## *2.4. Challenges and Opportunities of Integrating Local Knowledge into Environmental Management*

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### 2.4.1. Introduction

A popular Christmas pastime for many 19th century North America hunters was a competition in which the hunter who shot the most birds and small mammals was declared the winner (National Audubon Society, 2011). The Audubon Society turned this tradition on its head and in 1900 organised the first bird census undertaken by laypersons, which has come to be known as the Christmas Bird Count. The Christmas Bird Count is one of the earliest examples of an organised effort to gather and make use of local knowledge held by individuals outside of the research community.

Such flora and fauna monitoring programmes have increased in popularity, as has academic interest in the value of local knowledge for natural resource management. Growing interest in local knowledge is in many ways linked to increased awareness of the shortcomings of scientific knowledge in explaining and solving environmental problems. There is however a dichotomy between the theoretical benefits of local knowledge use and integration into management and the actual practice linked to local knowledge capture. Indeed, most local knowledge capture takes place as part of "citizen science" projects, where laypersons gather data as part of studies designed, analysed and used by researchers. While such projects have undeniable benefits, not only in terms of data gathering but also in terms of increased environmental awareness on the part of participants, they do not involve local knowledge holders in all parts of the process, from research design to ultimate decision making.

This chapter will focus on one example of local knowledge — that held by a group of anglers who have fished the Motueka River catchment in New Zealand for many years (Fig. 2.8). The local knowledge held by these anglers was sought in the context of a study seeking to determine the causes of an observed decline in the river's brown trout (*Salmo trutta* L.) population. The case study revealed some characteristics of angler knowledge that make it useful for catchment management, while also highlighting some deficiencies of local knowledge that can partly be resolved through appropriate research design. The study also demonstrates that the Motueka River catchment management framework and institutions are structured in a way that allows for full integration of local knowledge into management. The integration of local knowledge therefore faces challenges both in terms of the ways in which it is produced and conceptualised, and in terms of how it can be utilised.

The chapter aims to draw lessons from the Motueka River catchment and draw broad conclusions about the integration of local knowledge into environmental management, both at the scale of the Motueka River catchment and more generally for other local knowledge use initiatives. We also summarise the current discourse concerning local knowledge, its definitions and integration into the research process.

**Fig. 2.8.** Fly fishing for trout (Source: David Eccleston)

The first section will clarify some of the many terms and definitions relating to local knowledge and provide an overview of the main options for local knowledge acquisition and analysis, and will also present the parameters of the Motueka angler case. The second section will provide the main results of this research, both in terms of the investigation on trout decline and sedimentation, and in terms of local knowledge use for catchment management. Finally, we discuss the opportunities and challenges of integrating local knowledge in natural resource management.

### 2.4.2. Local knowledge: its definition, capture and analysis

Some of the earliest *practical* examples of data collected utilizing local knowledge include published records kept by North American fish and game organizations, including hunters and fishermen who recorded species distributions and specimen size ranges (e. g. Gray, 1932; IGFA, 1941). Making use of the knowledge held by local people for the management of natural resources has been the subject of *academic* enquiry since at least the 1950s (Dove et al., 2007). There has, however, been a relatively recent surge in interest in acquiring local knowledge for environmental monitoring (Anthony, 2002; Anadon et al., 2009; Danielsen et al., 2007, 2009), developing conservation plans (Oscarson & Calhoun, 2007), and particularly for the management of resources facing over-exploitation and depletion, such as fisheries. Indeed, some perceive scientific knowledge as having failed to address many environmental problems, while pointing to other types of knowledge as possible complementary or even alternative solutions for improved natural resource management (Baird & Flaherty, 2005; Bergmann et al., 2004; Close & Hall, 2006; Mackinson & Nøttestad, 1998; Mathooko, 2005; Murray et al., 2006, 2008).

### 2.4.3. Defining local knowledge

The terminology used in relation to local knowledge is extensive and subject to overlap, and is also related to the ways in which local knowledge is proposed to be used. It is important to first clarify what is meant by both local knowledge and citizen science, two often-used terms in scientific literature.

## Local knowledge as situated knowledge

The knowledge possessed by those whose are not professionally involved in knowledge-production institutions has been variously termed traditional knowledge, indigenous knowledge or local knowledge. Several terms are offshoots of these main branches, including Traditional Ecological Knowledge (TEK), Indigenous Technical Knowledge (ITK), Indigenous Ecological Knowledge (IEK) and Local Ecological Knowledge (LEK). Such knowledge can also be specific to a certain area of activity, such as Fishermen's Ecological Knowledge (FEK). The concept of indigenous knowledge is one that emerged from anthropological research upon contact with non-western cultures. 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 changes, which affect all types of knowledge as a result of interactions with other people and places (Ingold, 2000; Sillitoe, 2002).

