Use of Matauranga (Maori Traditional Knowledge) and Science to Guide a Seabird Harvest : Getting the Best of Both Worlds?

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Use of Mātauranga (Māori Traditional Knowledge) and Science to Guide a Seabird Harvest: Getting the Best of Both Worlds?

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1. INTRODUCTION

Internationally there is growing acknowledgement of the importance of Traditional Environmental Knowledge[1] (TEK) in wildlife management, paralleled by an increased recognition of indigenous peoples rights to self-governance of environmental management [POSEY 1996; BORRINI-FEYERABEND 1996; TAIEPA et al. 1997; MOLLER et al. 2000; BERKES et al. 2000]. TEK is considered to confer numerous benefits to local communities wishing to participate in resource management. These range from detailed scientific to broad socio-political [HUNTINGTON et al.

2002] benefits. However as Huntington et al. [2002] point out, such benefits are often claimed only by scientists and managers rather than by all stakeholders. Coupled with this concern are a number of associated issues relating to the practicalities of combining TEK and science for environmental management benefits, the utility of TEK in assisting scientific approaches and the areas of convergence and divergence between the two knowledge systems [HUNTINGTON et al. 2002].

Co-management is one approach that shows great potential in terms of benefiting the environment and all stakeholders involved, including scientists, managers and local communities. Co-management, also known as 'collaborative' or 'co-operative management', is often defined as some form of power sharing between different organisational levels, from government to community [BORRINI-FEYERABEND 1996]. It embodies subsidiarity, or 'bottom-up' management by local communities.

In New Zealand the exact role of Māori (New Zealand's indigenous people) in wildlife and resource management often remains unclear and undeveloped, despite the fact that most major acts of parliament give reference to the Treaty of Waitangi [TAIEPA et al. 1997; MOLLER et al. 2000]. The Treaty is a legally binding agreement made between the British Crown and Māori chiefs in 1840. It granted governance to the British colonists and a right to settle, but importantly guaranteed the right of Māori to "full exclusive and undisturbed possession of their lands, estates, forests and fisheries". The Treaty effectively guaranteed Māori *rangitiratanga* (Māori authority and governance) over their land and resources. This power sharing is demonstrated by New Zealand's Conservation Act (1987), which must "give effect to the principles of the Treaty of Waitangi". This still leaves considerable room for interpretation, and the level of involvement by Māori in the management of the conservation estate remains debatable. Few examples of true power-sharing or Māori controlled management of environmental resources exist.

As part of the wider conflict over the role of Māori in managing the conservation estate, there has been debate over the relative merits of *Mātauranga*[2] *Māori o te taiao* (Māori Traditional Ecological Knowledge) and science for conservation and resource management purposes or *Kaitiakitanga*[3] [MOLLER 1996; TAIEPA et al. 1997]. In theory, co-management has the potential to provide benefits for both Māori communities and conservation goals, but in practice there are few detailed reports of case studies to evaluate their success in delivering this promise [FISHER 1995; TAIEPA et al. 1997; MOLLER et al. 2000].

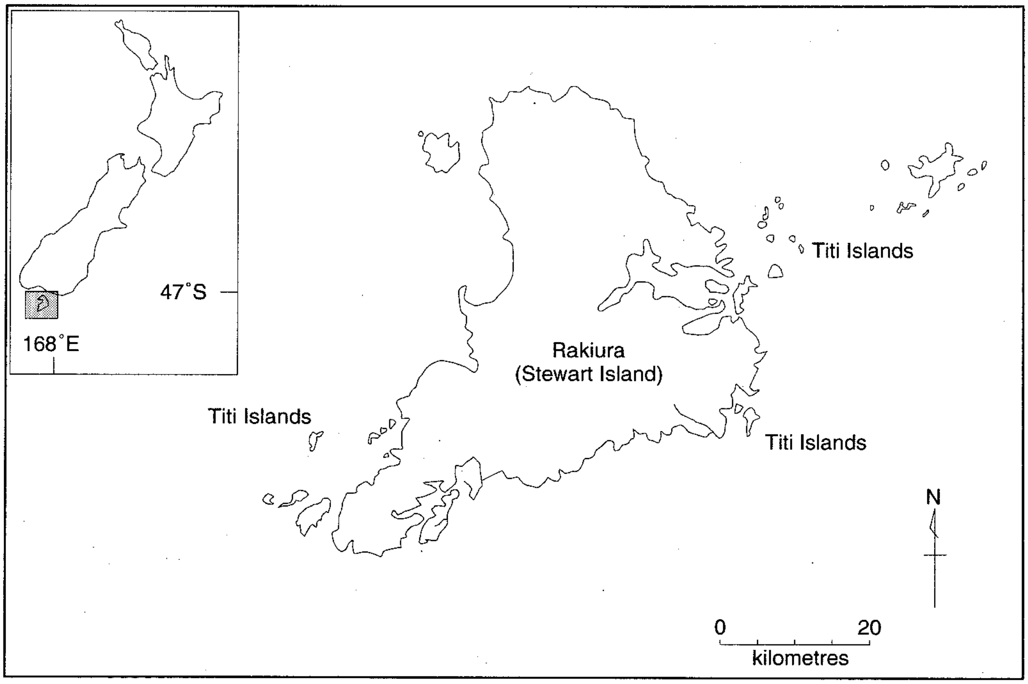
This paper highlights lessons learnt through a university research team's involvement with a Māori community in a co-managed research project to guide a customary harvest of a seabird. It should be emphasised that these lessons are being illustrated from a researcher's perspective; nevertheless, they may be of relevance to other collaborative efforts between scientists, local communities and Māori, and similar collaborations with indigenous peoples' communities worldwide. Our case study identifies the comparative strengths and weakness of science and TEK working together in a research project, highlighting the possible causes of convergence and divergence between the two approaches. It also considers the implications of these findings for optimising management outcomes for the community involved and highlights lessons for effective co-management in general.

