not all of the accounts of photography of perceived damage were from the Motueka, this was not overly important in terms of analysis. Indeed, although it would have been useful to obtain

photographs (with dates and locations) of events such as sedimentation, equally important was to find out to what extent fishermen are willing to engage in such documentation activities, and also to understand what their reasons for doing so are. Two of the anglers who photograph perceived damage mention sending these to Fish and Game, for example for use in their publications. Another does not specify in what way he used the photographs of gold mining effluent in another catchment, but he does say: "[it] made me very unpopular in town". Yet another did not end up using his photographs: "I thought I was going to fire them off to someone, I was annoyed, but of course I calmed down quicker than I got around to it".

Two additional anglers mentioned non-photographic means of recording things: writing poems and taking videos – in one case to illustrate a point the angler wanted to make to Fish and Game.

5.1.4 Opinions of management measures

In section 7 of the questionnaire, anglers were asked their opinion of different management measures, relating both to the fishery and to the catchment in general. Reactions to each management measure are examined in turn, and a wider view of opinions on management is presented.

5.1.4.1 Fishing regulations

Opinions regarding Fish and Game (FGNZ) fishing regulations were expressed not only with question 25b, but also question 27 regarding suggestions for the best management of the fishery, as well as throughout the interviews as a whole. The majority of opinions regarding the regulations are positive, with a mean score of 0.87, placing it in the 'agree' category; most anglers expressed general agreement with the regulations, with some minor reservations (figure 5.6).

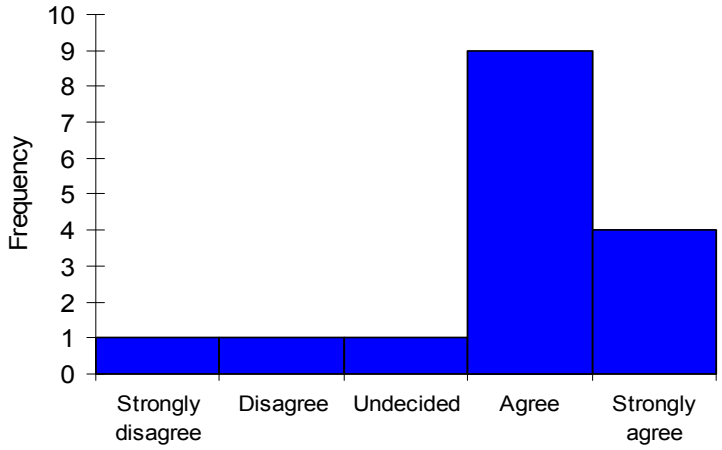


Fig. 5.6. Frequency distribution of angler opinions regarding fishing regulations

As outlined in section 4, Fish and Game's fishing regulations cover a number of areas; opinions expressed by anglers regarding these different areas are indicated in table 5.3.

Table 5.3. Angler opinions of fishing regulations

Area of regulation	Comments #	Opinions expressed
Method of fishing	4	Would like to see more fly fishing-only waters
	3	Would not like to see more fly fishing-only waters
	3	Would like to see more catch-and-release only waters
	1	Does not agree with catch-and-release only regulations on sensitive waters
Fishing season length	1	Would like the winter fishing allowances reduced
	1	Would like the fishing season open one more month
Bag limits	1	Would like the bag limit reduced
	1	Would like the bag limit increased
	1	Would like to be able to continue catching and releasing fish after he has caught his bag limit
	1	Would like to see a limit of two fish caught only per angler per day, even if released

As demonstrated in the table above, no consistent message emerges from the opinions expressed by anglers: as is the case with bag limits and fly fishing-only waters, roughly equal numbers of fishermen express diametrically opposed views. Those in favor of more fly fishing zones are so because they believe the rival spin fishing method causes too much disturbance on a river, given that a spin fisherman is able to cover more ground in a day's fishing. They believe a fly fishing-only river is able to accommodate more fishermen than a river open to all fishing methods; on the contrary, those against method restrictions believe rivers should be open to all anglers. They also argue that given it is not possible to spin fish in some waters this naturally creates de facto fly fishing only areas. What this table illustrates is that fishermen have widely varying perceptions of the impact of various regulated issues, and hence of the management measures needed (or not) to address these. Bag limits are a perfect example: the angler wanting them increased does not believe fishermen have any effect on the state of the fishery, while the one who wants them decreased does. Additional comments and recommendations regarding Fish and Game's policies were given by fishermen (table 5.4).

Table 5.4. Angler opinions of Fish and Game policies

Comments #	Opinions expressed
6	Think the decision to ban felt-soled wading boots was unwise
5	Would like a non-resident angler license put into place
1	Would like a fishing guide license installed
1	Would like guides to be banned from some rivers
1	Would like some rivers closed until they recover
4	Would like rivers to be stocked
3	Would not like rivers to be stocked

Some of the comments reveal some negative angler perceptions of fishing guides – both comments were actually made by a single angler, but another did say he does not agree with the concept of fishing guides and their making money out of a resource for whose upkeep they do not contribute.

A management proposal put forward by five anglers is that of a non-resident angler license; at present, both local fishermen and tourists pay the same fee for a fishing license, which is a very unusual situation when placed in a worldwide context.

Whether or not to stock rivers, i.e. to release captive-bred fish, is another issue which polarizes angler opinions. Out of the seven fishermen who mentioned this topic, three are against the stocking of rivers: one angler feared the negative implications for the fishery in terms of genetics, while another expressed cynicism in the face of angler requests for re-stocking, saying that his own fishing success in places that have been suggested for stocking has not diminished. Also, even though four fishermen had a more positive view of stocking, two gave some caveats, saying it has not been proven to work in the Nelson area, or that if done the fish should be from the fishery itself in order to minimize the risk of disease; one angler merely said stocking should remain a weapon in the management arsenal and not be rejected as a possibility altogether.

A final recurring theme within the views expressed about the fishing regulations is disappointment with Fish and Game's decision to ban fishermen's use of felt-soled wading boots; 37% of anglers brought up this issue, often in very strong terms. The decision was related to the spread of the invasive algae Didymo, and was justified by evidence of long-term Didymo cell survival in the footwear (Kilroy et al. 2006). While some anglers highlighted the shortcomings of the decision itself, seeing it as inconsistent and somewhat pointless (for example given the lack of uniform application of the ban beyond anglers), others were also critical of the manner in which the decision was reached. These anglers see the decision as a public relations mistake, because it was reached without adequate consultation with fishermen and subsequently alienated a proportion of the angling public. One fisherman in particular highlighted what he saw as the deleterious consequences of the decision on felt soles for the future of Fish and Game: "they're not going to achieve any better outcome, and they've probably cost themselves millions of dollars of bloody volunteer labor [and] knowledge". Naturally, the importance of this issue should not be overestimated, as the majority of fishermen did not mention it, and as one of those who did recognized it as a side issue.

In sum, although the anglers in general agreed with the fishing regulations, this item of the questionnaire often led to the expression of some very strongly held views, which some of the fishermen have obviously held for some time, and in some cases have actively campaigned for or against through the relevant channels. This subject will be returned to later, as it is closely linked with the way anglers regard Fish and Game as an organization.

5.1.4.2 The Motueka Water Conservation Order

As mentioned in section 3, the phrasing of the questions in section 7 of the questionnaire resulted in some complications of interpretation; this is particularly the case for the question relating to the Water Conservation Order on the Motueka, where the divergence between theory and practice was most apparent. Summary table 5.9 presents the opinions of anglers as given during the interviews; however, in order to more usefully evaluate this topic, this section manipulates the answers slightly.

Indeed, six interviewees expressed the view that although they agreed with the concept of the Water Conservation Order, they did not feel its practical application was equally beneficial. The origin of this view stems in large part from the controversy surrounding an application to amend an existing Water Conservation Order for another regional river, the Buller, in order to facilitate the construction of a hydroelectric plant on one of the river's tributaries. Although the proposal was rejected, it did highlight the fact that Water Conservation Orders do not provide permanent protection for a water body, but instead that their provisions may be the subject of appeal after 10 years (Basher pers. comm.). This fact appears to be of some concern to anglers; for example, Angler N said he strongly agrees if the Order is strong, and strongly disagrees if it is weak – if the protection it provides is not permanently guaranteed. In order to account for the distinction made by some anglers, the results were changed in order to score opinions of the Conservation Order's intent as well as its practical application; the results are reflected in table 5.5.

Table 5.5. Altered angler opinions of the Water Conservation Order, in theory and practice

Angler alias	Management measure	
	Water Conservation Order (theory)	Water Conservation Order (practice)
Angler R	2	2
Angler D	2	-1
Angler M	2	-1
Angler A	1	1
Angler T	1	1
Angler G	/	/
Angler E	1	-1
Angler O	1	1
Angler X	2	2
Angler C	1	-2
Angler F	2	2
Angler W	2	2
Angler N	2	-2
Angler P	2	2
Angler U	1	-1
Angler S	1	1
Mean	1.53	0.4

Anglers who did not express concern about the Conservation Order retained the same score as previously, while those who did received a lower score for the practical aspect (conservatively downgraded to -1, or "disagree", except for Angler N who clearly gave an opinion about both aspects) and in two cases a higher score for the theoretical aspect. The shortcomings of this method are obvious: the manipulation was done post-interview without verification with the interviewees – it is therefore possible that they may have expressed a different opinion if asked during the interview. However, it does give an indication of the difference between the two aspects. Opinion of the Water Conservation Order in principle remains strong agreement (mean= 1.53), while that of its practical application is agreement, but closer to neutral (mean= 0.4).

As well as the perceived dichotomy between theory and practice, another point to highlight is the strong positive perception of the intent of the Water Conservation Order, as illustrated by a number of

comments, calling it “desirable” “good” and “important”. No angler expressed a negative opinion of the Order, making this the most positively viewed management measure, as illustrated in figure 5.7.

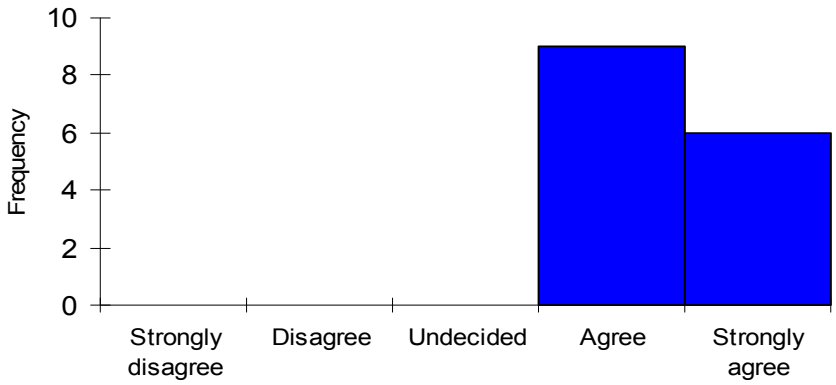


Fig. 5.7. Frequency distribution of angler opinions regarding the Water Conservation Order

5.1.4.3 Tasman District Council’s water allocation policies

Water allocation policies, as decided and implemented by Tasman District Council, received a mean score of -0.83 (the lowest score of amongst the management measures), placing it in the ‘disagree’ category. Of the management measures reviewed in section 7 of the questionnaire, this one received no positive opinions from anglers, as shown in figure 5.8.

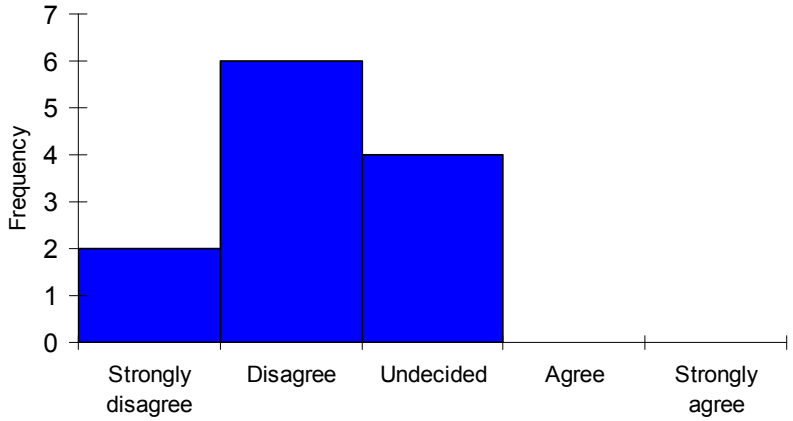


Fig. 5.8. Frequency distribution of angler opinions regarding water allocation policies

A number of comments were made to justify the opinions put forward, and are listed in table 5.6.

Table 5.6. Angler opinions of water allocation policies

Comments #	Opinions expressed
2	There is too much water abstraction from the Motupiko river
2	There is too much water abstraction in other catchments and regions, so it probably is happening in the Motueka catchment too
2	Policies are supported by incomplete knowledge of resources and takes
1	Both urban and agricultural water use is too high
1	Policies are made based on economic and not ecological grounds
1	There should be a time limit on water allocations, after which users should make provisions to store the water they need
1	There is not too much water abstracted from the Motueka river

In four cases, negative overall opinions were linked to perceived over-abstraction in either one of the tributaries of the Motueka, the Motupiko River, or in other catchments and regions of New Zealand. For the latter, the anglers admitted incomplete knowledge of over-allocation on the Motueka, but instead expressed their concern about a perceived general tendency to over-allocate water. This line of thinking is also shared by some other fishermen, who fear decisions do not adequately consider the in-stream values of water, and moreover are not based on full knowledge of existing resources and water takes.

In answer to this question, one angler proposed a 10-year time limit on water allocation rights, in order to encourage water users to store water to meet their needs. This support of water storage as a future management option for the Motueka catchment was echoed by two other interviewees in different parts of the interviews.

5.1.4.4 Water quality standards

Opinions on water quality standards are on average neutral (with a mean score of 0), and distributed widely within the opinion spectrum, as illustrated in figure 5.9.

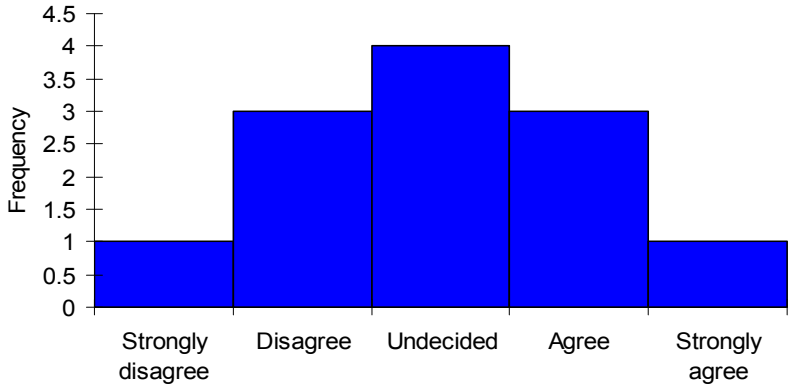


Fig. 5.9. Frequency distribution of angler opinions regarding water quality standards

As is obvious with such a spectrum of opinions, anglers expressed a number of different views regarding the water quality standards; these are summarized in table 5.7.

Table 5.7. Angler opinions of water quality standards

Comments #	Opinions expressed
3	The standards are sufficient, it is enforcement that is lacking
3	Water quality suffers as a result of stock farming activities
2	Water quality degrades short-term with sediment from forestry
1	Wider catchment management does not consider water quality
1	Water quality is getting worse
2	Water quality is unchanged, not a problem
1	Water quality is improving

Two land uses are targeted by anglers as causes of water quality degradation: forestry and dairy farming. One angler in particular expressed concern about the potential long-term effects of dairy farming on water quality, for example on groundwater, and felt that the standards did not take these wider implications into consideration. A second salient point is, similarly to the Water Conservation Order, criticism of the enforcement of existing standard rather than of the standards themselves; to quote one angler: “it’s sort of like slapping people on the hand with a wet bus ticket”.

5.1.4.5 Tasman District Council’s land management measures

With a mean score of -0.67, placing it in the ‘disagree’ category, Tasman District Council’s land management measures score among the lowest in terms of angler opinions (figure 5.10). These measures also have the highest number of anglers in disagreement (whether strong or not) and also only generated two positive overall opinions.

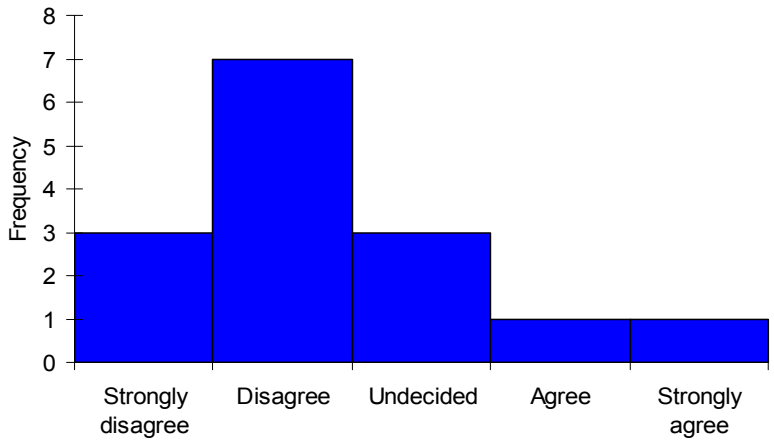


Fig. 5.10. Frequency distribution of angler opinions regarding land management measures

Because TDC’s land management measures cover a number of areas, the particular aspects commented on by anglers also varied widely (table 5.8).