TEXT BOX 2.2

***Local knowledge: a working definition***

*The local knowledge of an individual is unrelated to any institutional affiliation, and is the product of both the individual's cultural background and of a lifetime of interaction with his or her surroundings. A holder of local knowledge does not belong to any particular social group nor does he or she necessarily lead a traditional lifestyle.*

If approached from Ingold’s (2000) ‘situated knowledge’ perspective, the 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). The concept of situated knowledge is one derived from Ingold’s (2000) anthropological work, where knowledge is shaped by an individual’s lifelong interactions within his or her environment, rather than transmitted genealogically at a single point in time. 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, spatial or temporal scales. 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 dissimilar from the more temporary and observational role of scientific research (Ingold, 2000; Sillitoe, 2007). Fig. 2.9 illustrates how the different types of knowledge fit in the situated knowledge spectrum of space, time and culture.

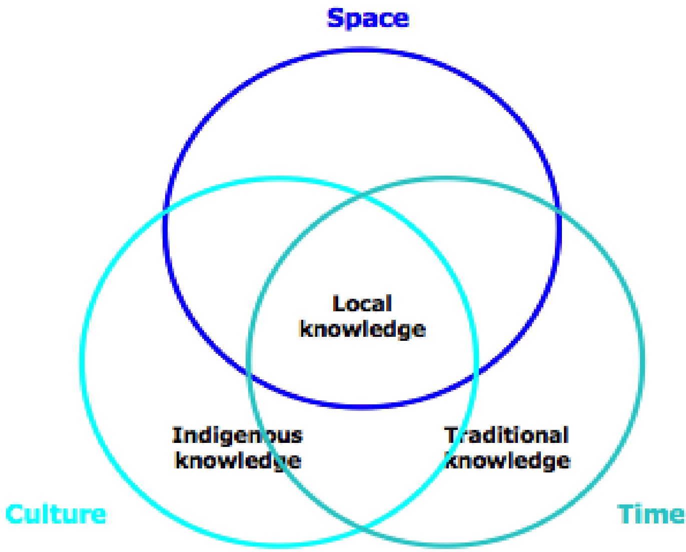


**Fig. 2.9.** Distribution of different local knowledge types in a situated knowledge spectrum

**Local knowledge use: an academic perspective.** Before explaining the concept of citizen science, it is worth reviewing the main arguments that have been put forward to justify the use of local knowledge. One category relates to increasing the validity of scientific research by supplementing it in areas where it is deficient, including the local relevance of research (Fischer, 2000; Sable et al., 2007; Williams & Bax, 2007). In the case of fisheries, replacement of traditional or local knowledge by centrally generated data has led to largely locally irrelevant 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 (often hegemonic) expert-driven transmission of knowledge for a more holistic and integrated approach are increasing (Agrawal, 1995; Siebers, 2004; Anthony et al., 2011).

A second argument promotes 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 and validity of scientific research, through participation in both formulation and implementation (Fischer, 2000; Mackinson & Nøttestad, 1998; Marzano, 2007; Sillitoe, 2002, 2007; Stanley & Rice, 2007). Fischer (2000) sees local involvement in environmental management as vital given the local origin of many environmental problems. A third category of arguments 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 (Maffi, 2001; 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).

**Citizen science or the practical application of local knowledge.** Citizen science mainly relates to the third category of arguments outlined above: that local knowledge can become an integral part of scientific research. Citizen science is not synonymous to local knowledge but rather refers to ways in which this knowledge can be applied in practice. 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).

### 2.4.4. Capturing and analysing local knowledge

While the general consensus is that local knowledge has inherent value, views on how valuable this knowledge can be for environmental management and on how it can be integrated within it are much less unified. Some researchers see 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 (Gilchrist et al., 2005). Others take 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. A third view of local knowledge research does not necessarily promote its integration into management but rather sees the mere fact of gathering knowledge and interacting with the local knowledge holders as achieving a positive environmental outcome. Although there is a paucity of research which has evaluated the validity of local knowledge versus 'science-based' knowledge, there is indication that local knowledge can yield statistically similar results (Engel & Voshell, 2002), and may even be superior in some cases (Anadon et al., 2009).

**Capturing local knowledge.** 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 & Hall, 2006; Hall & Close, 2007; Schafer & Reis, 2008). Researchers may either gather positional information from local knowledge holders on printed maps and subsequently digitise this information using GIS software, or they may accompany local knowledge holders on the ground and record coordinates using GPS technology (Schafer & Reis, 2008). Also, a number of interview techniques have been devised to attempt to capture the richness of local knowledge while accounting for the fact that it may not come in the same format as scientific data. For example, some researchers use colour photographs of species (Silvano et al., 2006; Silvano & Valbo-Jorgensen, 2008; Valbo-Jørgensen & Poulsen, 2000) or actual specimens (Anthony & Bellinger, 2007) when going through questionnaires and interviews, while others use trend timelines made by the local knowledge holders themselves (Píriz, 2004).