2. THE Tītī HARVEST

The centuries-old harvest of *tītī*[4] by Rakiura Māori (New Zealand's southernmost Māori) represents one of the few large-scale customary harvests that are currently practiced in New Zealand. The harvesting of *tītī* (often referred to as 'Muttonbirding' or 'birding') is permitted on 36 Tītī Islands around Rakiura (Stewart Island) between March and May each year (Map 1). The harvest is exclusive to Rakiura Māori and their families and is of great social and economic importance to the community [WILSON 1979]. Only the chicks are harvested on family (*whānau*) birding areas (*manu*), to which both the birders and the breeding adult *tītī* return annually.

2.1. The History of the Tītī Harvest and Its Management

Written histories record a number of changes in the management of the Tītī Islands after the settlement of New Zealand by Europeans in the 19th century [KITSON and MOLLER n.d.]. For most of the last century the Commissioner of the Crown Lands ultimately controlled the islands, but even this legal regulation was instigated at the request of the birders and framed in a way that reflected traditional lore. In recent decades, through a series of law changes and devolution of power, this control was returned to Rakiura Māori as part of a Treaty of Waitangi settlement as redress for broken Treaty promises. This return was conditional upon a number



Map 1 Map of Rakiura and surrounding Tītī Islands.

of provisos, including that the *tītī* breeding islands be managed in a similar way to a nature reserve [MOLLER et al. 2000].

The process by which the Crown Tītī Islands were returned to Rakiura Māori involved a series of public hearings, allowing individuals and organisations to make submissions on the proposed return. At the time, a more general debate on customary use of indigenous wildlife revealed deep divisions in Māori and non-Māori environmental philosophy and management approaches [reviewed by MOLLER 1996; NZCA 1997]. Numerous assertions were made regarding the ability of Māori to effectively manage customary use of resources, including the *tītī* harvest. It was claimed that Māori would not be able to manage harvests in a sustainable manner because:

- *Mātauranga Māori* had been lost, or never even existed;
- new threats such as introduced predators exist today which Mātauranga Māori can not cope with;
- new technologies that facilitate harvests, such as electrical generators, motorised plucking machines and helicopters, would make the current harvest unsustainable;
- Māori society has lost the ability to control and manage its own people and resources;
- population pressure is too great: too many people could now claim the right to harvest and would overpressure the resource, especially since the loss of traditional social controls has weakened management; and
- science is superior to traditional knowledge as a guide for sustainable management.

Perceived lack of utility of *Mātauranga Māori* and scepticism that Māori can safely manage New Zealand's natural resources is widespread in New Zealand, despite the fact that in many areas the management of New Zealand's conservation estate, using ecological science for guidance, is failing [CRAIG et al. 1999]. Potentially, there could be great benefits from incorporating *mātauranga* and *kaitiakitanga* approaches into both management and research [TAIEPA et al. 1997; MOLLER et al. 2000]. This debate is further compounded by confusion between genuine management capacity concerns and more basic philosophical objections to the harvesting of native species and over who has power to manage customary harvests [MOLLER 1996; NZCA 1997; MOLLER et al. 2000; MOLLER 2001a].