Table 5.8. Angler opinions of land management measures

Comments #	Opinions expressed
Overall view	
4	Better than in the past
3	Not good enough to very poor
Specific points	
6	Inadequate management of riparian zones against the effects of both dairy farming and forestry
5	Willow removal policy is not sensible
8	Insufficient controls over forestry practices
1	Sufficient controls over forestry practices
3	Land use in general is not planned for adequately
2	The Council should not have bulldozers working in the riverbeds
1	Riparian rights granted in a way that restricts public access to rivers

Overall opinions of TDC's management of land are quite polarized, with roughly equal numbers of fishermen seeing an improvement or being more critical of the Council's policies. Management of riparian zones is a cause of concern for a number of fishermen; two land uses (forestry and dairy farming) are highlighted as needing improved riparian management, which links to the comments about water quality outlined in the previous section. In particular, some fishermen would like to see wider riparian strips to protect streams from erosion and decreased water quality.

Another concern linked to riparian management is the issue of willow tree removal; these trees are not native to New Zealand, and as such are the subject of control measures. Anglers are concerned both about the willow removal policy in itself (seeing willows as superior to native vegetation solutions in terms of streamside erosion control) and about the methods used to control the trees, such as use of diggers to smash willows down, or non-removal of cuttings. The concern is particularly related to crack willows (*Salix fragilis*).

Regarding concern over controls on forestry practices, seen as a cause of concern by half of the fishermen, things like planting of trees too close to stream edges as well as inappropriate stream crossings for forestry trucks were mentioned. One angler expressed satisfaction with the Council's degree of control over forestry practices. Another recurring theme is that of land use planning for the long term, which three fishermen see as being a problem for the catchment. In their view, the Council should be more prescriptive in terms of the land uses it allows, by identifying suitable activities for different types of terrain, instead of taking a more laissez-faire attitude to land use. For example, one angler thinks dairy farming should not be allowed in dry areas, as they are not suitable for it and as a result put additional pressure on the environment, for example in terms of water abstraction for pasture irrigation.

5.1.4.6 Overall opinion of management measures

In assessing overall opinions of management, two aspects are of particular interest: first of all, the scores of the management measures as a whole and compared with each other (ranging from -0.83 to

1.4), and secondly individual angler opinion profiles, with mean scores ranging from -0.4 to 2 (table 5.9). Immediately apparent is the dichotomy between the positive and negative scores for the different management measures, as well as the lack of overall strong negative perceptions of the policies. Anglers are most positive about the Water Conservation Order, though the phrasing of the question may have played a particularly strong role in responses to this question. Anglers hold negative opinions about both water allocation and land management policies, but these are not within the bottom quarter of possible scores (the 'strongly disagree' category). Overall, the total mean score for the management measures is 0.15, indicating angler opinions of management measures affecting both the fishery and the catchment as a whole are slightly above neutral.

The "don't know" responses were excluded from the analysis; however, two things can be highlighted in their regard. First of all, for the Water Conservation Order, the fishing regulations and the land management policies, zero or one such responses were given, indicating fishermen are generally aware of the provisions of these management policies and/or hold opinions about them. Secondly, the proportion of "don't know" responses was higher (25% each) for the questions on water allocation and water quality management, which could indicate either that some anglers are unaware of these particular management policies, or that they have not noticed anything particular about water quantity or quality in the Motueka catchment. The second explanation is supported by the fact that in a few cases, in section 7 of the questionnaire, responses were given addressing the object of policy rather than the policy itself.

Table 5.9. Angler opinions of management measures in the Motueka catchment

Angler alias	Management measure					Mean angler score
	Water Conservation Order	Fishing regulations	Water allocation	Water quality	Land management	
Angler R	2	2	-2	-2	-2	-0.4
Angler D	2	2	0	0	0	0.8
Angler M	1	-1	/	/	/	0
Angler A	1	2	0	0	-1	0.4
Angler T	1	1	-1	1	-1	0.2
Angler G	/	1	0	/	-1	0
Angler E	1	1	-1	0	-1	0
Angler O	1	0	/	0	-1	0
Angler X	2	1	0	1	1	1
Angler C	1	-2	/	1	-1	-0.25
Angler F	2	2	/	2	2	2
Angler W	2	1	-1	-1	0	0.2
Angler N	1	1	-2	/	0	0
Angler P	2	1	-1	/	-2	0
Angler U	1	1	-1	-1	-1	-0.2
Angler S	1	1	-1	-1	-2	-0.4
Total mean score	1.4	0.87	-0.83	0	-0.67	**0.15**

The second interesting aspect of this table relates to the individual angler scoring profiles, split into four opinion categories (figure 5.11). No angler overall strongly disagreed with the management

measures, and 6 received a 'neutral' score of 0. Five anglers expressed general agreement, and 4 disagreement, while only one strongly agreed with the management measures.

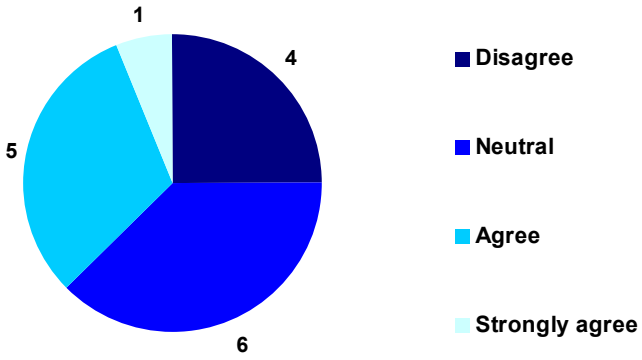


Fig. 5.11. Number of anglers per opinion category

To conclude this section on management measures, both general trends and specific points can be drawn out of the results gathered from anglers. In general, though the overall view of existing management measures relating to the fishery and the catchment of the Motueka River is slightly above neutral, some measures are more criticized than others. In particular, TDC's water allocation and land management measures scored negatively, and water quality measures received a neutral score. Despite some strongly worded criticisms of particular policies, the global view of the fishing regulations is positive; opinions of the Water Conservation Order were the most positive, though an analysis experiment places doubt on the phrasing of the question that led to this result. Asking anglers about their opinions of management measures not only helped to reconfirm and clarify some views held about potential causes for any perceived decline in the fishery, but also helped to build a picture of angler opinions regarding not just the management measures themselves, but also in many cases the organizations in charge of said management.

5.1.5 Interaction with the angling community

Anglers interact with each other, both on a personal level and through fishing clubs, and also interact with various agencies in charge of managing the catchment. During the interviews, specific questions were asked regarding membership in fishing clubs as well as networking with other anglers, but relevant statements were also made in the rest of the interview sections. The aim of these questions was to determine what level of interaction occurred within the angling community, particularly in relation to environmental issues, in order to shed light on the extent to which certain views held by anglers may be influenced by others.

5.1.5.1 Interaction through fishing clubs

Fishing clubs entail regular meetings of local anglers to learn about and often discuss various aspects related to fishing; according to the FGNZ website, there are six fishing clubs in the Nelson/Marlborough region (Fish and Game New Zealand N.d.). Within the angler sample, 70% of interviewees are (7) or have been (3) members of a fishing club; the 3 are no longer members either because their particular fishing club folded through member disinterest, or because they moved away.

Half of the present or past club members attend or attended meetings regularly, i.e. once a month, which is the norm, while the other half have sporadic attendance patterns, either because of lack of time or interest in the particular monthly theme, or for other reasons. Anglers were also asked whether they participate or participated in discussions held at the fishing clubs: 7 out of the 10 concerned anglers do or did so consistently, 1 did not, and 2 answered that discussions do not normally occur in the meetings, which are instead dedicated to presentations about various topics from one guest speaker, with usually little room for interaction. Some of the anglers who participate or participated in discussions indicated that they took a leading role in discussions, with comments such as "usually started them" or "go down and take the bloody thing over". A few fishermen also mention having held positions of responsibility in their fishing club, such as secretary, treasurer or president, indicating an increased degree of involvement with the club.

Interesting results were gathered by asking anglers to what extent environmental issues are or were discussed at meetings; an overview of the comments given is provided in table 5.10. A number of fishermen made the distinction between formal and informal meeting time, informal meeting time referring to discussions occurring during the coffee break following the presentation. Generally, informal meeting time appears to be the main forum during which environmental discussions occur, with formal meeting presentations often unrelated to environmental issues. One angler's fishing club discusses environmental issues for approximately 50% of the meeting time, a percentage which has grown in recent years as a result of a controversy surrounding a proposed hydroelectric power plant on a local river. Most interesting was a comment made by three anglers, explaining that the small percentage of time devoted to environmental issues in formal meeting time is a response to the low level of interest of most club members in such issues.

Table 5.10. Comments on frequency of discussion of environmental issues at fishing clubs

Comments #	Opinions expressed
4	Yes, all the time
3	Yes, a small percentage during formal meeting time
2	Yes, a large percentage during informal post-meeting conversations
2	Sometimes – depending on the topic presented by the speaker
3	No, not usually

5.1.5.2 Personal interaction with other anglers

Anglers also interact with each other on a more personal level, as a result of the friendships formed around the sport – including through membership in fishing clubs. Indeed, there appears to be quite a close network of anglers in the region – many of the interviewees actually mentioned one another. Most of the anglers mentioned having an extensive network of fishing friends, and the rest a smaller network; the term 'fishing friends' was usually taken to mean friends that they talk about fishing with, rather than friends that they go fishing with. Indeed, most (but not all) of the anglers seem to prefer fishing on their own, making comments like: "that's why I've got a Labrador, because Labradors don't tell anyone where you've been fishing". For one angler, the friendship within his close circle of fishing friends is unrelated to their background; instead, he says "it's the fishery that ties us together".

Anglers discuss environmental issues with their friends to varying degrees: 25% talk about them all the time, 63% sometimes do, and one angler does not. Some anglers specified the types of environmental issues they discuss, things such as observations of events, land use patterns, and forestry. For one angler, the frequency with which he and his friends talk about the environment has increased, and has been brought about by a desire to understand the causes of the decline which they have perceived in the fishery. Three anglers found that they agree with their friends on most things relating to the environment; there are mixed views for three others, and one angler found himself disagreeing with his fishing friends on a number of issues. A number of statements made by interviewees highlight the exchange of views that takes place among fishermen: “I know [he] thinks the same thing”, “my discussions with other fishermen” and “talking to a number of other experienced people”.

5.1.5.3 Interaction with Fish and Game and Tasman District Council

Beyond friendships and angling clubs, there is a third level of interaction for fishermen: this relates to the interactions anglers have with FGNZ and TDC. Interviewees were not directly asked about their level of interaction with or opinion of these management agencies, but many spontaneous comments were made in relation to both.

Angler interaction with FGNZ adds another layer to the information about factors which may potentially influence angler views. FGNZ employs volunteer rangers, who check anglers for their licenses and compliance with fishing regulations when they are out on the river; one angler was a ranger for approximately 25 years, while two more are currently rangers. Ranger meetings are held with FGNZ, giving rangers a greater degree of interaction with the fishery managers than average anglers – moreover, in the course of performing their ranging duties, they interact with a large number of anglers. Two of the anglers were part of the Acclimatisation Society council, one for 9 and one for 15 years; one of these has also been a member of the elected FGNZ council for some years, along with two other anglers within the sample. These appointments obviously increase the degree of interaction of these anglers with other anglers, as well as with the professional employees of FGNZ. Acting as a councilor does not influence the opinion score of these anglers regarding the fishing regulations, although two of the three jokingly refer to their role as councilor as the reason for their agreement with the regulations. As for the other anglers which are not involved with FGNZ in an official capacity, some make references to conversations with Neil Deans, manager of the Nelson/Marlborough region for FGNZ.

A number of anglers expressed reservations about the performance of FGNZ in terms of management of the fishery, though this bears no relation to their opinions of the fishing regulations themselves, which the anglers mostly agree with. For four anglers (one of which used to be on one of their councils), the Acclimatisation Societies did a better job of managing the fishery than FGNZ, while another believes FGNZ to be more effective based on his council experience with both organizations. A summary of the type of comments made about FGNZ is presented in table 5.11.

Table 5.11. Angler opinions of FGNZ

Comments #	Opinions expressed
5	They do the best they can at a local level with limited resources (staff and money)
3	They do not spend enough time in the field, and are not proactive enough in managing the fishery
3	They do not communicate with anglers adequately
1	Anglers have ample opportunities to communicate with FGNZ
2	There is systemic failure at the national FGNZ level
1	They do not have answers for important questions regarding the fishery

Positive opinions expressed are regarding the local level of FGNZ management, and acknowledge the good efforts made in the face of financial restrictions, which limit the number of staff that can be hired. While some other anglers also recognize these constraints, they have a negative opinion of the local FGNZ's overall performance. Of most interest here are the comments made regarding inadequate communication with anglers; one angler in particular criticizes the public relations skills of the organization, citing poor feedback at a national level, and failure to respond to emails at a local level: "you just get fobbed off". Two other anglers believe FGNZ fails to consult with the anglers who hold valuable knowledge about the fishery: they "can't see the wood for the trees, they're not talking to the people that actually understand what's happening to the fishery".

As for opinions of TDC, the spontaneous comments that were made were also quite varied, although most anglers only commented on the specific management measures they were asked about and not on the Council's performance as a whole. Some (3) anglers expressed generally positive views ("trying hard", "quite good") while others (4) were scathing in their critique of TDC ("disaster", "incompetent", "unimpressed"). An angler involved with a fishing club expressed frustration at the difficulties he had in communicating with TDC on the numerous occasions in which he met with them, and felt that his views (and by extension those of the other anglers of the fishing club) were not valued adequately. One angler admits having other issues with TDC at present, which may affect his views of the Council's performance on environmental issues. On average, the opinion scores for the three specific environmental management measures which anglers were asked about (water allocation, water quality and land management) are lower (mean= -0.87) for the anglers who expressed strong negative views of the Council than for the anglers who did not (mean= -0.33). While there may not be a correlation between the two things, it is nonetheless interesting to note.

"The management of the trout fishery is most affected by habitat quality, and Fish & Game for example, as the manager of the trout fishery, doesn't have any control over habitat quality"

The spontaneous comments made by anglers regarding the management agencies, outside of the questions regarding specific management measures, provided valuable insights into the opinions they have of these agencies. Although determining anglers' opinions of management agencies is not directly related to the aim of gathering their knowledge, it can certainly feed into the discussion of how

to integrate fishermen's knowledge into management. Indeed, opinions (both positive and negative) about management agencies can have a bearing on potential interaction with the latter.

5.2 Angler knowledge of environmental processes

Important information was obtained by asking fishermen about their experience of the catchment, their ways of recording information, and their opinion of management measures. However, the core of the interviews involved asking fishermen about their knowledge of past sediment events in the catchment, as well as questions relating more generally to the trout fishery and the factors affecting it. This section attempts to capture the quantity and diversity of the answers given by fishermen, as well to bring out the most salient trends within them. The aim is to present the information given in the interviews – a critical review of which will be given later.

5.2.1 Knowledge of sediment events

Anglers were asked about the location, timing, duration, type and severity of any sediment events which they may have noticed in the Motueka River and its tributaries, as well as about their opinion of the causes of these events.

5.2.1.1 Observations of sediment events

Table 5.12 presents angler observations of sediment events in the Motueka and its tributaries. The main stem of the Motueka has been divided into two reaches, one above and one below the Wangapeka confluence. Though some anglers provided more detailed locations of sediment events, this division is sufficient to capture the main distinction, which is between sediment entering from the west bank through the Wangapeka, and sediment coming out of the upper Motueka area. The table presents the data as given by interviewees; events are classified by sediment type and location, and are given a date where relevant, as well as the source of the sedimentation where specified by respondents. Numbers in parentheses indicate the number of anglers making such an observation – there are very few exact matches. However, despite the lack of precise matches, some groupings can be made; these are indicated in bold font in the table.

Table 5.12. Angler observations of sediment events

Affected water body	Sediment type			
	Silt	Sand	Gravel	In-filling
Motueka below W. confluence	. No date (1) . 80s (1) . Gradual, since early 90s (1) . Early- mid 90s, from Dart (1) . 90s, from Pearse, Pokororo etc (1) . 1995-8, from upper Mot (1) . 2004-6, from upper Mot (1) . 2005-6, from Wangapeka (1) . 2008-9, from Wangapeka (1) . 2008-9 (1) ➔ **2008-9 (2)**	. No date (1) . Early 70s, from upper Mot (1) . Early- mid 90s, from Dart (1) . 1995-6, from Dart (1) . 2000-1 (1) . 2005-6, from Dove (1) . 2005-6, from east bank (1) . 2008-9 (2) ➔ **Mid 2000s, from east bank (2)** ➔ **Early- mid 90s, Dart (2)** ➔ **2008-9 (2)**	. No date (1) . 2008-9 (1)	. No date (1) . Gradual, since late 80s (1)
Motueka above W. confluence	. 40s and early 50s (1) . Early 70s (1) . 1995 (2)	. 1970-1 (1) . 2004-5 (1)	. No date (1) . 1988 (1) . 1995 (1)	
Wangapeka	. Late 80s, from Dart (1) . 1997-8, from Rolling (1) . 2007-8 (1) . 2008-9 (1) ➔ **Late 2000s (2)**	. No date (1) . Mid to late 70s (1) . 70s, from Dart (2) . Early 90s (1) . 90s, from Dart (1) . Early- mid 90s (1) . Early- mid 90s, from Dart (1) . 1995-6, from Dart (1) . 1994-5 (1) ➔ **Early- mid 90s (6)** ➔ **70s (3)**		
Motupiko	. Early 90s (1) . 1995 (1) ➔ **90s (2)**	. No date (1)		. No date (1) . Since early 2000s (1)
Dart	. 80s (1) . Early- mid 90s (1)	. No date (1) . Late 80s (1) . Early- mid 90s (1) . 1995-6 (1) . 90s (1) . 2008-9 (1) ➔ **90s (3)**		. Since 70s (1)
Baton	. No date (1)			
Pokororo	. 90s (1)			
Tadmor		. 1996 (1)	. No date (1)	
Rocky			. Mid to late 70s (1)	
Rolling	. 1997-8 (1)			
Dove		. 2005-6 (1)		
Pearse		. 1987-8 (1)		

Key
(1): Number of anglers making a particular observation

Text: Date of sediment event
➔ **Text**: Observations made by more than one angler

Some of the main apparent trends are the fact that the main stem of the Motueka downstream of the Wangapeka confluence is affected both by silt and sand; for the silt, though there is disagreement on the exact period and source of the sediment, both the mid-90s and the late 2000s appear to be periods where the lower river has been most affected. For the presence of sand, there are three main periods of sediment production identified by anglers: early and late 90s and mid 2000s, sourced from different parts of the catchment. The highest degree of consensus is around the presence of sand in the Wangapeka tributary in both the 70s and the early to mid-90s, with many anglers identifying its source as being the Dart River; these events link to the observations of sand in the Dart in the 90s. Silt in the Motupiko tributary in the 90s is also mentioned by more than one angler.