The fact that levels of knowledge may not be equally distributed among members of a community or resource user group is one of the main limitations relating to local knowledge capture. For example, one study found that fishermen using larger equipment possessed less knowledge than those using smaller equipment (Wilson et al., 2006); differences can also be due to differences in age and/or diversity of fishing areas utilised. Hence, selecting the 'wrong' fishermen for data may skew the results (Close & Hall 2006; Davis & Wagner 2003; Drew, 2005; Murray et al., 2006, 2008; Silvano et al., 2006; Silver & Campbell, 2005; Wilson et al., 2006). Another limitation relates to the perceived sensitivity of some forms of knowledge. The knowledge held by commercial natural resource users is subject to some particular considerations; these may feel their knowledge is of commercial value and hence should remain confidential (Close & Hall, 2006; Drew, 2005; Maurstad, 2002). They 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 (Silver & Campbell, 2005; Williams & 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 valid and reliable data from local knowledge holders.

**Analysing local knowledge.** Following its collection, local knowledge usually undergoes various stages of analyses, either through GIS software, statistical and modelling techniques, and/or qualitative analysis (Olson et al., 1995; Kelle, 2001; Campbell, 2002). The use of GIS also allows for the storage of information that cannot be spatially represented on maps in linked databases, text files or photographs (Hall & Close, 2007; Harmsworth, 1998). This approach is particularly valuable, as it captures the varied nature of local knowledge and comes at a relatively low cost. The data obtained from interviews and focus groups can also be entered into databases and statistically analyzed (Baird & Flaherty, 2005; Anthony & Bellinger, 2007).

The analysis of local knowledge can be hampered by the fact that it is not always valid or reliable. For example, some aspects of fish biology may take place outside of the sphere in which 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). Since local knowledge comes in different formats, it is neither easily made compatible with existing scientific structures, nor simply communicated to others in a fishery management setting (Mackinson & Nøttestad, 1998; Agrawal, 2002; Anuchiracheeva et al., 2003; Davis & Wagner, 2003; Píriz, 2004; Drew, 2005; Baird & Flaherty, 2005; Close & Hall, 2006; Wilson et al., 2006; Schafer & Reis, 2008). Since the analytical tools local knowledge is often repackaged into often have pre-existing requirements in terms of the type of data and information, which they can utilize, some data representing local knowledge must sometimes be discarded, regardless of its value or relevance.

**Gathering and using local knowledge in developing countries.** The chief difference between fisheries research in developing and developed countries is that 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 employ more modern techniques. While this may very well be a reflection of the reality on the ground, it has implication in terms of research methods used; a good example is the use of GIS. Research using GIS to systematise local knowledge 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.

### 2.4.5. An example of local knowledge: brown trout fishermen of the Motueka River catchment

As a case study of the existence, capture, analysis and possible use of local knowledge, here we focus on the local knowledge held by a group of fishermen of the Motueka River catchment in New Zealand. A study of local angler knowledge was undertaken in 2009 as part of the Integrated Catchment Management Motueka Research Programme[1] and focused on the knowledge of environmental and sedimentary processes held by a group of long-term local anglers. This section will briefly explain the methodology followed in the study.

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[1] From 2000 to 2010, the Integrated Catchment Management programme took an integrated and multi-disciplinary perspective to the management of the catchment, researching social and economic issues as well as biophysical variables while seeking to involve affected stakeholders in environmental management decisions. For more information, see: [Electronic resource]: URL: http://icm.landcareresearch.co.nz/

TEXT BOX 2.3

***The Motueka River catchment***

*Located in the north-west of the country's South Island, the Motueka River catchment drains an area of 2,180 km$^2$ and is composed of the Motueka River, whose main stem is 110 km in length, as well as a number of tributaries (Fig. 2.10). The catchment is predominantly rural and characterised by mountains and hills, making most of it ill-suited for arable cropping; land cover in the catchment is mostly a combination of native forest, planted exotic forest and pastoral grassland (Basher, 2003). The catchment is managed by the Tasman District Council (TDC), while the catchment's trout fishery is under the authority of Fish and Game New Zealand (FGNZ).*