3. THE *Kia Mau Te Tītī Mo Ake Tōnu Atu* RESEARCH PARTNERSHIP

The *Kia Mau Te Tītī Mo Ake Tōnu Atu* ('Keep the *Tītī* forever') Research Project was formed between the Rakiura Māori birding community and the Department of Zoology at the University of Otago in 1994. This co-managed research project is directed by the Rakiura Māori community and managed by the university research team. At the onset of the project a number of scientific and social objectives were identified at several *hui* (meetings) between the birding community and the research team. These included the following scientific objectives:

- measuring the current harvest levels of *tītī* by Rakiura Māori and estimating the maximum sustainable yield;

- determining what sets the limits of past and present harvests;
- investigating the impacts of climate change, fisheries bycatch, introduced predators and pollution on the population; and
- comparing science and TEK to help determine the best method of managing *tītī* harvests.

The last scientific objective reflects a desire from both partners to identify the most appropriate techniques to allow the community to guide the harvest.

The social objectives included:

- science was to support Rakiura Māori management of the *tītī*;
- Rakiura Māori were to make all public statements on information generated by the project;
- Rakiura Māori would direct the research programme; and
- the science team would endeavour to train Rakiura Māori in scientific methods and techniques so that the community could continue with scientific research beyond the duration of the project if it so wished.

These social objectives represented new ground, both in terms of the manner in which a research project was run by the university and the actual partnership itself. In recognition of this fact, and in an attempt to maximise results and minimise disputes, a 'Cultural Safety Contract' was drawn up between the research team and the community. The purpose of this document was to build and maintain trust and respect between the two parties (which had no past history of working together) and to guide the research team on important issues regarding the way the two groups interact and manage conflict.

As part of this contract, both partners committed to work together for 10 years[5)], the minimum time required for first predictions of sustainability based on ecological monitoring and modelling of the population. It was also agreed that all of the science would be jointly owned by both parties, while any TEK collected would be owned by Rakiura Māori. Although Rakiura Māori would handle all publicity relating to the project in the media, the research team was free to publish the scientific findings, no matter what the research predicted about sustainability of current harvesting. This was an important clause to ensure that the scientific integrity of the research team was maintained. In addition, a process was set up whereby all science reporting (including this manuscript) are reviewed by the birders via the Rakiura Tītī Islands Administering Body. This review process, whilst adding another layer of administration to the project, allowed the community to comment on any science findings prior to publication and to provide a traditional knowledge peer review of the scientific interpretations. Provision was also made in the contract for the settlement of any disputes arising over the interpretation of scientific results, although this process has not yet been required. The *tītī* harvesters also have the right to seek a second opinion from another team of scientists if they doubt the university's eventual predictions about sustainability. The research team is also required to make annotated raw data available for any such second opinion.

Another undertaking as part of the cultural safety contract was to try to involve Rakiura

Māori as much as possible in the research and scientific aspects of the project and to build their own science capacity. More details of the project design can be found at the project's website: http://www.otago.ac.nz/titi/default.html or in Moller et al. [1999].

4. SCIENCE AND TRADITIONAL ECOLOGICAL KNOWLEDGE

From the onset, the project was designed to identify the most appropriate components of science and TEK that would most benefit the renewable resource management of the Tītī Islands. Sources of TEK included informal discussions with individual birders as well as a series of oral histories and interviews with *kaumātua* (respected Māori elders). On the basis of this information, scientific hypotheses relating to ecological factors were generated. Conversely, ecological predictions could be compared, contrasted and challenged by the TEK of Rakiura Māori. This reciprocal peer review was considered "the best way to keep the *tītī* for the birders' *mokopuna* (grandchildren)". This was not an attempt to blend science and TEK into one, but rather a commitment to work both in parallel. That is, both partners recognised that while science and TEK may have relative strengths and weaknesses, there may be mutual benefits from working together.

The Tītī Research Project has now been in operation for nine out of an initially planned ten-year period. It is still too early to be able to provide reliable harvest management options, as the synthesis and recommendation stages are not complete. Nevertheless, the research team has been remarkably productive, both in terms of conventional scientific outputs and reporting directed towards the birding community. Community directed outputs, such as a biannual newsletter (the *Tītī Times*[6]) and scientific meetings have been critical components of the project's success so far. Some of the lessons learnt from this novel collaboration are discussed below.