In addition to timing and location of sediment events, anglers were asked about several elements pertaining to the nature of the events; the results of these queries are reviewed below.

- **Sediment location in river cross-section**

Interviewees provided some indications about the location of sediment in the river during the sediment events they describe. Some general trends could be drawn out, and are summarized in table 5.13.

Table 5.13. Comments on location of sediment in river

Comments #	Location of sediment
Sand	
8	Sediment deposited in slugs
3	More widely dispersed across the riverbed
5	Deposition in pools and in slower velocity areas of the river, including in beaches on the edges of rivers
Silt	
1	Sediment deposited in slugs
2	More widely dispersed across the riverbed
6	Deposition in pools and in slower velocity areas of the river, including the edges of rivers
2	Suspended sediment in running water
In-filling	
6	Less variability of habitat, pools filled in

Anglers have mainly observed sand deposited in slugs in the riverbed, though sometimes it has also been seen almost bank-to-bank in certain quieter stretches of the river. Sand deposition is associated with decreases in the velocity of water, and indeed is often observed forming beaches along the river's edge. Anglers' observations of silt deposition place it mainly in slower velocity areas, and also on riverbanks where it has been deposited by a falling river. Two fishermen also mention silt as being temporarily suspended in the water following disturbance. For a number of fishermen, the river has filled in with sediment, where a previously varied habitat consisting of pools, runs and riffles becomes more uniform, regardless of the sediment type with which it is filled.

- **Duration of sediment events**

Finding out the duration of sediment events was important in order to determine the duration of their impact on the river; table 5.14 presents a summary of angler observations.

Table 5.14. Comments on duration of sediment events

Comments #	Duration of sediment events
Sand	
3	Takes around 2 to 4 years to move through
2	Takes around 10 to 12 years to move through
1	Doesn't know; at least 3 years
1	Takes around 5 or 6 years to move through
1	Is gone after one season, or a few freshes
Silt	
3	Is gone after one season, or a few freshes
1	Takes around 2 or 3 years to move through
1	Doesn't know; at least 3 years

Again, though sand events seem to affect the river for longer periods of time than the silt, there are wide variations within the specific time spans mentioned by anglers. Not all anglers were able to provide estimates of duration, some because they stopped going to affected areas after a number of years of noticing sedimentation, something which will be discussed in section 6 of the thesis.

- **Type of sediment**

As previously alluded to, anglers distinguish between a number of different sediment types; the terms used to describe these are listed in table 5.15, and have been grouped where the descriptive terms were quite closely matched. The total number is larger than 16, because some anglers have observed more than one type of sediment event. In their descriptions of sand, it is clear that most anglers are referring to the same thing (granite sand, coarse and pale-colored), but the diversity of terms is nonetheless interesting. There is more variation in descriptions of silt, with different colors mentioned, as well as in descriptions of larger particles, which range from pebbles to cobbles.

Table 5.15. Angler descriptions of sediment types, grouped

Anglers #	Description of sediment type
Sand	
4	“Pale granite sand”, “yellowy-white”, “white”
1	“Sand” “very fine stuff”
1	“Brown-y sand”
2	“Separation Point granite sand” “golden”
2	“Granite sand”
3	“Rough sand”, “coarse sand”, “sand pumice”
1	“Rubbish” “sand or debris”
Silt	
3	“Silt”
1	“Fine black silt”
1	“Muddy silt” “grey”
2	“Mud”, “spongy”, “muddy”
1	“Muddier silty-er stuff”
1	“Thick silt” “yellow muck” “sediment” “silty goldy looking stuff”
1	“Fluffy silt”
1	“Sediment” (not sand)
Gravel and larger-sized materials	
1	“Gross cobbles”
4	“Shingle”, “pea gravel”, “wee pebbles”, “pretty fine pea grain type stuff”, “little stones”, “fine gravel”
2	“Gravel”, “gravel” (4cm diameter)

- **Loss of diversity of habitat**

For some anglers, a gradual loss of diversity of habitat through in-filling is the main symptom of sedimentation in the Motueka catchment; this in-filling is generally mentioned in association with particles larger than sand (i.e. gravel, shingle or cobbles). Rather than more transient sediment events which move through the river, this in-filling tends to be seen as a more gradual process, which makes more uniform riverbeds previously consisting of a series of different habitats: pools, runs and riffles. Of course, loss of diversity of habitat can also be an effect of finer particle sedimentation, as spaces between rocks become filled in by sand or silt, sometimes to the point where large areas of cobbles and rocks become completely submerged. However, the term “in-filling” was used by fishermen to describe the former process and not the latter.

- **Severity of sediment events**

Assessing the severity of sediment events proved to be more useful for cross-interview comparisons rather than markers of general trends. Indeed, the nature of sediment movement means that it is not deposited uniformly across the riverbed, but instead tends to settle in slower velocity areas such as pools and edges. As a result, interviewees often did not point to a single severity sample photograph, as shown in table 5.16; indeed, two anglers specified they had seen all three levels of sedimentation in the river.

Table 5.16. Angler perceptions of severity of sediment events

Comments #	Severity
4	Mostly 1
4	Mostly 2
2	Mostly between 2 and 3
6	Mostly 3
7	Depends on velocity

5.2.1.2 Perceived causes of sediment events

Five possible causes of sediment events were mentioned by the interviewees; these are listed in order of perceived importance in table 5.17. Forestry, and its impacts from roading, preparation of land for planting and finally harvesting, is seen as the main cause of sedimentation. Storms, heavy rainfall and associated flooding are seen as the second most important cause, while the other potential reasons are mentioned by fewer fishermen. As a note, there is not a perfect distinction between some of the categories: for example, while most anglers see forestry as the main cause, they often specify that its effects in terms of sedimentation are often compounded by the effect of flooding, which transports released sediment down through the river system. In order to reflect this in the scoring, if flooding was mentioned as an aggravating cause (after forestry), it was treated as a minor cause, in addition to any other secondary cause mentioned by the interviewee.

Table 5.17. Angler perceptions of causes sediment events

Score	Potential cause
9.1	Forestry (roading, preparation for planting, harvesting, and post-harvest)
4.85	Flooding (in association with forestry or not)
1.05	Slips in the native bush (in association with heavy rainfall, usually)
0.7	Consequence of long-term changes (be it land uses, or climate)
0.3	Gravel extraction in the riverbed

5.2.2 Knowledge of the fishery

Interviewees demonstrated extensive knowledge of the fishery, both in response to specific questions and as part of more general comments. The following sections attempt to summarize the information provided.

5.2.2.1 The effects of sediment on trout fishing

All of the interviewees noticed effects of the sediment events on their fishing – the perceived ways in which these changes manifested themselves are shown in table 5.18.

Table 5.18. Angler perceptions of consequences of sediment events for their fishing

Comments #	Consequences
12	Reduction in suitable habitat for trout food (invertebrates)
2	Reduction in suitable habitat for trout (lack of cover)
2	Reduction in fish numbers in affected areas, reason unspecified
2	Smothering of trout spawning redds
1	Clogging of fish gills (suspended sediment)

Primarily, anglers believe sediment to affect invertebrates at a localized level, by smothering the riverbed and creating unsuitable habitat for the trout's main source of food. This has the effect, as mentioned by a number of anglers, of forcing fish to move to areas unaffected by sedimentation. The same trout movement away from areas of sedimentation is believed by some fishermen to be caused by a reduction in available habitat for trout, which need sheltered spaces in which to take cover. Only three anglers mentioned a direct effect of sediment on trout populations: two the smothering of trout eggs by sediment, which may decrease the supply of oxygen and therefore affect egg survival rates, and one the clogging of gills by suspended sediment, which the angler had observed as having caused some trout mortality.

5.2.2.2 The state of the fishery

Interviewees have widely varying perceptions about the state of the fishery. This section highlights two aspects in particular, namely general observations about the state of the fishery and its change through time, and the view among some fishermen that the changes in the Motueka fishery are mirrored in other regional fisheries.

One of the more interesting elements to emerge from the interviews was the variation in opinions regarding the changes undergone by the trout fishery through time. In an effort to summarize these opinions, anglers have been placed into a few opinion categories in table 5.19, based on the views they expressed.

Table 5.19. Angler views of changes in the trout fishery through time

Anglers #	Opinions expressed
1	Severe deterioration
4	Gradual deterioration, which has accelerated of late to become severe
5	Gradual deterioration
2	Gradual deterioration, but possibly in cycles
3	No deterioration, only a change – possibly a cyclical phenomenon
1	N/A

One angler did not express a view regarding long-term changes in the fishery, because he fished the Motueka catchment for a relatively short period 40 years ago and has not returned since. For the other anglers, 12 out of 15 anglers believe the Motueka fishery has deteriorated, either severely or gradually, in the period during which they have fished it. In contrast, 3 others do not perceive the changes in the fishery to constitute deterioration, but rather see them as a change in the character of the fishery, possibly as part of a cyclical pattern. Opinions of the state of the fishery, whether positive or negative, are based largely on observed changes in both the number and size distribution of the trout population, as will be examined in the next section.

"I've always regarded the trout as a barometer for the general health of the whole area, and when the fishery starts to die then you've got bigger problems going on around you than just in the river"

For half of the fishermen, the decline they have seen happen in the Motueka catchment is common to many other catchments in the region. The most-cited rivers are the Riwaka, the Pelorus, the Rai, the Wakapuaka and the Maitai. Indeed, in two cases, the anglers see the more severe collapse of other fisheries as being detrimental to the Motueka fishery, as anglers transfer their fishing effort to the relatively less affected Motueka catchment. Anglers often advanced theories as to the causes of the perceived decline in the other fisheries; some of these will be returned to in latter parts of the thesis.

5.2.2.3 Changes in the number and size distribution of fish

Related to the perception amongst most interviewees that the number of trout has undergone a decline from the time they first fished it are the comments made relating to numbers of fish observed in the past. As bridges are used by anglers as observation points, many of the comments refer to fish numbers seen off bridges. For example, four fisherman recall seeing important numbers of fish swimming off the Woodstock (also known as Baton) Bridge, from 15-20, 20-30, “dozens upon dozens”, to 100 fish; all of these fishermen point to the contrast with present numbers, a few at most to none at all. Another example is the Ngatimoti Bridge, where some anglers reported seeing up to 20, 20-30, and 60-70 fish; again, anglers see an important difference with present numbers, which range from none to a few fish. As well as bridges, anglers report witnessing important numbers (hundreds) of fish in other areas of rivers, for example in slower velocity stretches like Haycock’s Bush, where one angler reported seeing 500 fish rising, in contrast to the maximum of 30 he might now see in the same stretch in the same season. This impression of bounty is reinforced by comments such as "you couldn't believe that there were so many fish there". Not all fishermen made such observations, some because they only fished the catchment for a restricted period of time and therefore did not notice any changes; one angler was specifically asked whether he used to see large numbers of fish swimming off bridges, and he said that he did at times, but not consistently.

For a number of fishermen (10), the decline in the number of fish is closely associated with a change in the size distribution of fish, namely with a change from a fishery characterized by large numbers of small fish to one characterized by smaller numbers of fish, of a larger size. Several fishermen given indications of the scale of change, from small fish weighing around two pounds, to a current average of four to five pounds; in the words of one angler: “if you got a 3 pounder you got a whopper, whereas you go over there now and if you don’t get a 3 pounder you throw it back!” Interestingly, the interpretation of the significance of this size distribution change varies amongst anglers: some (6) see the lack of small fish as a symptom of the deterioration of the fishery, while others (4) see it as a cyclical phenomenon. For one angler, there has not been a perfect trade-off between numbers and size and the total biomass in the river has declined slightly; for another, the biomass has remained the same – however, both are of the opinion that the fishery has not deteriorated, but merely changed in character.

5.2.2.4 Changes in the location of fish

Another trend which became apparent from fishermen’s spontaneous comments was a change in the location of fish in the river cross-section. Over half of the fishermen (9) mention having noticed a

movement of fish away from shallow water, be it fast riffles or slower water on the edges, into deeper water. Again, those interviewees who attribute causes to this phenomenon have different views: two think increased fishing pressure has lead to an adaptation of fish behavior. For five fishermen, sedimentation has also played a role in this change of fish location. Specifically, for four of them, it is the effect sedimentation has had on insect populations which has driven the change, as it has reduced the suitable habitat area for insects, and consequently for trout, who naturally locate themselves near their food source. The following section reviews angler observations regarding invertebrates in the Motueka catchment.

5.2.2.5 Invertebrate communities

As mentioned previously, some anglers spontaneously mentioned having observed changes in the location of trout, which they partly attributed to changes in the availability of trout food in certain parts of the river. In addition, when asked if they had noticed any changes in the abundance of trout food in the river, anglers made some more specific comments relating to abundance and composition of invertebrate communities (table 5.20).

Table 5.20. Angler observations regarding trends within invertebrate communities

Comments #	Abundance and composition of communities
6	There has been a decline in the mayfly population (and mayfly hatches)
6	Caddis numbers stable –> increasing net-spinning caddis (1)
3	There has been a decline in caddis populations and hatches -> some caddis species (1)
5	Have noticed a decline in the magnitude, frequency and predictability of insect hatches, including evening rises (4)
2	Hatches of insects (including the evening rise) have never been reliable
4	No noticeable long-term trends in insect numbers
3	Decline in insect numbers, species not specified
2	Increased reliance of trout on terrestrial insects

Again, there is a lot of variation in angler comments regarding invertebrates, not only in terms of long-term trends, but also regarding species and hatches. Overall, more comments were made indicating a decline in insect populations, both overall and more specifically for mayflies (less so for caddisflies). Four anglers mentioned having noticed a decline in the occurrence of the evening rise, which is a trout feeding response to evening hatches of insects on the river; two anglers attributed this drop-off to a decline in the abundance of caddisflies, while another believed there might be a correlation with the introduction of Didymo in the river. A fifth angler had not spent enough time on the river recently to be able to observe such a change, but assumed it had occurred, not because of any change in invertebrate populations, but rather because of the steep decline in the number of fish in the river. Observations of declines in the evening rise and of insect numbers are countered by comments from other anglers, who point out the consistent variability of insect hatches over the time they have known the river, the lack of any particular long-term trend in insect populations, as well as the stability (and in one case the increase) in caddisfly numbers.

"I remember one evening on the Motupiko in the '80s, the mayflies were so thick it was like looking through smoke, whereas now you hardly notice them"

5.2.2.6 Summary: factors affecting trout numbers

In an effort to understand the relative importance of different factors, anglers were asked to name the factors they believed are instrumental in driving the variation in trout numbers over time. Table 5.21 shows the results of the scoring described in the methodology. Another possible method of analysis would have been to count the number of anglers mentioning a particular factor, and establish a ranking; however, although the results show the same general trends (perceived importance of sediment, invertebrates and forestry), there are some interesting variations. For example, in the results shown in table 5.21, juvenile recruitment ranks as the second most important factor, while if the alternative method is applied, it is placed in the middle range in terms of importance. The difference is explained by the fact that while only a small number of fishermen mentioned this as a factor affecting trout numbers, these anglers felt that this was a very important factor, in some cases the only one.

Table 5.21. Angler opinions of factors affecting trout numbers

Score	Factor	Category
2.75	Sedimentation and in-filling	Habitat quality
1.75	Juvenile recruitment	Juvenile recruitment
1.51	Invertebrate numbers	Food supply
1.43	Regional climate	Regional climate
1.35	Forestry (general)	Habitat quality
0.85	Chemicals	Water quality
0.83	Water uptake of pine trees	Hydrological factors
0.76	Role of pH	Water quality
0.73	Floods	Hydrological factors
0.67	Fishing pressure	Fishing pressure
0.60	Consequences of works in the river	Habitat quality
0.58	Pollution – diary farming effluent	Water quality
0.33	Droughts	Hydrological factors
0.20	Flow regimes different compared to native trout habitat	Hydrological factors
0.13	Shag predation	Predation
0.10	Nitrogen from pine trees	Water quality
0.10	Tributary – water quality change following water diversion	Water quality
0.10	UV rays	Regional climate
0.10	Eel predation	Predation
0.10	Predation of large trout on smaller trout	Predation
0.10	Competition from wasps on invertebrates	Food supply
0.06	Over-abstraction of water from irrigation	Hydrological factors

Anglers identified sedimentation as the main factor driving variations in trout numbers, followed by juvenile recruitment, invertebrate numbers, regional climate, and forestry (minus its possible effects on water flows, pH and nitrogen levels). The answers depend in part on the interviewee's interpretation of the question; indeed, while some anglers pointed out juvenile recruitment as the main factor, they may have felt that other factors play a role in controlling juvenile recruitment. Conversely, the anglers who

pointed to forestry operations as affecting trout numbers may believe these influence juvenile recruitment, but some did not point to any relationship between the two.