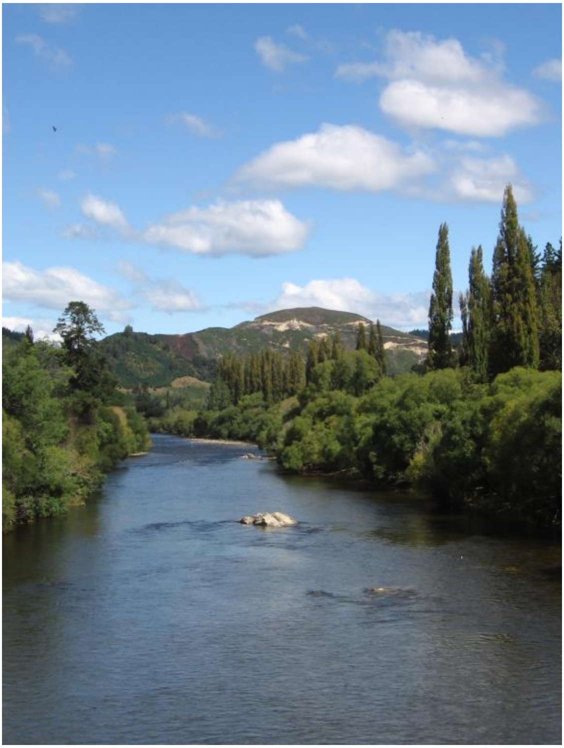

**Fig. 2.10.** The Motueka River catchment (Source: Anne-Claire Loftus)

Some key challenges face the Motueka River catchment: competition for limited water supplies both between different water-consumptive land uses and between these and non-consumptive uses of water; the influence of sediment on river ecology and its relationship with land use; deteriorating water quality due to the cumulative input of nutrients and bacteria; and possible negative trends in riparian management affecting aquatic species (Basher, 2003). In the mid-1990s, brown trout (*Salmo trutta* L.) numbers were observed to decline in the catchment, with sedimentation identified as a possible causal factor. Anglers who have fished in the catchment over a long period of time were identified as potentially valuable sources of information about sedimentation events, the trout fishery and other environmental processes.

**Methodology**

Fieldwork for this study consisted of semi-structured interviews with long-time anglers of the Motueka River catchment. Interviewees were not selected randomly, but rather were chosen because of the breadth of their experience of the river. The lack of randomized sampling was justified by the need to obtain information covering a long historical period, from anglers who frequently use the catchment; lack of representativeness was therefore not seen as an issue. To understand if and how angler knowledge can be used for catchment management, a number of persons involved in management of the catchment and trout fishery were also interviewed.

The angler interviews had two objectives: first, to ascertain what knowledge the anglers possess and second, to identify the characteristics of the knowledge that could play a part in determining to what extent it can be integrated in catchment management. A number of aspects of the interviews were tailored to meet the specific features of local knowledge:

- Anglers were encouraged to bring any fishing diaries they might keep to the interviews (Fig. 2.11).
- In recognition of the strong visual component involved in fishing, the interview protocol involved asking anglers if

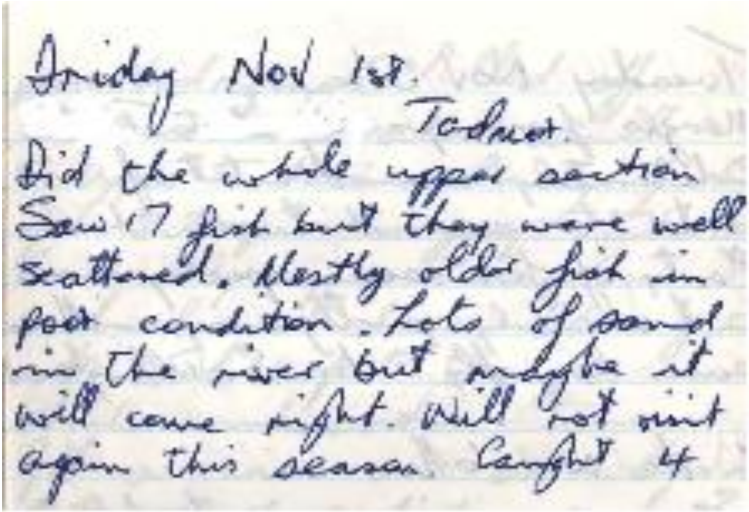
Friday Nov 1st.
Tadmor.
Did the whole upper section
Saw 17 fish but they were well
scattered. Mostly older fish in
poor condition. Lots of sand
in the river but maybe it
will come right. Will not visit
again this season Caught 4

**Fig. 2.11.** Example of angler diary entry

they used any visual means of recording events during fishing trips, such as photographs.