The interviews produced a large quantity of angler observations of sediment events and other environmental processes, as well as very varied views about both the state of the fishery, and the possible driving forces behind it.

5.3 Validation of interview results

Having laid out the knowledge held by anglers, it is important to examine its validity. The aim of this section is not to show comments made by individual anglers in a negative light; rather, it is to attempt to bring further clarity to the analysis, by building links between responses and other available sources of data. This approach is pertinent because of one of the stated purposes of the thesis, which is to determine to what extent angler knowledge can be used by those in charge of catchment management. Given that angler knowledge is not currently incorporated to any large extent into catchment management, this study has a rather exploratory purpose. As such, the information given by anglers is not yet an accepted and trusted source, and an examination of its validity will necessarily feed into any discussion about the extent to which it can be used in the future. Indeed, a policy planner from the TDC expressed the view that local knowledge would need to be substantiated and assessed prior to consideration for management (Baker pers. comm.). Moreover, the validation approach is consistent with one type of knowledge integration mentioned in section 2, that where the original aim of the study is to gather data, rather than empower knowledge holders. Firstly, individual interviews are scrutinized for inconsistencies; secondly, interview results are compared to each other, and finally certain themes are examined using information from other sources.

5.3.1 Intra-interview validation

This section presents some examples of self-contradiction within particular interviews. Overall, the inconsistencies contained within the interviews are minor, and spread throughout the angler sample. Most relate to imprecision with relation to sediment types (which use of more appropriate supporting material in the interviews might have resolved), as well as confusion regarding dates of specific events.

- **Observations of sediment events**

For several (2) anglers, observations of a particular sediment event were made in an area which they did not fish regularly. Although this does not mean that the event was not witnessed, it does raise questions regarding the accuracy of these recollections, particularly in the case of one angler who could not recollect the impact of sediment on the section he did fish the most.

- **Sediment types**

As shown previously, anglers used a large number of terms to describe different sediment types; in some cases, there was internal contradiction about the described sediment type, indicating possible confusion arising from the different terms, as mentioned in the methodology section. For instance, one angler first referred to “fine […] sediment or shingle”, but later in the interview referred to the same sedimentation event as being “pea gravel”. This lack of precision in sediment characterization might cause problems for interpretation of such data in other studies; indeed, Landcare Research defines fine sediment as ≤ 2mm, and according to the Unified Soil Classification System gravel is between 4.75mm and 75mm (Winegardner 1995).

In one interview, the angler mentions increased sedimentation (composed of granite sand), but then says there is no more sand in the river, in reference to a comment about gravel extraction. Although it is likely that the angler was referring to gravel in the latter point, this imprecision again creates confusion. Yet another angler refers to one sediment event as “yellow sand” but then states “it wasn’t sand, it was silt”. Finally, one angler notes a sediment event consisting of “fine muddy material” in his fishing diary, but defines it as coarse sand in his interview.

Given the complex geology and diverse land use within the catchment, precision regarding sediment type and location in the river system is important to determine the source and cause of a given sediment event.

- **Dates**

One interviewee referred to a decline in the fishery starting around 10 years ago (i.e. around 1999), but he then confirmed when asked that the timing of the decline was the early to mid-1990s (i.e. 14 to 19 years ago). Another angler agrees that forestry planting occurred in a section of the Motueka approximately 30 years ago, but then states the planting was in the 1940s and 1950s, which is actually 50 to 70 years ago. Finally, one angler mentions the decline in the trout fishery starting in the mid-1990s, but subsequently answers that he did not notice any changes when asked about the trout population trends in that decade.

- **Factors affecting the fishery**

As previously alluded to, interpretation of angler rankings of factors affecting the trout fishery was made more difficult by apparent inconsistencies during the interviews. For example, one angler states that fishing pressure does not adversely affect the trout fishery, but goes on to recommend the creation of more catch-and-release only fisheries to lessen the impact of fishing pressure on fisheries.

- **Other inconsistencies**

Self-contradiction occurred in the interviews regarding a number of topics: one angler mentions the cyclical nature of climate, with more extremes in temperature, but later says he has not noticed any climate cycles. Finally, some anglers made comments that, while not contradictory, showed a lack of

correlation of events to one another. For example, one angler admits that he has changed his fishing style in response to the move of trout to deeper water, not making the link with his earlier assertion of a drop in trout numbers.

5.3.2 Inter-interview validation

Examples of differences between angler statements arose in most parts of the questionnaire, for instance where two anglers who were part of the same fishing club said that environmental issues were discussed often (for one) or not really (for the other). Also, anglers have varying opinions on factors determining variations in trout numbers, and indeed on the very state of the fishery itself. The problems of trying to assess value based on corroboration by other interviewees are apparent, particularly given the often highly polarized opinions presented by anglers, as illustrated by the two opposing comments made about insect hatches: “it’s what I call a hatch-driven fishery” and “our fishery’s not tied to hatches”, as well as by two views of the type of fish killed in floods: “fish that survived were just real little ones” and “what happens is the big fish get killed, not the little ones”. Noting mismatch between specific descriptive statements made by anglers, instances of which are best illustrated by information gathered on sediment events, is less fraught.

Table 5.12 shows the variety of comments made about sediment event occurrences in the Motueka catchment. Although it is possible that all of the events described actually took place, comparison of angler comments appears to reveal inconsistencies. For example, two anglers recall sediment coming out of the Dart River in the late 1980s, but their recollection of the duration of the event differs: on angler says it moved through in approximately 2 years, while the other believes it took around 10 years. Another example can probably be attributed to differences in terminology: one angler refers to silt coming from the Dart River in the early to mid-90s, while all other of the other anglers who mention sediment from the Dart River at that time refer to it as sand.

Using comparison of statements made by different interviewees has limited application, particularly in a case where interviews cover a long period of time, rely heavily on interviewee interpretation and opinion, and are administered to a small sample. The use of cross-interview validation as a sole method of verification is unadvisable, as show in this research, where use of alternative sources of data showed that widely held opinions were not always supported by existing research, which, while it does not negate those widespread views, does support a combined verification approach.

5.3.3 Triangulation

The purpose of the thesis was neither to determine whether the Motueka trout fishery has declined, nor what the causes of any such potential decline are, although the results of this study will feed into current scientific research into these topics (Basher pers. comm.). As a result, the validation by triangulation presented in this section only presents an overview of available information, rather than an in-depth analysis.

Triangulation using scientific and other recorded data can be problematic, not only from a practical but also from a theoretical perspective. Indeed, in some cases, recorded information with which to corroborate statements is simply not available; in fact, regarding sedimentation events, the very idea behind asking anglers to recollect their experiences of such events came out of the fact that no scientific measurements of sedimentation in the Motueka catchment were made before 2005. Also, triangulation using only available scientific data poses some interesting questions about perceptions of validity: if anecdotal information is only considered valid when it matches scientific data, what is the real added value in seeking to incorporate it into decision-making? This wider theoretical question will be returned to in section 6; however, it is hoped the approach taken in this section presents a more balanced view, as it also uses other recorded information of a non-scientific nature. This approach is privileged because, as will be discussed in section 6, one of the main problems with the angler knowledge gathered in this study is its lack of precision, which is mainly due to a failure to record information in writing in a timely fashion.

The main source of written non-scientific information are copies of old Nelson Acclimatisation Society annual reports, for the period from 1963 to 1990, copies of which were provided by one interviewee, an avid collector of fishing literature. The reports contained general comments about the year's events in terms of fishing and hunting, as well as summaries of the Society's activities during the year. Of most interest for this research is the fact that the summaries comment on the state of each of the regional rivers' fisheries for the year in question, and sometimes include comments about sedimentation, fish size, or invertebrate populations. The river reports were compiled from comments sent in by several anglers each year, indeed sometimes by anglers who were interviewed for this study. Consequently, the source of data is still experienced fishermen; however, comparison with information given during interviews is valuable, because the records in the annual reports were compiled within a less than a year of the events taking place, while the interviews rely on anglers remembering things sometimes decades after their occurrence.

This section is divided thematically, looking in turn at sedimentation, size of fish, invertebrates, and factors affecting trout numbers; within each section, interview results are, where possible, compared to both scientific and non-scientific sources of information.

5.3.3.1 Sedimentation

Angler accounts of sediment events within the Motueka catchment are compared to written accounts from Acclimatisation Society reports, for the period from 1963 to 1990. The accounts are subsequently evaluated against existing scientific research on sedimentation.

- **Written accounts**

Some of the Acclimatisation Society reports contain information about sedimentation in the catchment, which can be compared to angler recollections for that same period (table 5.22).

Table 5.22. Angler observations of sediment events (1963 to 1990), compared to records in Acclimatisation Society annual reports

Affected water body	Sediment type			
	Silt	Sand	Gravel	In-filling
Motueka below W. confluence	. 80s (1) **. From Dove, 1982/83**	. Early 70s, from upper Mot (1) **. Sand/silt, from west bank, 1975/76, effect seen until late 70s** **. From Wangapeka, 1981/82, effects for a few years** **. Late 1980s**	**. Shingle, from a Baton tributary, 1981/82**	. Gradual, since late 80s (1)
Motueka above W. confluence	. Early 70s (1)	. 1970-1 (1)	. 1988 (1) **. 1985/86**	
Wangapeka	. Late 80s, from Dart (1) **. 1980/81, from Dart**	. Mid to late 70s (1) . 70s, from Dart (2) **. 1975/76** **. 1981/82**		
Motupiko			**. 1985/86**	
Dart	. 80s (1) **. 1980/81**	. Late 80s (1)		. Since 70s (1)
Baton			**. Shingle, from tributary, 1981/82**	
Rocky			. Mid to late 70s (1)	
Pearse		. 1987-8 (1)		

Key
Text: Date confirmed, but not sediment type
Text: Date and sediment type confirmed
Text: Unconfirmed by reports
Text: Additional data from reports, not mentioned in interviews

Half of the sediment events mentioned by anglers are confirmed by the reports, either fully (both date and sediment type) or partly (date, but not sediment type); the other half are not mentioned in the reports. Since the annual report summaries were the product of observations made by anglers at the time, the fact that a particular event listed by an interviewee is not mentioned does not mean that it did not happen – it could be that the event was not witnessed by those who wrote that year's report. Similarly, accounts of sedimentation contained in the reports but not mentioned in the interviews could be due to the fact that none of the interviewees witnessed that particular event.

The observations of sediment events recorded in the Acclimatisation Society reports suffer from some of the same problems as the information provided during interviews. For instance, some reports refer to "sand/silt" deposits (Nelson Acclimatisation Society 1976) instead of specifying a single type of sediment, while a number of reports mention sedimentation without giving specific indications of its location in the river system.

- **Scientific accounts of sedimentation**

The paucity of scientific records of past sedimentation was actually the impetus behind this project; there is not therefore much information with which to compare angler recollections. Accounts of high sedimentation levels in the river in the early 1970s are supported by one piece of research (Graynoth 1979). Some angler descriptions of sediment movement were unsupported by existing knowledge about these processes (Basher pers. comm.).

5.3.3.2 Size distribution of fish

Most anglers were of the opinion that the size distribution of trout has changed over time, and that the population is now composed of larger fish than previously; for some fishermen, this change is cyclical. Some available written accounts give indications of fish weight, as shown in this section.

- **Written accounts**

The possible cyclical nature of the size distribution of fish is supported by a 19th Century account of trout fishing in New Zealand, which remarks on the Motueka containing "only very large trout, varying from 6lb. to 14lb." (Spackman 1892).

A summary of angling results derived from fishing diary data found that the average weight of trout between 1946 and 1967 in the Motueka River was 2.2 pounds, with little variation in size during that period, which the authors see as possible evidence of constant fish density (Graynoth and Skrzynski 1974).

Acclimatisation Society annual reports often remark upon the average weight of fish in the lower Motueka, for the period from 1963 to 1990. Where available, these are illustrated below (figure 5.12). Additional written comments within the reports give an indication of the opinions of the report authors regarding fish size: "all natural trout fisheries, such as the Motueka River, go through cycles of lean and plentiful years" (Nelson Acclimatisation Society 1976), and "there has been no extreme fluctuation of trout numbers in recent years as compared with the late 1950s and 1960s" (Nelson Acclimatisation Society 1977). In addition, two further reports hint at variations in size: one states "there are records of some big fish taken, and one or two of 10 pounds and over" (Nelson Acclimatisation Society 1969), and another notes fish in the Motueka "somewhat larger than the previous season" (Nelson Acclimatisation Society 1983). Detailed records kept over a period of 40 years by one angler support the view of an increase in the average size of fish in the river, with more short-term fluctuations (figure 5.12).

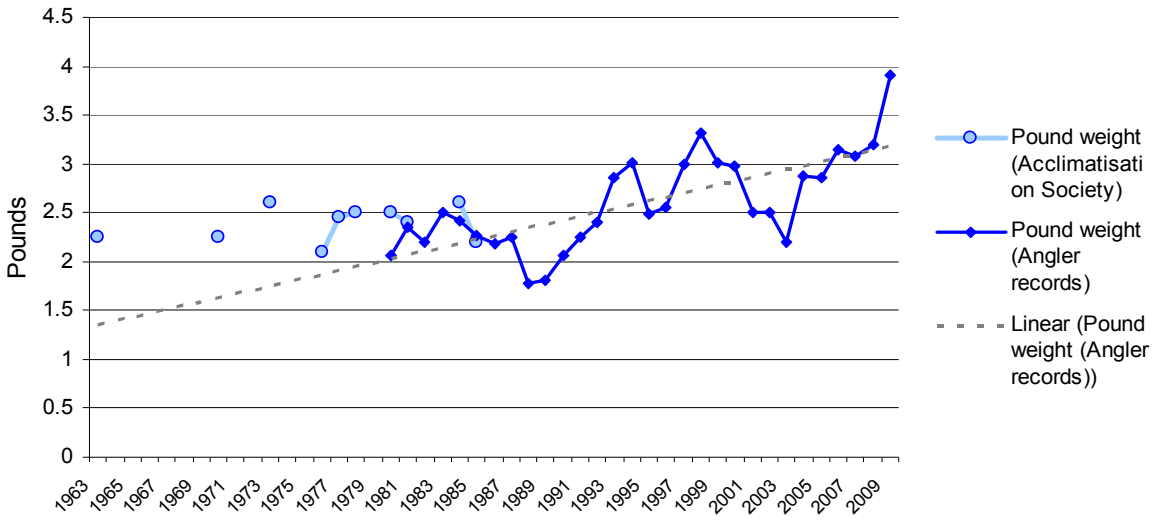


Fig. 5.12. Average weight (in pounds) of trout in the main stem of the Motueka

- **Scientific research**

Regular variations in trout size across are also noted by Hobbs (1948), who warns that "fluctuations shown earlier in these waters suggest the inadvisability of attaching too much significance to them".

5.3.3.3 Invertebrate communities

- **Written accounts**

Acclimatisation Society reports make regular mention of invertebrate numbers, either noting the occurrence of "good hatches" of caddis and mayfly (Nelson Acclimatisation Society 1975, 1984, 1985, 1986), or providing more detail on relative abundances of specific invertebrate species (Nelson Acclimatisation Society 1973, 1981). No population trends can be discerned from these reports, the only notable fact being the rapid recovery of bottom fauna following large population reductions caused by flooding (Nelson Acclimatisation Society 1978, 1982).

- **Scientific research**

Research on invertebrate populations is also lacking in the Motueka, meaning it is not possible to compare scientific records with angler observations. The TDC does sample invertebrates regularly, but run semi-quantitative analysis of abundance rather than the quantitative assessments which would be needed to compile long-term data sets (James pers. comm.).

5.3.3.4 Factors driving variations in trout numbers

- **Written accounts**

The use of Acclimatisation Society reports as a singular tool for triangulation in terms of comments about factors driving variations in trout numbers is not a robust method, given that these are as much subject to angler opinions as are the interviews themselves – conversely to comments about sediment or invertebrates, which rely more on observation than interpretation. Indeed, in a number of annual reports forestry operations are pointed to as causes of sedimentation, and as being of concern in terms of their effect on the trout fishery (Nelson Acclimatisation Society 1977, 1981, 1982, 1989). While these reports match the interviewees' views about the importance of sedimentation and forestry practices, they are reflections of the views of the small number of anglers involved in the Acclimatisation Society reporting of the time.

The factors mentioned by interviewees broadly match the angler concerns identified in the NIWA lowland river survey (Jellyman *et al.* 2003), in which most of the interviewees participated, which centre for the Nelson/Marlborough region around land use changes – essentially forestry, and its associated sedimentation, particularly in the Motueka. Forestry was already identified as a primary source of concern to anglers in the 1980s (Richardson *et al.* 1984).