- Interviewees were asked to identify from a series of photographs the severity of the sediment events, which they encountered. This visual support was established in an effort to facilitate comparison across interviews.
- A map showing the main bridges within the Motueka River catchment was used during the interviews to ensure clarity of communication and to aid with identification of the areas predominantly fished. Indeed, a pilot interview conducted showed that anglers primarily locate themselves according to the main access points to the river: its bridges.
- Confidentiality of interviews was ensured in recognition of the sensitivity of opinions given about current fishery and environmental management measures and of information about favoured fishing spots. Although such information would only be commercially valuable for the several fishing guides interviewed, it could be of value to the rest of the

anglers in other ways. Indeed, their enjoyment of fishing can depend 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.

In the analysis of interview responses, the characteristics of local knowledge were also taken into account. Namely, validation was used in order to try and assess the validity and reliability of the largely anecdotal responses elicited by the questionnaire, using three main methods:

- Comparison of statements made during each interview to identify inconsistencies.
- 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.

### 2.4.6. Local knowledge integration in environmental management

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 a number of local knowledge research projects. This section will focus on integration of local knowledge, taking both lessons from the Motueka River catchment case and from other examples.

**Findings from the Motueka River catchment study relating to sedimentation and other environmental processes.** The first objective of the interview process was to determine what knowledge the anglers possess. 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. The interviews produced a large quantity of angler observations of sediment events and other environmental processes, as well as widely varying views concerning both the state of the fishery, and the possible driving forces behind it.

TEXT BOX 2.4

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***The angler sample***

*The 16 anglers interviewed for the study have been fishing in the Motueka River catchment for a mean of 36 years (min = 7, max = 71). The average number of days fished per year is 25, with some of the anglers fishing over 50 days per year — much more than average fishing license holders in the region. Their fishing habits vary, with some alternating fishing spots quite often and others choosing to fish in one area exclusively. The fact that some of the anglers change their privileged fishing spots in response to the number and size of fish has implications in terms of their familiarity with certain parts of the catchment.*

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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. Anglers reported the occurrence of sediment in a wide variety of locations and over a range of timescales, and also broadly agreed that the aquatic habitats in the catchment have become more uniform over the years due to sedimentation and consequent in filling. Anglers primarily believed sediment affected trout at a localized level, by smothering the riverbed and creating unsuitable habitat for the trout’s main source of food: invertebrates. Most anglers blamed forestry and its associated roading, preparation of land for planting and finally harvesting for the sedimentation observed in the catchment. Apart from observations about sedimentation, most anglers also observed a change in the population distribution of trout, which transitioned from housing large numbers of small fish to hosting small numbers of large fish. However, there was wide variation in opinions regarding the magnitude of change undergone by the trout fishery through time, some seeing it as having deteriorated severely and others as responding to more cyclical patterns. Although a large number of possible causes for the perceived decline in trout numbers were mentioned by anglers, sedimentation and the failure of juvenile recruitment were the most frequently cited.

**Findings from the Motueka River catchment study relating to local knowledge in general.** The second objective of the interviews was to determine what aspects of angler knowledge affect its integration in catchment management. Overall, the aspects identified seem to negatively affect the possibility of integrating the local knowledge into the management of the catchment, though the influence of the study design must be highlighted.

The fishing experience of the interviewed anglers varied quite widely: some had both wide spatial and temporal experience, while others had shorter-term experience in more limited parts of the catchment. However, these differences did not necessarily correspond to the degree of recollection of events in the catchment; indeed, the extent to which fishermen record events in written form appeared to play a more important role. Many of the anglers keep or kept fishing diaries, though the level of detail and the consistency of diary-keeping varied widely. Most of the information recorded related to fish catches, with few diarists noting information about habitat or insect life. Overall, the fishing diaries provided little useful information regarding sediment, but were useful to help understand the ways in which anglers conceptualise and present information relating to the catchment.

TEXT BOX 2.5

***Brown trout in New Zealand***

*Brown trout (Salmo trutta L.) (Fig. 2.12) was introduced to New Zealand during the 18$^{th}$ century for sport fishing purposes and can now be found in most of the country's rivers. Although 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 & Rowe, 2008), brown trout nonetheless negatively impacts freshwater ecosystems (Townsend & Simon, 2006). However, because the negative impact of trout on ecosystems is less pronounced — or at least less visible — than that of introduced land mammals, and since trout is the centre of a lucrative sport fishing industry, no organised control measures for trout populations exist.*

**Fig. 2.12.** Brown trout (Salmo trutta L.). Copyright Eric Engbretson, US Fish and Wildlife Service

The degree to which statements were an individual's memory or recall was hard to establish. 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). Anglers interact with one another through their participation in angling clubs and through friendships formed with other anglers.

In attempting to validate the responses given by interviewees, the study came across some difficulties. Cross-checking of statements within the angler sample was particularly challenging 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. Furthermore, the validation of responses using other sources of information such as scientific research was not only hampered by the lack of research on particular topics but also gave rise to a wider ethical question regarding the need for validation of local knowledge by science.