- **Scientific research**

Scientific knowledge of drivers of variations in trout numbers is still incomplete, and is currently the subject of a research project within the ICM programme. Some drivers that have been preliminarily identified are: regional climate, hydrological factors (floods and low flows), habitat quality, food supply, water quality and temperature, fishing pressure, juvenile recruitment and disease (Basher pers. comm.). Many of the drivers mentioned match those given by anglers, although disease was not mentioned by any interviewees; predation is the main additional factor given by anglers. One angler's views regarding the effect of predation by shags is supported by scientific research (Hayes and Hill 2005, Hayes pers. comm.)

One angler mentioned wasps as potentially having an effect on invertebrate numbers, and by extension on the trout population. This hypothesis was confirmed as valid by a Landcare Research scientist, whose studies of the invasive species have found that wasps can indeed feed on insects favored by trout. Given that the biomass of wasps exceeds that of all the birds and introduced mammals in New Zealand, it is likely that they are having an important impact on invertebrates and other foods, although this impact has not yet been quantified (Toft pers. comm.).

Although the effect of catch-and-release fishing on trout behavior has been confirmed (Young and Hayes 2004), it has been proven to cause limited trout mortality, something which some anglers felt could be of concern (Hayes and Hill 2005).

5.3.3.5 Other

Although I was not able to view a copy of an Acclimatisation Society diary, an analysis of diary data presented in an annual report from the Nelson Acclimatisation Society confirmed that the type of information sought was quite limited, as indicated by those anglers who had participated in such schemes. Indeed, the specific diary scheme mentioned seemed to ask for name of river, days fished, fish caught, fish killed, as well as length and weight of fish caught (Nelson Acclimatisation Society 1970).

While a number of fishermen expressed discontent with FGNZ policy regarding Didymo prevention, and mentioned the algae's negative impact as well a possible link between it and sediment, only one expressed a very strong view about the threat ("our biggest") posed to the fishery by the invasive diatom. This may be due to the fact that Didymo presence has been less pronounced in the last couple of years compared to when it was first introduced (Basher pers. comm.), or to the lack of scientific research establishing a conclusive link between Didymo presence and reduction in trout food supply (Hayes *et al.* 2006).

5.4 Summary: meeting the research objectives

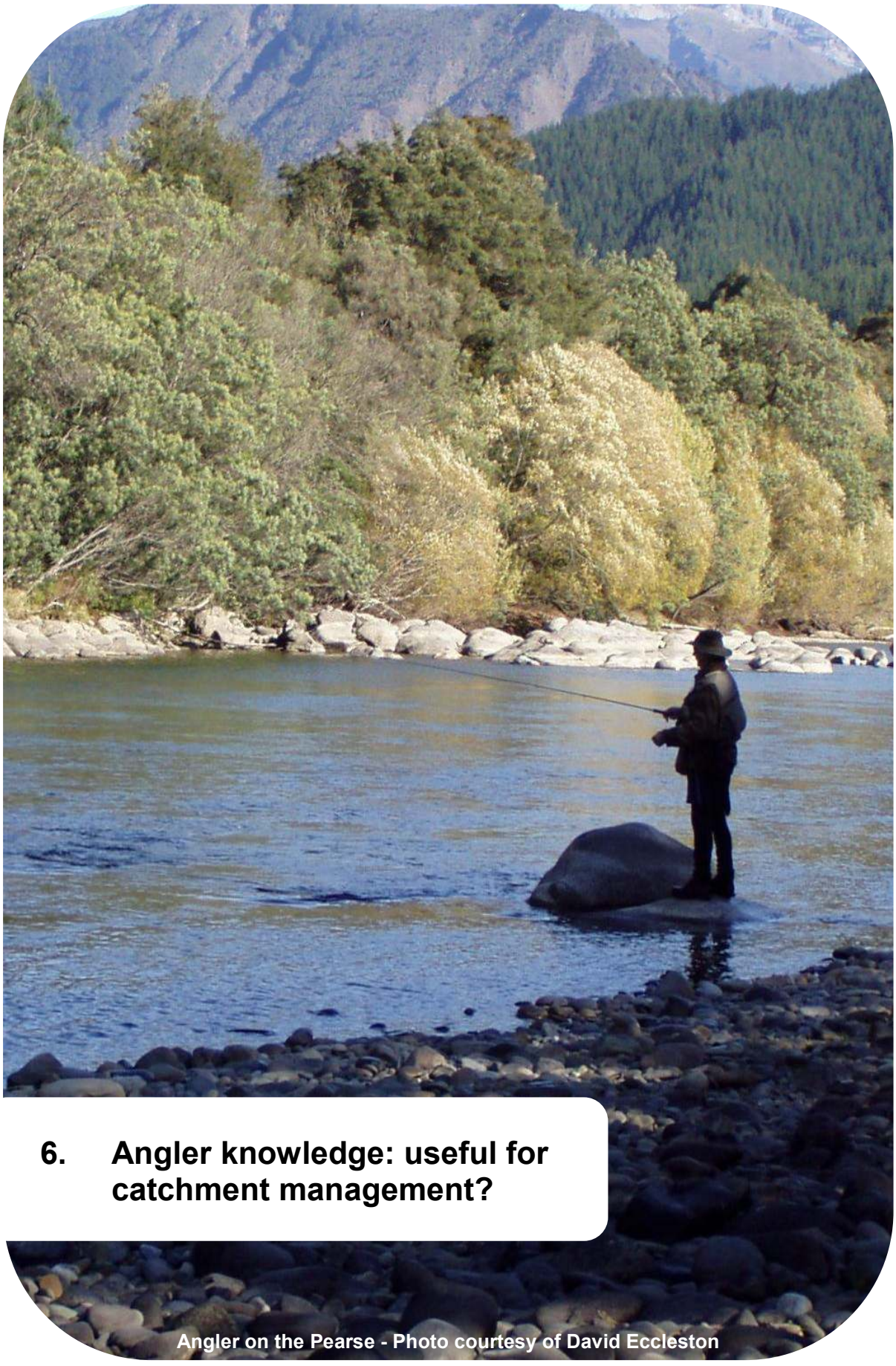
The aim of this section of the thesis was to establish what knowledge is held by anglers regarding environmental processes in the Motueka River catchment, and to try and assess its value.

5.4.1 Objective 1: what knowledge do anglers hold?

Through their extensive experience of the catchment, both in terms of distance covered and time spent on the river, anglers have accumulated a vast store of information about the trout fishery, and environmental processes in the catchment as a whole. Within the angler sample, there exist important differences in observations and opinions, some about specific events and issues, and others about more fundamental views on the state of the fishery and its relation to land use within the catchment.

5.4.2 Objective 2: is angler knowledge valuable?

Corroboration is never an easy task; one survey cites “differences in survey objectives, methodology, and information sought, [which] were generally too great to allow meaningful comparisons” with other existing surveys (Jellyman *et al.* 2003). The validation exercise run for the purposes of this thesis was limited in its extent, focusing on comparisons within and between interviews, as well as with existing records in an albeit more limited way. Intra-interview validation only produced small inconsistencies, while inter-interview validation did highlight the differences between angler recollections, but was largely unable to place a value judgment on the observations. Triangulation using other sources of data yielded interesting results, but it was not within the scope of this thesis to run a full validation of all statements made by anglers, often in the face of incomplete scientific records with which to compare them.



6. Angler knowledge: useful for catchment management?

Angler on the Pearse - Photo courtesy of David Eccleston

The following discussion draws conclusions from the analysis of interview results presented previously; in doing so, it seeks to meet the third and fourth objectives of the thesis, namely, to determine if, how and to what extent angler knowledge can be used for Motueka River catchment management. Wider conclusions regarding the usability of local knowledge for environmental management will also be drawn. The section first examines interviewees' own thoughts about fishermen's knowledge, and subsequently outlines the features of angler knowledge that give it use value for catchment management, and also hinder its potential use.

6.1 Anglers' opinions of fishermen's knowledge

The first part of this discussion examines anglers' own views regarding the potential role of fishermen's knowledge in fishery and river management.

6.1.1 Opinions regarding use value

When asked whether they thought fishermen's knowledge could benefit fishery and river management, interviewees broadly gave 3 categories of answers: 44% gave a very positive answer, another 44% answered positively but also expressed some reservations, while 13% of interviewees thought that angler knowledge would not be of great benefit for management. Direct answers to the question were quite positive overall, but subsequent comments made by anglers also contained many caveats to the use value of fishermen's knowledge (table 6.1).

Table 6.1. Angler comments regarding the benefits and disadvantage of fishermen's knowledge use

Comments #	Comments regarding use value of angler knowledge
Positive comments	
10	Anglers are good observers of events in the river, and spend a lot of time on it
4	Angler knowledge is most valuable when amalgamated, rather than taken individually
Negative comments	
8	Most anglers have a very limited understanding of environmental and trout population dynamics, and are not objective enough in assessing these
6	Anglers' memories are imperfect – only current or written observations should be sought
4	Angler-provided information must be backed up by scientific evidence
3	Knowledge levels vary among anglers – some can be of no help
2	Anglers can be somewhat emotional or opinionated about the fishery
1	Anglers are not consistent in their movements and therefore cannot monitor changes in specific locations

The majority of positive comments made regarding angler knowledge relate to anglers' observational skills, and to the significant amount time they spend on rivers; one interviewee referred to anglers as "environmental watchdogs". Also, some anglers felt the most positive contribution from anglers could be made by amalgamating large quantities of angler knowledge, rather than relying on individual opinions to guide management.

Reservations about the extent to which angler knowledge can be used relate to the perceived deficiencies in angler knowledge of environmental processes and of the fishery, which is presumably the reason behind some fishermen's comments about the need for scientific research as a precursor or supplement to use of local knowledge. The second most prevalent criticism concerns anglers' memories, which are found wanting. This does not necessarily indicate overall negative views regarding angler knowledge on the part of those interviewees; indeed, for many it accompanies a positive view of anglers' observation skills of current events. Three anglers made disparaging comments about the levels of knowledge held by the majority of anglers, saying only a minority of fishermen could contribute effectively to management. For one angler, decision-making processes regarding the fishery are not set up to incorporate any new ideas, and angler knowledge therefore goes unused.

One of the most interesting comments was made by one interviewee, who spoke of anglers as being "fickle" in terms of their choice of fishing spot, and therefore as being unreliable observers of long-term trends in a particular location. It is easy to imagine that if the quality of fishing is the main factor motivating the choice of fishing location (as is the case for almost half of the angler sample, as shown in section 5), then if the quality of fishing changes through time it is likely that the fisherman will no longer frequent this location, resulting in "positive reinforcement" about the conditions in that area. Although it is not possible to verify this hypothesis using the data gathered in this study, it is certainly something to bear in mind when discussing the potential role of anglers in management.

6.1.2 Potential avenues for knowledge use

The anglers who expressed broadly positive views about the use value of fishermen's knowledge were also asked their opinion of the ways in which angler knowledge could benefit fishery and river management (table 6.2). The last four comment categories were compiled from answers to this specific question, while comments about the suitability of diary schemes were supplemented by opinions given throughout the interviews.

Table 6.2. Angler suggestions for fishermen's knowledge use

Comments #	Comments regarding beneficial uses of angler knowledge
9	A diary scheme
4	Contributing to management surveys/interviews
3	Fishermen as environmental watchdogs
2	Fishermen as habitat monitors
1	Systematic only repository of information

The most frequent suggestion made by anglers for beneficial use of angler knowledge was a diary scheme; of the 9 anglers who made this suggestion, not all currently keep regular diaries themselves. However, of the 6 who do not keep one, 2 mentioned that they would happily participate in a diary scheme if asked to do so, and if provided with the diary and instructions about the type of information they would be required to record. A further suggestion made by 4 anglers was to involve fishermen in management surveys, using for example detailed questionnaires or interviews; for one angler, diary

schemes could not successfully gather adequate information on habitat quality, and this would need to be done via interviews. Another angler was unsure whether the surveys should cover a random sample, or target more experienced fishermen, and yet another thought canvassing large numbers of anglers' opinions could provide a good indication of potential problems in the catchment.

Suggestions departing from current practice were made by smaller numbers of fishermen; for example, some (2) suggested that small numbers of fishermen could be used as habitat monitors, and given appropriate training to carry out simple measurements as needed by managers. Some (3) interviewees also thought anglers could play an active role as environmental watchdogs, for example by taking photographs of things they perceived as threats to the river. One angler's suggestion of an online repository of observations is discussed later.

Contradictory views about diary schemes were expressed by four interviewees, who did not think diary schemes could be useful for fishery or river management. One thought drift dives were a better way of estimating fish numbers, while another expressed doubt about the willingness of more experienced fishermen to share data with managers. Two anglers were dubious about the success of such a scheme, given the fact that most fishermen would not take the time to record information in diaries; one also thought anglers may be tempted to tailor their records to fit the perceived needs of management agencies.

6.1.3 Summary

Two interesting trends emerge from investigations into interviewee opinions of the use value of fishermen's knowledge. First, although the majority of interviewees expressed generally positive opinions about the use of fishermen's knowledge for management, the subsequent comments made were dominated by negative ones. Second, of the 14 interviewees who saw a positive use value for fishermen's knowledge, half were unable to provide any suggestions as to how fishermen's knowledge could be used for management purposes.

6.2 Angler knowledge as useful for catchment management

A number of features of angler knowledge, including some which have been identified by interviewees, make it valuable for Motueka River catchment management; these are outlined below.

6.2.1 Observation skills

The main characteristic which anglers identified as being beneficial for fishery and river management within the knowledge of their peers was the fact that it is based on direct observation of the catchment. This characteristic is closely related to the amount of time spent by anglers on the river each year, which, at 25 angler-days per year, is likely to be considerably higher than that spent by catchment and fishery managers (Basher pers. comm.). As hunters, fishermen must pay particular attention to their surroundings, and to the habitat conditions of their prey. A perfect example is invertebrates, which

many fishermen pay close attention to, because being knowledgeable about the trout's food source is important to improve their fishing success.

This combination of observational skills and time spent on the river is a potentially powerful tool for management; angler knowledge can for instance help serve as an early warning system. Anglers are currently able to act as environmental watchdogs and contribute to fishery management by voluntarily getting in touch with FGNZ to report potential threats to the river: anglers "spend a lot of time as a collective on a lot of water, and so if something happens there's a reasonably high likelihood we'll hear about it" (Deans pers. comm.). The Nelson/Marlborough FGNZ office receives several communications from concerned anglers per week; the fishery managers are seen as the first point of contact, and are able to find the appropriate organization to resolve the issue (Deans pers. comm.). The current system could conceivably be improved and expanded upon. One possibility could be an online information repository, as suggested by one angler; he imagined a system similar to biological recording websites currently in place, such as the New Zealand Biodiversity Recording Network, where any registered user can enter observations about flora and fauna (New Zealand Biodiversity Recording Network N.d.). The New Zealand website mainly records observations of a species' occurrence, and is modeled on a similar system in Sweden – Artportalen (Swedish Species Information Centre N.d.). It would be technologically feasible to extend this system of observation to include not only information about a given species, but also photographic and other records relating to its habitat; moreover, although anglers could play a central contributing role, the website could be open to anyone else observing things in the catchment. Interestingly, Trevor James, water scientist at the TDC, mentioned a possible role for blogs in helping to develop an interest in water quality within the community (James pers. comm.).

Another solution, less dependent on technology, could be for FGNZ to extend its network of voluntary rangers and use them as collectors of information. The rangers within the angler sample appeared to obtain a good overview of the fishery through speaking to anglers while fulfilling their ranging duties; conceivably, a larger group of rangers could play a central role in an information collection system. Such a system could also help re-build the relationship some anglers feel they have lost with FGNZ, by incorporating some of the positive elements they saw in Acclimatisation Societies, namely a heavy reliance on volunteer labor.

6.2.2 An army of samplers

Given that anglers, or certainly experienced anglers such as the ones interviewed for this study, spend a significant amount of time on the river, they would be ideally placed to take part in an initiative requiring regular sampling of habitat indicators. One angler took it upon himself to sample streambed invertebrates for a number of seasons in another river, and a number of other anglers also mentioned keeping a close watch on trends in invertebrate species. The records kept by some anglers as part of their fishing diaries also indicate an aptitude for sampling and measurement of habitat indicators such as water temperature. Anglers could be asked to measure and record certain types of information, as

required for either fishery or catchment management, and submit results either as part of a diary scheme or using some other reporting tool, perhaps like the web-based one mentioned above.

An example of measurement tools which have been designed to be used by non-scientists are Stream Health Monitoring and Assessment Kits (SHMAK), intended as a supplement to more formal monitoring of stream health, and enabling the involvement of community members – particularly farmers. The kits collect data about land use, stream habitat and indicator organisms, and consists of a measurement kit and a manual; often, however, kit users undergo a training session to familiarize themselves with the procedures (Biggs *et al.* 2002). The monitoring can be undertaken at three different levels of detail; level 1 involves 50 minutes per site every 3 months, level 2 monitoring 1 hour 20 minutes per site every 3 months, and level 2+ monitoring requires 2 hours 10 minutes per site every 3 months, or monthly (Biggs *et al.* 2002). It is possible that the requirements of the SHMAK monitoring kits in terms of time, training and motivation may be too important to make it usable by more than the most enthusiastic of anglers (James pers. comm.). Involving fishing clubs could be a way to spread the effort and multiply monitoring sites, though again the consistency of monitoring would be dependant on the willingness of participants.

Given the apparent willingness of some anglers to undertake simple monitoring steps as part of their fishing diary records, there may be scope for the implementation of a simplified version of the kit amongst local fishermen who use the river often and regularly. Some interviewees suggested this approach in relation to invertebrates, saying fishermen could undertake simple bottom fauna counts.

6.2.3 A systematic approach

Related to the previous points regarding observational and sampling skills is evidence of a systematic approach being taken by many anglers in their relations with the trout fishery and the environment as a whole. This approach can be seen in the choice of fishing location, with one angler returning to the same reaches every year for “quasi-scientific reasons”, and another choosing to fish a different spot every time. It is also evident in some reasons behind diary keeping, one angler keeping regular entries because he is interested to know what the fishery is doing, and because it might help him if he goes again on same day.

Some anglers made comments demonstrating the ability to formulate hypotheses and prove or disprove them through observation or experimentation, as would be done in scientific research. For example, one angler initially hypothesized that the exotic forestry, in combination with the underlying rock type, was releasing magnesium into streams and having a negative effect on trout eggs. However, he subsequently disproved his own hypothesis by observing a similar decline in trout populations in a neighboring catchment, where the underlying marble rocks would counter the possible effect on eggs. A number of anglers were also able to downplay the importance of floods in affecting the trout population by pointing to past large flood events which did not affect it.

A systematic approach is also evident in the way some anglers learn through experience. For example, one interviewee sometimes returns to the same fishing spot several days in a row to determine whether there is a pattern in his fishing success or whether it is due to simple luck. Another recognizes that his fears of a severe decline in the fishery in the mid to late 1990s were exaggerated, because he has since realized that trout move in response to habitat deterioration or decline in availability of prey.

Finally, a few interviewees were unwilling to make categorical statements, acknowledging their uncertainty about certain phenomena. For instance, one angler has noticed higher diatom coverage on rocks, but is unsure about the cause and effect relationship between grazing invertebrate numbers, and increased coverage. The same angler noticed a decline in the trout fishery after a flood in 2005, but is unsure whether this was part of a larger decline, or a new trend.

6.2.4 Applicability of diary schemes

If the aim is to obtain representative data regarding things like catch rates from all types of anglers, the use of diaries is questionable, since these tend to be filled in by anglers who are above average in terms of skill (Deans pers. comm., Graynoth and Skrzynski 1974). If, on the other hand, diaries were to be used to obtain specific types of information where capacity for reliable, regular and long-term observation is key, then higher levels of skill (and therefore presumably more experience of fishing) might actually be an advantage. As part of FGNZ's involvement in the resource consent hearings regarding a proposed hydroelectric plant on the Wairau River, a number of fishermen have been asked to fill in diaries (figure 6.1). For FGNZ, the fact that experienced anglers are overrepresented makes the data obtained all the more valuable. The diary scheme was instigated by FGNZ's need to demonstrate the relationship between river flow and fishing success, to use as evidence against the hydroelectric plant, which proposes to divert up to three quarters of the river flow (Deans pers. comm.).

Name: _____ _____

				Hours Fished				Fish Landed				
Date	River/Lake	Location	Didymo	From	To	Method	No. Fish Hooked	Species	Sex (M/F)	Weight (Kg)	Length (mm)	Kept (Y/N)
22-Nov	Wairau	Conders	NV	1000	1300	F	1	BT	F	0.5 *	350 *	n
22-Nov	Wairau	Conders	NV	1000	1300	F	1	BT	F	1.57 *	430 *	n
22-Nov	Wairau	Conders	NV	1000	1300	F	1	BT	M	2.25 *	550 *	n
23-Nov	Wairau	Marchburn	NV	800	1330	F	1	BT	F	1.58 *	430 *	n
27-Nov	Wairau	Mouth	NV	2200	2400	F	1	BT	F	2.025	580	y

Fig. 6.1. Example of entries in a FGNZ diary for the Wairau river

A number of fishermen indicated a willingness to participate in diary schemes if provided with instructions and a template, and one angler who keeps his own independent diary noted that the columns he has made in his diary 'force' him to record more information than he probably would

otherwise. A targeted diary scheme, which would include some elements of sampling mentioned above, might yield results in terms of habitat quality monitoring.

6.2.5 The case of Angler X

An ideal transition between the section explaining the factors that make angler knowledge useful for management, and the section laying out the barriers to integration of said knowledge into management, is the case of Angler X. Indeed, this angler personifies the value of angler knowledge, but also represents quite a rare case, which might not have wider applicability because of some of the arguments outlined below.

Although some other anglers also keep detailed records in their fishing diaries, Angler X is unique in that he notes information relating to invertebrates, algae and sediment, in addition to highly detailed information about his fish catches, and has done so for over 40 years. He produces annual reports, which he has been sending to FGNZ since 1968, which summarize the main trends in terms of invertebrate species and numbers, incidence of algae, and presence of sediment.

6.3 Barriers to angler knowledge integration

Although some features of angler knowledge make it highly valuable for fishery and catchment management, others may hinder the possibility of its integration, as outlined in this section.

6.3.1 Limitations of fishing diaries

Fishing diaries can provide valuable information in certain instances, as mentioned previously; however, apart from deficiencies in terms of sampling, diaries also come up against other limitations.

Although the severity of the impact of low participation rates in diary schemes is dependant on their purpose, they can be one of the main challenges the schemes face. For example, a diary scheme run by the Nelson Acclimatisation Society during the 1969-70 fishing season only received 32 responses, a response rate which the Society qualifies as “extremely disappointing” (Nelson Acclimatisation Society 1970). Although low response rates are more likely to affect widely disseminated diary schemes rather than ones targeted at more experienced anglers, it can also be a problem for these. For example, 62% of the anglers interviewed for this thesis do not currently keep a fishing diary; of these, some cite a fundamental incompatibility between diary keeping and their personality: “I’ve never been a diary person”, “I’m not a numbers man anyway in that sense”, and “I’m just not that sort of person”. Others have sporadically kept diaries, but stopped doing so because they lacked time, lost interest or simply forgot to fill them in. It is likely that all of these factors would affect participation rates, even in a targeted diary scheme.

Moreover, given the level of detail and commitment which would be needed to obtain useful data on habitat, it is likely that the number of fishermen willing and able to participate in such a scheme would be quite limited.

6.3.2 Observation and hearsay

Section 5 showed the level of interaction of the angler sample with fishing club members, friends, and management agencies. As indicated in the limitations section, the extent to which an angler's opinions and memories of events are influenced by his interaction with others is difficult to determine, and beyond the scope of this thesis. However, a number of statements made by anglers show how views can be acquired ("I think it was Neil Deans [who] told me") or transmitted ("I'm at last getting one or two to agree with me"). One angler makes an observation about reduced fish numbers in a particular location twice, but the second time the observation is attributed to a friend of his; this exchange of views might lead to "mutually reinforcing perceptions" (Deans pers. comm.).

Several fishing guides (3) appear to interact closely with other guides, often using the terms "us" or "we" during the interviews, and acknowledging that they often share observations of events within the group: "you have a lot of guys out there and a lot of activity so that you're hearing little things all the time: the passion vine hoppers are on, or the river's got real low, […] you hear little bits and pieces that are useful". Indeed, when asked about their fishing experience in the Motueka, two guides began referring to the common experience of the guides they work with.

Five anglers show evidence of keeping up with research concerning the fishery and the catchment, mentioning various studies, usually in support of their claims; for example, a number mention a report showing the behavioral response of trout to fishing pressure to corroborate their personal observations of the same trend (Young and Hayes 2004). The quarterly magazine published by FGNZ is also a source of information for anglers, and often contains a great deal of information about environmental issues, in line with the type of work FGNZ does. It is possible that the issues and views mentioned in the magazine are sometimes mirrored in the views subsequently expressed by anglers (Deans pers. comm.).

6.3.3 Knowledge extinction

The concept of Shifting Baseline Syndrome, first coined by Pauly (1995) defines a process by which humans change their perception of biological systems as knowledge of past conditions is lost. It was first identified to describe a trend in fisheries science, where scientists used data from the beginning of their career as the baseline with which to evaluate any changes in fish stocks, unmindful of any pre-existing trends, and therefore under-reported fishery depletion. Personal amnesia is identified by a group of researchers as one of the two forms of Shifting Baseline Syndrome, and is defined as "knowledge extinction [that] occurs as individuals forget their own experience" (Papworth *et al.* 2009). For the researchers, personal amnesia can be diagnosed where available records of biological change belie the perceptions of unchanging conditions held by individuals. As a result, the precise definition

does not apply to the angler sample, the majority of which has instead perceived a change in the trout fishery. However, the idea that an individuals' perception of change does not necessarily match his or her observations, or indeed reality, is valuable for discussion of the knowledge held by anglers. Simply put: are memories accurate?
The validation exercise run for the purpose of this thesis has illustrated some of the problems encountered in terms of angler recollections, the most important of which was lack of precision in terms of descriptions of events.

Seven interviewees openly admitted the deficiencies of their memory, mainly in relation to the associated salutary nature of their fishing diaries. An example of this was provided by one angler, who illustrated the value of his diary with the following anecdote of an unsuccessful fishing trip on a neighboring river: "I think 'god, I haven't caught anything in two trips in a row […]' then I go back and find that 10 years ago I also didn't catch any fish two years in a row […] but I'd forgotten about that, I remembered all the fish I caught". Two anglers in particular expressed strong reservations about the capacity of anglers to retain long-term information; for one, accurate recollections probably do not extend past the current fishing season, and for the other, not even past the end of a fishing day.

While the exact cut-off point for accuracy of memories, if there is one, is not known, it is clear that any deficiencies in the memories of anglers only impact upon its use value for management if anglers are asked to reach far back into those memories, as they have been in this case. Many of the methods of angler knowledge utilization proposed above instead rely either on recent observations or recorded ones.

6.3.4 Factors affecting angler knowledge of environmental processes

A number of factors may affect the way in which anglers observe and interpret environmental processes.

- **Choice of fishing location**

As mentioned previously, if the motivating factor behind the choice of fishing location for an angler is the quality of fishing, the location of fishing is subject to change, which may make him or her less able to observe long-term changes in a given area. Lack of consistency of observation goes against the principles of scientific monitoring, one of the main tenets of which is to maintain fixed monitoring points over the period of study, in order to accurately capture changes. This factor has a particular impact on studies such as this one, which seeks to capture information about historical trends, but may also play a role in the success of habitat diary schemes or other initiatives. Indeed, fishermen may be unwilling to participate in initiatives which dictate fixed monitoring points.

- **Drivers of perceptions of change**

According to the NIWA survey of lowland rivers, angler perceptions of angling quality were a function of the numbers of fish rather than their size (Jellyman *et al.* 2003). This may help explain some

anglers' negative views of an observed shift in the trout population, to one composed of smaller numbers of fish of a larger size. The negative perception may remain even if it is determined, as some anglers have hypothesized, that the river has maintained a constant biomass of trout despite this change.

- **Visually perceptible impacts**

Many of the factors mentioned by anglers as potential drivers for variations in trout numbers are visually perceptible – but what of those that are not? As an example, Hayes and Hill (2005) speak of the possibility of unseen damage inflicted upon trout redds by wading anglers, which can cause a significant percentage of egg mortality. This possibility was not mentioned by anglers; their criticism of fishing pressure centered on behavioral changes, as well as killing of mature fish. This type of fishing pressure is not only more visual, but is also more easily attributed to other anglers. It is conceivable that this view of impacts might in part be driven by perceptions of angler encounters as being detrimental to fishing (Walrond and Hayes 1999).

According to some, the perceived importance of the effect of the forestry industry on the trout fishery is greater than its actual impact, and is partly due to the strong visual impact of recently harvested forests (Basher pers. comm.). The potential for incorrect correlations between effect and cause made by anglers is one a number of their peers have identified, often in relation to positive comments about angler observations of effects. Indeed, while some anglers categorized some of their own statements as guesswork, or in some cases were reluctant to even formulate a hypothesis, others expressed opinions without caveats. The OECD's pressure-state-response framework (Organisation for Economic Co-operation and Development 2001) demonstrates how incorrect assessment of the pressure linked to an observed state of the environment can lead to inadequate action being taken in response. The possible mistaken identification of causal factors is not limited to local knowledge, and it should not prevent its incorporation into management, but it must be taken into account prior to implementation of management measures.

6.3.5 Other considerations

Because of their sensitivity to environmental conditions, trout are considered as a good bioindicator species, and the protection of their habitat is beneficial for the environment in general; anglers therefore have an interest in environmental protection. If, hypothetically, the conditions required by trout were damaging to the wider environment, would anglers and their knowledge be as valuable for environmental management? The degree to which habitat protection is inherently important to fishermen, as well as important as a support for their hunting activity, is not known. Comments made by anglers indicate that there is probably an element of both; for example, a number of interviewees mention low flow conditions as ideal for fishing, because the trout are then more concentrated – these may not be optimal for the environment.

6.4 Synthesis – angler knowledge integration into management

6.4.1 Angler opinions of the use of their knowledge

Approximately half of the angler sample spontaneously expressed discontent with their interactions with management agencies such as FGNZ and TDC, feeling that their comments and opinions are not listened to enough. This may indicate that there is room for improvement in communication and interaction between catchment and fishery managers and their constituency.

6.4.2 How is angler knowledge currently used?

Angler knowledge is currently used within management mainly in its capacity as an early warning system.

For example, anglers and any other members of the public may contact TDC to report environmental incidents, for example discharges or wetland drainage. The Council receives in the order of 10 reports per day; angler complaints mostly occur during the summer fishing season, particularly at its start as this coincides with the most intense dairying activity. Not all reports are able to be followed up. No other systematic use of local knowledge is made within the Council, though community involvement is common in things like Streamcare groups, and seeking consultation with locals also forms part of some employees' work ethic. The small number of SHMAK assessments received every year are not integrated into the Council's database, but are used to alert water quality scientists to potential issue areas. Local knowledge is seen as valuable because it is held by large numbers of people who are in direct contact with the catchment and its issues, but its integration into management is limited by the extra time and effort it takes to manage such a process (James pers. comm.).

"The first thing we would need to do is substantiate the feelings or the claims" (Baker pers. comm.)

From the policy point of view, TDC is active in promoting public participation in the formulation of its plans, involving affected stakeholders and stakeholder groups, and inviting feedback regarding its proposals. Public participation is sought at various stages of the plan development process, when it is possible to incorporate relevant suggested changes. In seeking out knowledge to guide them in the decision-making process, TDC mostly turns to organizations such as FGNZ, since it is unaware of the identities of individual knowledge holders unless these contact the Council. A more formal example of local knowledge use relates to water quantity, where water user committees include elected members from within the permit holders; the committees take part in Council decisions, particularly relating to drought and water rationing. Substantiation or assessment of non-scientific observations or data is seen as key in order to overcome some of the limitations of local knowledge: "sometimes peoples' memories are faulty, […] or they don't have the full picture, and they have *very strong opinions*, and it's not always in line with what we know as fact" (Baker pers. comm.). In order to force policy change, any angler concerns about the potential effect of TDC's policies on the fishery would first have to be substantiated by FGNZ and then by scientists; the policy change itself may take months or years to

come into effect. For the Council, public participation is both a means of feeding more knowledge into the decision making process, thereby increasing its quality, and of increasing buy-in to its policies, thereby increasing their effectiveness (Baker pers. comm.).

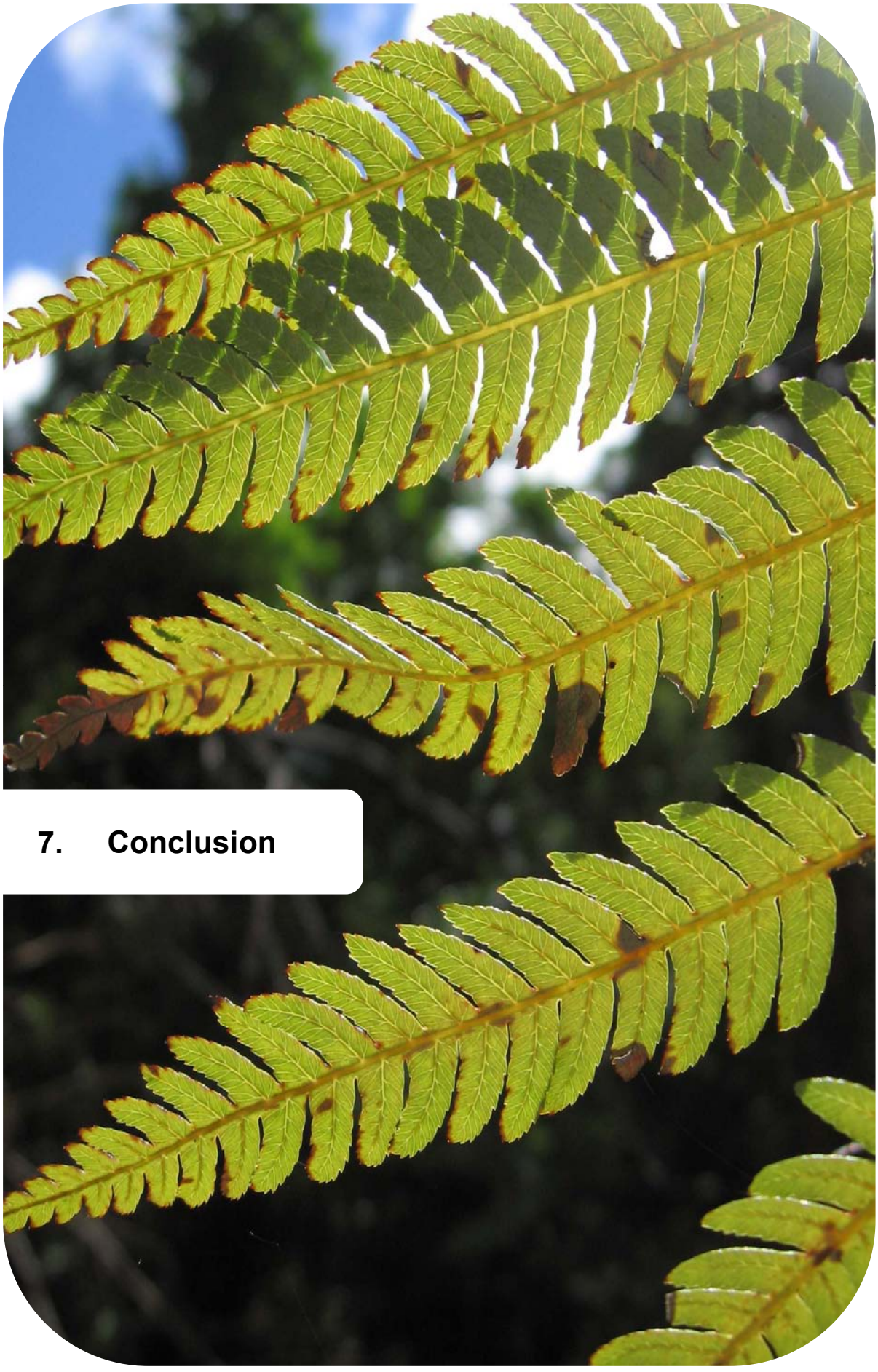
Interaction between FGNZ and anglers is not formalized; while anglers are able to report any concerns they have to management, these reports are not logged (Deans pers. comm.). Managers of the organization also engage in direct contact with anglers, for example through talks at fishing clubs. The informal contact FGNZ keeps with its angler base is partly due to its time commitments regarding resource management issues as well as national advocacy. For example, the NIWA lowland river survey mainly had a political use beyond the publication of the paper – to give weight to FGNZ assertions that fishing quality had declined in lowland rivers for use in lobbying government.