The following section will show how these findings can be embedded into the larger debate concerning local knowledge integration in environmental management by highlighting the opportunities and challenges of local knowledge utilisation in natural resource management.

## 2.4.7. Opportunities for local knowledge integration

Observations and opinions varied widely amongst Motueka River catchment anglers, but some overall trends that may be useful for further research were identified. Angler knowledge and local knowledge in general presents characteristics, which make it highly suitable for integration into management.

**Observation skills.** The Motueka River catchment anglers spent a considerable amount of time on the river over their lifetimes. Apart from the sheer amount of time their angling trips translated into, the observation habits of the anglers were also of benefit to catchment research. Similar to hunters, fishermen must pay particular attention to their surroundings and to the habitat conditions of their prey, in order to improve fishing success. A relevant example is observing the abundance and composition of invertebrates, which is a favoured food source for trout.

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 contacting FGNZ to report potential threats to the river. Moreover, the anglers also demonstrated their ability and desire to record visual information about the catchment, not only through the diaries they keep (we return to this later) but also because many fishermen routinely take photographs during their fishing trips, meaning that they may be willing to make use of this technology for management purposes. Such capacity for observation combined with a significant amount of time spent in the natural environment is not unique to anglers, but can also apply to hunters, bird watchers as well as other outdoor enthusiasts.

**Capacity for sampling.** Given that anglers, or certainly experienced anglers such as the ones we interviewed, spend a significant amount of time on the river, they would be ideally placed to participate in an initiative requiring regular monitoring of habitat indicators. 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 volunteers — particularly farmers. The kits collect data about land use, stream habitat and indicator organisms and consist of a measurement kit and a manual (Biggs et al., 2002). 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.

**Systematic thought.** As well as being observant and capable of sampling, the anglers showed evidence of a systematic approach being taken in their relations with the trout fishery and the environment as a whole. This approach can be seen in the choice of fishing location and in the diary keeping of some anglers. 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. A systematic approach is also evident in the way some anglers learn through experience and in the refusal of some interviewees to make categorical statements, acknowledging their uncertainty about certain phenomena.

### 2.4.8. Challenges to local knowledge integration

Many of the deficiencies of angler knowledge in this study could be remedied through modified research methods, for example by gathering data in a timely fashion rather than as part of a historical analysis. Some problems with local knowledge however lead to more all-encompassing questions about the role of local knowledge as compared to scientific knowledge.

**Problems with sampling and data capture.** Fishing diaries were identified in the study as a potentially valuable source of information, as long as the information collected was standardised and made more systematic. However, diary schemes can also suffer from low participation rates, because of lack of time or interest or other reasons, which would affect the quality and quantity of data collected, a fact particularly problematic for schemes relying on a high level of detail and commitment. Moreover, if the motivating factor behind the choice of fishing location for an angler is the quality (success) of fishing, this location is subject to change, which may predispose him or her to be less able to observe long-term changes in any 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 (Spellerberg, 1991). 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, a recognised drawback in other volunteer monitoring programs (Shirose et al., 1997; Mossman et al., 2002).

Also, sampling done by non-scientists can, unless the parameters of the study are set in a very precise fashion, suffer from a lack of accuracy. For example, a bird-spotting study might lead to the over-representation of particular species because of factors like personal preference, ease of spotting or choice of spotting location. A study comparing bird population data gathered from voluntary reporting with data from a standardised survey in Sweden found that volunteers tended to under-report common bird species, that their search effort varied over the years and that they did not choose bird spotting locations randomly but rather based on the likelihood of observation and ease of access. To limit these problems, the authors suggest that the use of full checklists (i.e. asking volunteers to record both presence and absence of species) might increase the validity of such studies, while acknowledging that the citizen science input could be particularly valuable for targeted studies of less common species and could therefore act as a complement to standardised scientific surveys (Snäll et al., 2011).

**Observation, hearsay and drivers of perception.** Several comments made in the angler interviews revealed a high level of interaction between fishermen and also with fishery managers. Moreover, anglers also showed evidence of having read or been made aware of scientific research results from the catchment, which, although a positive sign from the point of view of stakeholder interaction in catchment management, also made the distinction between pure observation and hearsay more challenging.

Furthermore, the angler study revealed the downsides of involvement of local knowledge holders in all aspects of research (including hypothesis formulation). For example, anglers tended to equate the quality of the fishery with the numbers of fish found in the river rather than their size, while in reality a shift to fewer bigger fish might not reflect reduced water quality. Anglers were also more likely to ascribe greater importance to visually perceptible factors such as forest harvesting rather than more concealed factors such as the damage inflicted upon trout redds[2] by wading anglers, which can cause a significant percentage of egg mortality (Hayes & Hill, 2005). 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.