6.4.3 Potential for use of angler knowledge

Many of the barriers to angler knowledge integration outlined in section 6.3 are linked to the specific research design of this study, which asked interviewees to remember events dating back decades in many cases. Solutions to overcome many of these barriers are simple, and essentially consist in modifying the research parameters.

However, the ways in which angler knowledge could be of most use run up against barriers relating to the current management of the fishery and catchment. For instance, though the idea of using anglers' observation skills as part of a monitoring network is promising, the time constraints experienced by FGNZ may result in a very limited use of any recorded observations. Also, the value of using anglers as part of a wide sampling network may be lost if this information is not used to its fullest extent, as is the case for current SHMAK assessments sent to TDC.

Perhaps the biggest barrier to the use of angler knowledge rests in the way 'integration' is approached: as incorporation into pre-existing management structures, regardless of the capacity of these structures to conceptualize it or have the necessary time to be able to work with it.



7. Conclusion

This paper looked at the knowledge of environmental processes held by a small number of long-term expert anglers of the Motueka River catchment. In-depth interviews, with both anglers and persons involved in the management of the catchment and its trout fishery, were used as a means to determine the depth and breadth of the knowledge held by anglers as well as its potential for use within management of the catchment.

The interviews run for the purposes of this thesis produced a wealth of information about the Motueka River catchment. Although basic interview validation revealed some inconsistencies relating to details of past events, as well as possible errors of interpretation, many interesting trends were revealed. Regardless of their positive, neutral or negative interpretation of the significance of some phenomena, some common threads ran through the interviews, particularly regarding trout size and location in the river cross-section. This information will feed into current research on the possible decline in trout numbers in the catchment. The value of angler knowledge in this case derives not only from the fact that they spend a lot of time fishing and cover a large area of the catchment, and therefore are able to witness a number of events, but also from their capacity for observation. Indeed, observation skills are intimately linked to fishing success. Furthermore, the anglers demonstrated on the whole a strong capacity for sampling and systematic thought.

However, a number of barriers to the integration of angler knowledge within catchment management were identified; these relate not only to characteristics of the knowledge itself, but also to factors relating to the management of the catchment and fishery. The possibility of integrating angler knowledge is lessened by the fact that angler observations can be colored by interaction with others and by deficiencies in memory. Also, the fact that the choice of angling location is partly driven by angling success can be detrimental to long-term observations in particular areas. Finally, the use of angler diaries, which could be extremely valuable from a monitoring point of view, is unlikely to become universal. Integration of angler knowledge is also hampered by staffing shortages within the organizations responsible for management of the catchment and fishery. For the TDC, the importance of substantiating claims and observations also places an additional barrier to the use of angler knowledge.

Recommendations for further research

The angler interviews provided many ideas for possible further research within the catchment. For example, in seeking to understand historical change to the catchment landscape, photographic records held by anglers and other catchment residents or visitors could enable comparisons between past and present areas of the river. Many of the photographs of the Travelling River project, a collaboration between artists, scientists and the inhabitants of the catchment, show that there is a vast treasure trove of historical records of the river (Mountains-To-The-Sea Project 2004). Also, the ICM programme is currently working on a number of projects seeking to build community involvement. These types of projects could help to identify people willing to get involved in projects, either picking up on existing passions, or creating new ones.

In their study of land cover changes in the Wild Coast of South Africa, Chalmers and Fabricius (2007) examine the local ecological knowledge held by randomly selected community members to that of a group of forest users generally regarded as experts. Their findings, that the randomly selected group had a simplistic and sometimes erroneous view of the causes of change in land cover, while the complex knowledge held by the experts not only confirmed but also supplemented scientific understandings of these changes, raise some interesting questions. For the authors, the findings imply that environmental studies using local knowledge should ensure collaboration with 'experts', as attempted in this study. However, it is possible that the results would vary widely if a different group of experts was interviewed. Given the timescales available for this project, it was not possible to run follow-up interviews with respondents, as recommended by some (Kvale 2009) in order to strengthen the analysis and interpretation of data; this may be a possible avenue for further research.

To conclude, while this study did not supply as many observations regarding sediment events and other environmental processes as hoped for, it did result in many interesting and novel observations. The potential for the use of angler knowledge has been established, as have the barriers which would need to be overcome for this to happen. Finally, according to a Senior Scientist at Landcare Research, the interviews have also helped build further links within the catchment community (Basher pers. comm.).

Blueberry cultivation and mountain ranges: western headwaters

References

Acornley, R. and Sear, D. 1999. Sediment transport and siltation of brown trout (Salmo trutta L.) spawning gravels in chalk streams. *Hydrological Processes* 13: 447-458.

Agrawal, A. 1995. Dismantling the Divide Between Indigenous and Scientific Knowledge. *Development and Change* 26: 413-439.

_____. 2002. Indigenous knowledge and the politics of classification. *International Social Science Journal* 54 (173): 287-297.

Anuchiracheeva, S., Demaine, H., Shivakoti, G.P., and Ruddle, K. 2003. Systematizing local knowledge using GIS: fisheries management in Bang Saphan Bay, Thailand. *Ocean and Coastal Management* 46 (11-12): 1049-1068.

Baird, I.G. and Flaherty, M.S. 2005. Mekong River Fish Conservation Zones in Southern Laos: Assessing Effectiveness Using Local Ecological Knowledge. *Environmental Management* 36 (3): 439-454.

Baker, B. 1995. Is overfishing or habitat destruction the key culprit in fishery depletion? *Bioscience* 45 (11): 751-752.

Basher, L., Marden, M., Barringer, J., and North, H. 2003. *Identification of major sediment sources in the Motueka River*. Lincoln: Landcare Research New Zealand.

Basher, L. and Young, R. 2006. *Fine sediment research issues in the Motueka River in the ICM programme: bringing the geomorphology and biology together. How are we progressing?* Nelson: Landcare Research New Zealand. http://icm.landcareresearch.co.nz/research/research.asp?theme_id=3&research_id=45 (accessed 11 November 2008).

Basher, L.R., ed. 2003. *The Motueka and Riwaka Catchments: a technical report summarising the present state of knowledge of the catchments, management issues and research needs for integrated catchment management*. Lincoln: Landcare Research New Zealand.

Bebbington, A. 1994. Composing rural livelihoods: from farming systems to food systems. In *Beyond farmer first. Rural people's knowledge, agricultural research and extension practice*, ed. Ian Scoones and John Thompson: 88-93. London: Intermediate Technologies Publications.

Begossi, A. 2008. Local knowledge and training towards management. *Environ Dev Sustain* 10: 591-603.

Bergmann, M., Hinz, H., Blyth, R.E., Kaiser, M.J., Rogers, S.I., and Armstrong, M. 2004. Using knowledge from fishers and fisheries scientists to identify possible groundfish 'Essential Fish Habitats'. *Fisheries Research* 66 (2-3): 373-379.

Berkes, F. 2004. Rethinking Community-Based Conservation. *Conservation Biology* 18 (3): 621-630.

Biggs, B.J.F., Kilroy, C., Mulcock, C.M., and Scarsbrook, M.R. 2002. *New Zealand Stream Health Monitoring and Assessment Kit. Stream Monitoring Manual. Version 2. NIWA Technical Report 111*. Christchurch: NIWA.

Bowden, W., Fenemor, A., and Deans, N. 2004. Integrated Water and Catchment Research for the Public Good: The Motueka River–Tasman Bay Initiative, New Zealand. *Water Resources Development* 20 (3): 311-323.

Brook, R. and McLachlan, S. 2005. On using expert-based science to "test" local ecological knowledge. *Ecology and Society* 10 (2): r3.

Bryman, A. 2001. *Social Research Methods*. Oxford: Oxford University Press.

Butler, J.R.A., Radford, A., Riddington, G., and Laughton, R. 2009. Evaluating an ecosystem service provided by Atlantic salmon, sea trout and other fish species in the River Spey, Scotland: The economic impact of recreational rod fisheries. *Fisheries Research* 96 (2-3): 259-266.

Cawthron Institute. About Cawthron - Overview. http://www.cawthron.org.nz/about-cawthron/overview.html [accessed 19 May 2009].

Chalmers, N. and Fabricius, C. 2007. Expert and generalist local knowledge about land-cover change on South Africa's Wild Coast: can local ecological knowledge add value to science? *Ecology and Society* 12 (1): 10.

Close, C.H. and Hall, B. 2006. A GIS-based protocol for the collection and use of local knowledge in fisheries management planning. *Journal of Environmental Management* 78 (4): 341-352.

Cooke, S.J., Dunlop, W.I., Macclennan, D., and Power, G. 2000. Applications and characteristics of angler diary programmes in Ontario, Canada. *Fisheries Management & Ecology* 7 (6): 473-487.

Crisp, D.T. 2000. *Trout and salmon: ecology, conservation and rehabilitation*. Oxford: Fishing News Books (Blackwell Science).

Davis, A. and Wagner, J.R. 2003. Who Knows? On the Importance of Identifying "experts" When Researching Local Ecological Knowledge. *Human Ecology* 31 (3): 463-489.

Ditton, R.B., Holland, S.M., and Anderson, D.K. 2002. Recreational fishing as tourism. *Fisheries* 27 (2): 17-24.

Dove, M., Smith, D., Campos, M., Mathews, A., Rademacher, A., Rhee, S., and Yoder, L. 2007. Globalisation and the Construction of Western and Non-Western Knowledge. In *Local Science Vs Global Science: Approaches to Indigenous Knowledge in International Development*, ed. Paul Sillitoe: 129-154. New York: Berghahn Books.

Drew, J.A. 2005. Use of Traditional Ecological Knowledge in Marine Conservation. *Conservation Biology* 19 (4): 1286-1293.

Ellen, R. 2006. Introduction. *Journal of the Royal Anthropological Institute* (Special Issue): 1-22.

_____. 2007. Local and Scientific Understanding of Forest Diversity on Seram, Eastern Indonesia. In *Local Science Vs Global Science: Approaches to Indigenous Knowledge in International Development*, ed. Paul Sillitoe: 41-74. New York: Berghahn Books.

Fischer, F. 2000. *Citizens, Experts, and the Environment*. Durham: Duke University Press.

Fish and Game New Zealand. N.d. *2008/2009 South Island Sports Fishing Regulation Guide*: Fish and Game New Zealand.

_____. Nelson/Marlborough fishing clubs. http://www.fishandgame.org.nz/Site/Regions/NelsonMarlborough/fishingClubs.aspx [accessed 24 May 2009].

Food and Agriculture Organization of the United Nations (FAO). 2009. *The State of World Fisheries and Aquaculture*. Rome: Food and Agriculture Organization of the United Nations.

Gilchrist, G. and Mallory, M. 2007. Comparing expert-based science with local ecological knowledge: what are we afraid of? *Ecology and Society* 12 (1): rl.

Gilchrist, G., Mallory, M., and Merkel, F. 2005. Can local ecological knowledge contribute to wildlife management? Case studies of migratory birds. *Ecology and Society* 10 (1): 20.

Grant, S. and Berkes, F. 2007. Fisher knowledge as expert system: A case from the longline fishery of Grenada, the Eastern Caribbean. *Fisheries Research* 84 (2): 162-170.

Graynoth, E. 1979. Effects of logging on stream environments and faunas in Nelson. *New Zealand Journal of Marine and Freshwater Research* 13 (1): 79-109.

New Zealand Ministry of Agriculture and Forestry - Fisheries Management Division. 1974. *The Nelson Trout Fishery - Fisheries technical report no. 119*, by Graynoth, E. and Skrzynski, W. Wellington: NZMAF.

Hall, G.B. and Close, C.H. 2007. Local knowledge assessment for a small-scale fishery using geographic information systems. *Fisheries Research* 83 (1): 11-22.

Harmsworth, G. 1998. Indigenous Values and GIS: a Method and a Framework. *Indigenous Knowledge and Development Monitor* 6 (3): 1-7.

Hayes, J. and Hill, L. 2005. *The artful science of trout fishing*. 2005: Canterbury University Press.

Hayes, J., Shearer, K., and Hay, J. 2006. *Interim Report: Invertebrate drift and trout growth potential in a Didymo (Didymosphenia geminata) affected reach of the Mararoa River - Prepared for Biosecurity New Zealand. Cawthron Report No. 1178*. Nelson: Cawthron Institute.

New Zealand Marine Department. 1948. *Trout fisheries in New Zealand – Their development and management*, by Hobbs, D. Wellington.

Ingold, T. 2000. *The perception of the environment: essays on livelihood, dwelling and skill*. London: Routledge.

Jackson, A.-M. 2008. Intern Research Report 2 - Towards understanding indigenous knowledge in environmental management practice: A discursive. *MAI Review* (1): 1-15.

Jellyman, D., Unwin, M., and James, G. 2003. *Anglers' perceptions of the status of New Zealand lowland rivers and their trout fisheries. NIWA Technical Report 122*. Wellington: NIWA.

Johannes, R.E. 1998. The case for data-less marine resource management: examples from tropical nearshore finfisheries. *Trends in Ecology and Evolution* 13 (6): 243-246.

Kerr, S.J. 2007. Characteristics of Ontario muskellunge (Esox masquinongy) fisheries based on volunteer angler diary information. *Environmental Biology of Fishes* 79 (1): 61-69.

Kilroy, C. 2004. *A new alien diatom, Didymosphenia geminata (Lyngbye) Schmidt: its biology, distribution, effects and potential risks for New Zealand fresh waters*. Christchurch: NIWA.

Kilroy, C., Lagerstedt, A., Davey, A., and Robinson, K. 2006. *Studies on the survivability of the invasive diatom Didymosphenia geminata under a range of environmental and chemical conditions*. Christchurch: NIWA.

Knudsen, S. 2008. Ethical Know-how and Traditional Ecological Knowledge in Small Scale Fisheries on the Eastern Black Sea Coast of Turkey. *Human Ecology: An Interdisciplinary Journal* 36 (1): 29-42.

Kumar, R. 2005. *Research methodology - A step-by-step guide for beginners*. London: Sage Publications.

Kvale, S. 2009. *InterViews: Learning the craft of qualitative research interviewing*. Los Angeles: Sage Publications.

Landcare Research New Zealand. 2008. *Annual report 2008*. Lincoln: Landcare Research New Zealand.

_____. Motueka River Integrated Catchment Management Programme website. http://icm.landcareresearch.co.nz/research/ [accessed 20 May 2009].

Leach, M. and Fairhead, J. 2002. *Manners of contestation: "citizen science" and "indigenous knowledge" in West Africa and the Caribbean*. Edited by UNESCO. Oxford: Blackwell Publishers.

Lien, M. 2007. Feeding fish efficiently. Mobilising knowledge in Tasmanian salmon farming. *Social Anthropology* 15 (2): 169-185.

Loftus, A.-C. 2009. *Fishermen's knowledge for fisheries management*. Lund: International Institute for Industrial Environmental Economics - University of Lund.

Long, A. 1992. Goods, knowledge and beer. The methodological significance of situational analysis and discourse. In *Battlefields of knowledge. The interlocking of theory and practice in social research and development*, ed. Norman Long and Ann Long: 147-170. London: Routledge.

Lummis, T. 1998. Structure and validity in oral evidence (1983). In *The oral history reader*, ed. Robert Perks and Alistair Thomson: 273-283. London: Routledge.

Mackinson, S. and Nøttestad, L. 1998. Points of View: Combining Local and Scientific Knowledge. *Reviews in Fish Biology and Fisheries* 8 (4): 481-490.

Margenau, T., AveLallemant, S., and Giehtbrock, D. 2008. Ecology and management of northern pike in Wisconsin. *Hydrobiologia* 601 (1): 111-124.

Marzano, M. 2007. Science and Local Knowledge in Sri Lanka: Extension, Rubber and Farming. In *Local Science Vs Global Science: Approaches to Indigenous Knowledge in International Development*, ed. Paul Sillitoe: 155-173. New York: Berghahn Books.