**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. In the study of Motueka River catchment anglers, problems were encountered in terms of angler recollections, the most important of which was lack of precision in terms of descriptions and dating of events. However, while this particular study — because of the need to gather data from the past — relied heavily on personal memory, it is likely and advisable that future studies should focus on recently collected data or on data recorded through diaries, smartphones or other means.

**Bias.** Since fishermen's knowledge is 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 & Nøttestad,

[2] spawning area

1998; Silver & Campbell, 2005; Wilson et al., 2006). Of these three articles, Silver & Campbell (2005) is the most detailed and outspoken on the topic; however, their work is rarely cited. It is possible that the limitation is overlooked because it affects the very core of the research done. Although bias is certainly not limited to local knowledge holders, it should be taken into account when seeking to gather knowledge for the management of natural resources, since many of these natural resources form either the basis of livelihoods or have a direct connection to the hobbies of the local knowledge holders addressed.

### 2.4.9. Synthesis: appropriate use of local knowledge for environmental management

Given the challenges and opportunities outlined above, it is possible to identify two principal ways in which local knowledge can be integrated into environmental management. The first is to view local knowledge holders as playing an active role in a part of the research process, that which involves data collection, while hoping to create additional benefits linked to awareness-raising — the "citizen scientist" view. The second is to view local knowledge holders as vital to the entire research process, from design through to analysis and implementation, as well as to the eventual use of this research for management purposes.

**Local knowledge holders as citizen scientists.** The potential of non-scientists to act as an extended sampling force is one of the central tenets of citizen science, whose practical application often involves people making observations according to set instructions from scientists so that more data can be obtained than if relying on their own sampling. For example, the Zooniverse portal run by the University of Oxford asks regular citizens to contribute to scientific understanding through a variety of projects, one of which is the Milky Way Project. This project seeks to increase scientific understanding of star formation, and asks laypersons to, using a simple bubble-drawing interface, identify the bubbles that characterise the life cycle of stars from a series of satellite photographs. With around 12,000 images to inspect, the project leaders hope that citizen scientists will help reduce the analysis burden (Adler Planetarium & the Zooniverse, n. d.). A wide variety of notable programs have utilized volunteers to monitor wetland habitats (http://www.ec.gc.ca/tho-wlo/default.asp?lang=En&n=B6B30A86), bees (University of Illinois, n.d.; Center for Biodiversity and Conservation at the American Museum of Natural History and the Greenbelt Native Plant Center, n. d.), and amphibians (http://www.pwrc.usgs.gov/naamp/) in North America. In Hungary, an interactive website and national map is also used to monitor flora and fauna based on uploading volunteer data (http://www.vadonleso.hu/fajok/terkep/). Other notable examples of using local knowledge to inform management is the observations of inter alia Arctic sea ice change, narwhal tusks and meteorological conditions by the Inuit in Canada (http://www.eloka-arctic.org/data/). Such initiatives typically provide training or basic instructions for volunteers to follow, and citizen scientists normally return data in the form of filled-in data sheets or photographs. As well as providing valuable information to scientists, these citizen science schemes have the added advantage of often being simple enough for children to participate in and help raise awareness about the natural environment.

Such a citizen science system could be put in place in the Motueka River catchment, where the incident reporting system currently in place could be improved and expanded upon. One possibility could be an online information repository, perhaps 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 modelled 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 making observations in the catchment and verified by experts. Such data recording websites are an ideal way to gather and ultimately analyse local knowledge in countries where internet access is widespread.

Through such media as web portals, modern technology is making it increasingly easier to take advantage of the sampling power offered by non-scientists. Smartphone applications will make it easier for users to enter information, record sounds and images and transmit the data back to central locations. With GPS soon to be integrated into smartphones, sampling initiatives will be made much more relevant and accurate. Many smartphone applications already exist in the field of citizen science, for example those enabling data collection about waterways (http://www.ibm.com/smarterplanet/us/en/water_management/article/creek_watch.html), birds (http://thewildlab.org/) and other species (www.inaturalist.org/).

**Local knowledge holders as integral to the research process.** Danielsen et al. (2009) identify five different categories of environmental monitoring, ranging from research undertaken exclusively by professional researchers (category 1) to monitoring conducted exclusively by local people (category 5). Fig. 2.13 summarises the characteristics of each monitoring category.