Mathooko, J.M. 2005. Application of traditional ecological knowledge in the management and sustainability of fisheries in East Africa: a long-neglected strategy? *Hydrobiologia* 537 (1): 1-6.

Maurstad, A. 2002. Fishing in murky waters-ethics and politics of research on fisher knowledge. *Marine Policy* 26 (3): 159-166.

Memon, P.A. 1997. Freshwater management policies in New Zealand. *Aquatic Conservation: Marine and Freshwater Ecosystems* 7: 305-322.

Menzies, C.R. and Butler, C.F. 2007. Returning to Selective Fishing through Indigenous Fisheries Knowledge: The Example of K'moda, Gitxaala Territory. *American Indian Quarterly* 31 (3): 441-464.

Ministry for the Environment. Water Conservation Orders. http://www.mfe.govt.nz/issues/water/freshwater/water-conservation/index.html [accessed 19 May 2009].

Ministry of Agriculture and Forestry. 2008. Exotic forest ownership/management - Nelson/Marlborough wood supply region. Wellington: Ministry of Agriculture and Forestry.

Mosindy, T.E. and Duffy, M.J. 2007. The use of angler diary surveys to evaluate long-term changes in muskellunge populations on Lake of the Woods, Ontario. *Environmental Biology of Fishes* 79 (1): 71-83.

Mountains-To-The-Sea Project. 2004. *Travelling River - A collaboration of artists scientists and the people of the Motueka River catchment*. Nelson: Landcare Research New Zealand.

Murray, G., Neis, B., and Johnsen, J.P. 2006. Lessons Learned from Reconstructing Interactions Between Local Ecological Knowledge, Fisheries Science, and Fisheries Management in the Commercial Fisheries of Newfoundland and Labrador, Canada. *Human Ecology* 34 (4): 549-571.

Murray, G., Neis, B., Palmer, C.T., and Schneider, D.C. 2008. Mapping Cod: Fisheries Science, Fish Harvesters' Ecological Knowledge and Cod Migrations in the Northern Gulf of St. Lawrence. *Human ecology : an interdisciplinary journal* 36 (4): 581-598.

Nadasdy, P. 1999. The politics of TEK: power and the "integration" of knowledge. *Arctic Anthropology* 36 (1-2): 1-18.

Nazarea, V. 1999. A view from a point: ethnoecology as situated knowledge. In *Ethnoecology: situated knowledge/located lives*, ed. Virginia Nazarea: 3-20. Tuscon: The University of Arizona Press.

Nelson Acclimatisation Society. 1968. *One Hundredth Annual Report and Accounts - "A Hundred Years On" A Century of Acclimatization in Nelson*. Nelson: Enterprise Printing Co. Ltd.

_____. 1969. *One Hundred and First Annual Report - Statement of Accounts and Balance Sheet*. Nelson: Enterprise Printing Co.

_____. 1970. *One Hundred and Second Annual Report - Statement of Accounts and Balance Sheet*. Nelson: Enterprise Printing Co.

_____. 1973. *One Hundred and Fifth Annual Report - Statement of Accounts and Balance Sheet*. Nelson: Enterprise Print.

_____. 1975. *One Hundred and Seventh Annual Report - Statement of Accounts and Balance Sheet*. Nelson: Enterprise Printing Co. Ltd.

_____. 1976. *One Hundred and Eighth Annual Report - Statement of Accounts and Balance Sheet*. Nelson: Enterprise Printing Co. Ltd.

_____. 1977. *One Hundred and Ninth Annual Report - Statement of Accounts and Balance Sheet*. Nelson: Enterprise Printing Co. Ltd.

_____. 1978. *One Hundred and Tenth Annual Report - Statement of Accounts and Balance Sheet*. Nelson: Enterprise Printing Co. Ltd.

_____. 1981. *One Hundred and Thirteenth Annual Report - Statement of Accounts and Balance Sheet*. Nelson: Enterprise Print.

_____. 1982. *One Hundred and Fourteenth Annual Report - Statement of Accounts and Balance Sheet*. Nelson: Enterprise Print.

_____. 1983. *One Hundred and Fifteenth Annual Report - Statement of Accounts and Balance Sheet*. Nelson: Enterprise Print.

_____. 1984. *One Hundred and Sixteenth Annual Report - Statement of Accounts and Balance Sheet*. Nelson: Enterprise Print.

_____. 1985. *One Hundred and Seventeenth Annual Report - Statement of Accounts and Balance Sheet*. Nelson: Enterprise Print.

_____. 1986. *One Hundred and Eighteenth Annual Report - Statement of Accounts and Balance Sheet*. Nelson: Enterprise Print.

_____. 1989. *One Hundred and Twenty-First Annual Report - Statement of Accounts and Balance Sheet*. Nelson: Enterprise Print.

New Zealand Biodiversity Recording Network. http://www.nzbrn.org.nz/ [accessed 24 May 2009].

Olsson, K. 2003. The influence of introduced brown trout (Salmo trutta) on the distribution and abundance of native crayfish (Paranephrops planifrons) and galaxiids (Galaxias spp.) in New Zealand streams, Lund University.

Organisation for Economic Co-operation and Development. 2001. *OECD environmental outlook*. Paris: OECD Publishing.

Papworth, S.K., Rist, J., Coad, L., and Milner-Gulland, L.J. 2009. Evidence for shifting baseline syndrome in conservation. *Conservation Letters* 2: 93-100.

Paulin, C., Stewart, A., Robert, C., and McMillan, P. 1989. *New Zealand Fish - A Complete Guide*. Edited by National Museum of New Zealand. Miscellaneous Series. Wellington: National Museum of New Zealand.

Pauly, D. 1995. Anecdotes and the shifting baseline syndrome of fisheries. *Trends in Ecology and Evolution* 10 (10): 430-430.

Píriz, L. 2004. Hauling Home the Co-Management of Coastal Fisheries: a study on the institutional barriers to fishermen's involvement in the management of coastal fisheries on the West Coast of Sweden. Ph D, Göteborg University.

Pollock, K., Jones, C., and Brown, T. 1994. *Angler Survey Methods and their Applications in Fisheries Management*. American Fisheries Society Special Publication. Bethesda: American Fisheries Society.

Richardson, J., Unwin, M., and Tierney, L.D. 1984. *The relative value of Nelson rivers to New Zealand anglers - Fisheries Environmental Report No. 45*. Wellington: New Zealand Ministry of Agriculture and Fisheries - Fisheries Research Division.

Richmond, C., Froude, V., Fenemor, A.D., and Zuur, B. 2004. Management and conservation of natural waters. In *Freshwaters of New Zealand*, ed. Jon Harding, Paul Mosley, Charles Pearson and Brian Sorrell. Christchurch: New Zealand Hydrological Society and New Zealand Limnological Society.

Sable, T., Howell, G., Wilson, D., and Penashue, P. 2007. The Ashkui Project: Linking Western Science and Innu Environmental Knowledge in Creating a Sustainable Environment. In *Local Science Vs Global Science: Approaches to Indigenous Knowledge in International Development*, ed. Paul Sillitoe: 109-127. New York: Berghahn Books.

Schafer, A.G. and Reis, E.G. 2008. Artisanal fishing areas and traditional ecological knowledge: The case study of the artisanal fisheries of the Patos Lagoon estuary (Brazil). *Marine Policy* 32 (3): 283-292.

Siebers, H. 2004. Management of knowledge and social transformation. In *Development and Local Knowledge*, ed. Alan Bicker, Paul Sillitoe and Johan Pottier: 31-50. Abingdon: Routledge.

Sillitoe, P. 2002. Globalizing indigenous knowledge. In *Participating in development: approaches to indigenous knowledge*, ed. Paul Sillitoe, Alan Bicker and Johan Pottier, 39. London: Routledge.

_____. 2007. Local Science vs. Global Science: an Overview. In *Local Science Vs Global Science: Approaches to Indigenous Knowledge in International Development*, ed. Paul Sillitoe: 1-22. New York: Berghahn Books.

Sillitoe, P., Barr, J., and Alam, M. 2004. Sandy-clay or clayey sand? Mapping indigenous and scientific soil knowledge on the Bangladesh floodplains. In *Development and Local Knowledge*, ed. Alan Bicker, Paul Sillitoe and Johan Pottier: 174-201. Abingdon: Routledge.

Silvano, R., MacCord, P., Lima, R., and Begossi, A. 2006. When Does this Fish Spawn? Fishermen's Local Knowledge of Migration and Reproduction of Brazilian Coastal Fishes. *Environmental Biology of Fishes* 76 (2): 371-386.

Silvano, R.A.M. and Valbo-Jorgensen, J. 2008. Beyond fishermen's tales: contributions of fishers' local ecological knowledge to fish ecology and fisheries management. *Environment, Development and Sustainability* 10 (5): 657-675.

Silver, J. and Campbell, L. 2005. Fisher participation in research: Dilemmas with the use of fisher knowledge. *Ocean and Coastal Management* 48 (9-10): 721-741.

Spackman, W.H. 1892. *Trout in New Zealand: Where to go and how to catch them*. Wellington: George Didsbury.

Stanley, R. and Rice, J. 2007. Fishers' knowledge? Why not add their scientific skills while you're at it? In *Fishers' Knowledge in Fisheries Science and Management*, ed. Nigel Haggan, Barbara Neis and Ian G. Baird: 401-420. Paris: UNESCO Publishing.

Strang, V. 2004. Close encounters of the Third World kind: Indigenous knowledge and relations to land. In *Development and Local Knowledge*, ed. Alan Bicker, Paul Sillitoe and Johan Pottier: 93-117. Abingdon: Routledge.

Swedish Species Information Centre. Artportalen. http://www.artportalen.se/default.asp [accessed 24 May 2009].

Townsend, C.R. 1996. Invasion biology and ecological impacts of Brown trout Salmo trutta in New Zealand. *Biological Conservation* 78: 13-22.

Townsend, C.R. and Simon, K.S. 2006. Consequences of Brown Trout Invasion for Stream Ecosystems. In *Biological Invasions in New Zealand*, ed. Robert Allen and William Lee, 186: 213-226. Berlin: Springer.

Toynbee, P.G. 1974. Trout fishing in Nelson: a study in recreational geography. Master of Arts in Geography, University of Canterbury.

Valbo-Jørgensen, J. and Poulsen, A. 2000. Using local knowledge as a research tool in the study of river fish biology: experiences from the Mekong. *Environment, Development and Sustainability* 2: 253-276.

Walrond, C. and Hayes, J. 1999. *Social Survey of Backcountry Anglers in Nelson-Marlborough & Otago. Cawthron Report No. 501*. Nelson: Cawthron Institute.

Water Conservation (Motueka River) Order. 2004. ed. Executive Council. Wellington.

Wilding, T. and Rowe, D. 2008. *FRAM: A fish risk assessment model for the importation and management of alien freshwater fish in New Zealand*. Hamilton: National Institute of Water and Atmospheric Research, New Zealand.

Williams, A. and Bax, N. 2007. Integrating fishers' knowledge with survey data to understand the structure, ecology and use of a seascape off south-eastern Australia. In *Fishers' Knowledge in Fisheries Science and Management*, ed. Nigel Haggan, Barbara Neis and Ian G. Baird, 4: 365-379. Paris: UNESCO Publishing.

Willms, A.R. and Green, D.M. 2007. Reconstruction of walleye exploitation based on angler diary records and a model of predicted catches. *Mathematical Biosciences* 210 (1): 96-120.

Wilson, D.C., Raakjaer, J., and Degnbol, P. 2006. Local ecological knowledge and practical fisheries management in the tropics: A policy brief. *Marine Policy* 30 (6): 794-801.

Winegardner, D. 1995. *An introduction to soils for environmental professionals*. Boca Raton: CRC Press.

Young, R. and Hayes, J. 2001. Assessing the accuracy of drift-dive estimates of brown trout (Salmo trutta) abundance in two New Zealand rivers: a mark-resighting study. *New Zealand Journal of Marine and Freshwater Research* 35: 269-275.

_____. 2004. Angling pressure and trout catchability: behavioural observations of brown trout in two New Zealand backcountry rivers. *North American Journal of Fisheries Management* 24 (4): 1203-1213.

Personal Communication

Baker, M-A. Policy Planner, Tasman District Council. Formal interview. Richmond, 26 March 2009.

Basher, L. Senior Scientist, Erosion and Sediment Processes. Landcare Research New Zealand. Multiple informal meetings. Nelson, 10 February to 01 April 2009.

Deans, N. Manager, Nelson/Marlborough region, Fish and Game New Zealand. Informal meeting. Nelson, 26 February 2009.

_____. Manager, Nelson/Marlborough region, Fish and Game New Zealand. Formal interview. Richmond, 01 April 2009.

Hayes, J. Senior Scientist, Freshwater Group, Cawthron Institute. Formal interview. Nelson, 02 April 2009.

James, T. Water Quality Scientist, Tasman District Council. Telephone interview. Richmond, 16 March 2009.

Toft, R. Scientist, Landcare Research New Zealand. Informal meeting. Nelson, 25 March 2009.

Appendices

Appendix 1

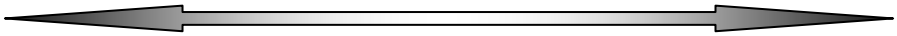
Interview questions	
Question number	**Question**
Section 1: Your experience and interaction with the Motueka River	
1	How many years have you been fishing overall, and how many years have you fished the Motueka?
2	Are you, or have you ever been, a fishing guide? *If yes,* • How long have you been guiding? • Is guiding your primary or secondary occupation?
3	Do you fish all of the river or particular parts? Can you point out on the map the spots where you fish the most?
4	What are your reasons for choosing these particular areas?
5	Do you typically move by car or by walking? *If by car*, how often do you move and how far do you go between stops?
6	How often do you fish the Motueka – how regularly and for how many hours?
7	In what kinds of weather conditions do you fish?
8	What determines the duration of a fishing trip?
Section 2: Information you record during fishing trips	
9	Do you keep a fishing diary?
10	If so, what kind of information do you record in the diary? Why?
11	Do you make any comments relating to habitat, specifically levels of sediment?
12	Do you have any other records of your fishing trips, for example photographs?
Section 3: Your observations of sediment events	
13	Have you noticed changes in the amount of sand in the river at any time?
14	Where did those changes occur?
15	When did those changes occur? How long did they persist?
16	Can you tell me what you observed?
17	For each change, can you rate them on a scale of severity?
Section 4: Effects of sediment events on trout fishery	
18	Did the changes in sand affect your fishing? If so, how?
Section 5: Causes of sediment events	
19	Can you think back to the time around the changes in sand levels, and remember any particular conditions or happenings at the time?

20	What do you think were the causes of the changes in sand levels?
Section 6: Other questions on trout fishery	
21	During the 1990s, did you notice any decline in trout numbers? If yes, what years? What did you personally observe?
22	After the 2005 flood in the upper Motueka and Motupiko, did you observe any changes in the fishery?
23	Have you noticed any change in the abundance of trout food since you've been fishing the Motueka?
24	What do you see as the main drivers for variation in trout numbers through time?
Section 7: General questions about river management	
25	I'd like to find out to what extent you agree or disagree with fishery management measures that have been applied in the Motueka catchment? SPECIFIED: a. Water conservation order (provisions pertaining to the trout fishery) b. Fishing regulations (Fish & Game)
26	To what extent do you agree or disagree with environmental conservation measures that have been applied in the Motueka catchment? SPECIFIED: a. Water conservation order (in general) b. Water allocation policy (TDC) c. Water quality standards d. TDC's Land use management in the catchment as a whole e. Other: specify
27	How do you feel the trout fishery could best be managed?
28	Do you think fishermen's knowledge can benefit fishery and river management? Why?
Section 8: Fishing club questions	
29	Are you a member of a fishing club?
30	Do you attend meetings? If so, how often? Do you participate in discussions?
31	Are environmental issues discussed in meetings? If so, roughly what percentage of the time is spent discussing them?
32	How extensive is your network of fishing friends, and do you spend a lot of time discussing environmental issues?
Section 9: Background questions	
33	What year were you born?
34	Are you presently employed? If yes, what is your job? If retired, what was your profession?
35	What is the highest level of education you attained: primary school – secondary school – tertiary education

Appendix 2

Circle as appropriate

Scale of opinion					
strongly disagree	disagree	undecided	agree	strongly agree	don't know



Theme: Fishery management measures					
Question: To what extent do you agree or disagree with the Water Conservation Order (provisions pertaining to the trout fishery)?					
strongly disagree	disagree	undecided	agree	strongly agree	don't know
Question: To what extent do you agree or disagree with the Fish & Game regulations?					
strongly disagree	disagree	undecided	agree	strongly agree	don't know
Theme: Environmental management measures					
Question: To what extent do you agree or disagree with the Water Conservation Order (in general)?					
strongly disagree	disagree	undecided	agree	strongly agree	don't know
Question: To what extent do you agree or disagree with TDC's water allocation policy (surface and groundwater abstraction)?					
strongly disagree	disagree	undecided	agree	strongly agree	don't know
Question: To what extent do you agree or disagree with water quality standards?					
strongly disagree	disagree	undecided	agree	strongly agree	don't know
Question: To what extent do you agree or disagree with TDC's Land use management in the catchment as a whole?					
strongly disagree	disagree	undecided	agree	strongly agree	don't know
Question: To what extent do you agree or disagree with Other: specify?					
strongly disagree	disagree	undecided	agree	strongly agree	don't know