Category 2 — citizen science — where data is collected by local people but where the research design and analysis is done by professional researchers has been discussed in previous sections. An example of category 3, where local people participate in data collection and analysis, comes from south-eastern Australia. Because of the paucity of data regarding the region, local fishermen were recruited to help with ecological mapping (Williams & 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 & Bax, 2007). Category 4 and 5 involve local people to a higher degree, in process design, data collection and analysis but also decision making. Such schemes represent the highest level of local knowledge use and integration into resource management (Danielsen et al., 2009).

| Monitoring category[b] | Characteristic[a]<br>cost to local stakeholders | cost to others (outsiders) | requirement for local expertise | requirement for external expertise | accuracy and precision | promptness of decision making | potential for enhancing local stakeholder capacity | capacity to inform national and international monitoring schemes |
|---|---|---|---|---|---|---|---|---|
| Category 1 | * | *** | * | *** | ***[c] | *[d] | * | *** |
| Category 2 | ** | ** | ** | *** | *** | * | * | *** |
| Category 3 | ** | ** | ** | *** | *** | * | ** | *** |
| Category 4 | *** | *-***[e] | *** | **-***[f] | ** | *** | *** | ** |
| Category 5 | *** | * | *** | * | * | *** | *** | * |

[a] *Key: *, low; **, intermediate; ***, high.*
[b] *Monitoring categories are defined in the text.*
[c] *Especially in developing countries, local people may be needed for locating and identifying (e.g., tracks of) wildlife species.*
[d] *An exception is remote-sensing schemes that detect, for example, forest fire in near real time and potentially may allow for almost immediate decision making.*
[e] *Recurrent costs to nonlocals low, set-up and training costs to nonlocals high.*
[f] *Recurrent requirement for nonlocal expertise intermediate; during set up/training requirement for nonlocal expertise high.*

**Fig. 2.13.** Variation in 8 characteristics across the 5 different categories of natural resource monitoring schemes (Source: Danielsen et al., 2009)

Citizen science projects essentially follow classic research methods (category 1), with researchers designing studies, providing volunteers with set instructions and ultimately being responsible for data analysis and making links to natural resource management. Conversely, local knowledge projects which involve citizens in steps outside of pure data collection — and particularly when it comes to decision making — require greater adaptability within natural resource management institutions. Angler knowledge is not currently incorporated to any large extent into management of the Motueka catchment, partly because catchment managers currently lack the time to be able to take local knowledge observations or comments into account to a greater extent. The information given by anglers is not yet an accepted and trusted source, and a local policy planner expressed the view that local knowledge would need to be substantiated and assessed prior to consideration for management. 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. Tasman District Council perceives angler knowledge as belonging rather to the area of public participation, which is both a means of feeding more knowledge into the decision making process, thereby increasing its quality, and of increasing buy-in to Council policies, thereby increasing their effectiveness (Baker, 2009, pers. comm.).

### 2.4.10. Conclusion on the case study

The case study of angler knowledge of sedimentary and other environmental processes within the Motueka River catchment produced inconclusive results. From the point of view of angler knowledge itself, interviews with the expert anglers produced results that varied widely amongst interviewees and between the anglers' views and available scientific and other records. Indeed, a forthcoming scientific study done within the Motueka River catchment has concluded that the trout decline was mainly due to above-average river flows over a period of a few years coinciding with the emergence of juvenile trout (Young et al., unpubl.), while the interviewed anglers had rather pointed to sedimentation (mostly due to forestry) as the primary cause of trout decline. However, many of the inconsistencies can be related to the design of the study itself, which relied for the most part on angler recollections unsupported by any means of recording. Better design of local knowledge studies, for example supported by data gathering means such as spreadsheets, photographs or GPS coordinates, can for the most part help overcome the deficiencies of local knowledge.

From the point of view of the integration of local knowledge within natural resource management, the Motueka angler case showed that perhaps the greatest barrier to the use of angler knowledge rests in the way 'integration' is often approached: as incorporation into pre-existing management structures, regardless of the capacity of these structures to conceptualise it or take its particular characteristics into account. Indeed, unless natural resource management structures perceive the value of local knowledge and are willing to adapt in order to be able to make full use of it, local knowledge use is likely to remain largely limited to citizen science projects. Although the value of these — as long as they follow certain parameters — is widely acknowledged, it does limit the involvement of non-scientists in natural resource management. One of the most exciting developments in local knowledge research has been the emergence of tailored ITC technologies such as smartphone applications, which show great promise in terms of supporting citizen science projects. Such software is becoming increasingly adapted for citizen science use; for example, one application provides images and sound bites of bird species to enable correct identification. The design of these technologies, which helps reduce some of the deficiencies of local knowledge, combined with their ease of use and ever-increasing technology penetration, indicates that citizen science initiatives will likely grow in popularity and use. These factors may, in concert with policy pushes for increased public participation in decision making, organically lead to more in-depth involvement of local knowledge holders in natural resource management.

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