4.1. TEK Helps Understanding Ecological Pattern

It has become apparent that the birders' TEK does not just relate to harvest optimisation, but can also be useful for understanding pattern in the ecological system. For example, birders noticed a changing relationship between chick weight and abundance, and interpreted this as a sign of an external perturbation to the system. In the past, 'good years' (when chicks were abundant) were also years when chicks were typically fatter, but recently there have been seasons when fat chicks were rare [Lyver 2002a]. This observation was one of the primary catalysts for the instigation of the *tītī* research project and highlights the utility of the birders' TEK for monitoring patterns [Moller et al. in subm.]. Scientific research is now investigating a major decline in *tītī* over the last few decades [Lyver and Moller 1999; Lyver et al. 1999; Scofield and Cheistie 2002]. The cause of this decline is presently unknown, although climate change leading to deceased productivity and/or decreased adult survival are likely.

4.2. TEK Helps Formulate More Powerful Scientific Hypotheses and Prioritisation of Research

By interviewing active birders and listening to *kaumātua*, the team was able to quickly focus its research effort, especially by defining its research emphasis and developing hypotheses that otherwise may have been overlooked or taken longer to formulate. For example, information from oral histories and discussions with *kaumātua* indicated that birders target bigger chicks in the harvest. This hypothesis was tested by comparing the weight, size and stage of development of *tītī* harvested by the birders to that of all available chicks [HUNTER et al. 2000a]. Survival from fledgling to breeding age is positively correlated with chick fledgling weight [SAGAR and HORNING 1997], so the birders' selection of bigger chicks potentially greatly affects harvest impact predictions. Omission of this information from the demographic harvest model would likely result in the harvest impacts being underestimated if overall harvest pressure is high.

Another example of hypothesis generation through TEK is demonstrated by the birders' consistent claim that breeding density is higher closer to the edges of islands and that fledgling *tītī* emerge from their burrows earlier on the west coast of an island than on the east. These hypotheses were tested by monitoring breeding burrow density and emergence behaviour of fledgling *tītī* from both sides of an island. It was found that hole density dropped between 10–74% 100 m inland from coast and that emergence was almost seven days earlier on the west coast compared to the east [CHARLETON 2002]. These findings have important implications for the research project in several ways. Spatial, temporal or environmental variables that help explain variation in *tītī* density or breeding success can now be incorporated into future analyses and sampling to help minimise residual variability and maximise inference of harvest effects. For example, one way that the ecological research is checking for harvest impacts is to compare breeding burrow density on harvested and unharvested islands. Sampling design and measuring of distance to island edge will now be included to allow more powerful tests of altered *tītī* abundance in harvested and unharvested areas, and a more accurate estimate of mean change in bird density in birded and unbirded breeding colonies will be possible. The size of any such difference in bird density will allow an important external validity check of demographic model predictions. Most unharvested islands are small, so the information on spatial variation also helps factor out the potential edge effects that could confound comparisons (smaller unharvested islands will have comparatively more 'edge' than larger harvested islands). Similarly, the information on earlier emergence of chicks on western sides of islands stresses the need to account for a shift in timing of harvest rate pulses when testing hypotheses about changing abundance (as indicated by catch per unit effort).

There are several other important research findings that benefited from TEK offered by the community. For example, researchers working alone would have taken considerably longer to develop appropriate sampling regimes, if they would have formulated them at all.

4.3. Data from TEK: Sharpening Long-term Ecological Perspectives

Another direct benefit from working with the birding community has been the proffering of long runs of historical data from individual birder's diaries. In some cases the diaries contain detailed information about the birders activities from over 50 years of birding—a long, diachronic data set. They often include details of weather, harvest tallies and harvest effort as well as changes to the local environment and notes of unusual events such as large storms. Purists may not define these data as TEK because traditional Māori histories are more usually recorded orally; however they constitute valuable TEK in the broader sense and indicate some form of synergy between *mātauranga* Māori and more conventional data recording. TEK helped guide the birders on what to record in these diaries. For example, their knowledge of moon, rain, and subtle wind strength direction effects on chick emergence behaviour led them to record the key variables needed to factor out short-term variation in catch rates from long term trends. One *kaumātua* said that he started recording the data because he mistrusted his memory, and also because he wanted to check whether the *mātauranga* taught to him by his grandparents would turn out to be right [pers. comm. to H. MOLLER, 2003].

4.4. Analysis of TEK Data Using Science: Sharpening TEK Perspectives and Strengthening Partnership

Although several birders have recorded diaries, none that we know had formally analysed them. We found birders to be intensely interested in scientific analyses of trends. Many hours of interaction between the researcher and the birders, often when pouring over graphs of 20–50 year trends, has strengthened trust and mutual respect between customary users and scientists. Ongoing trend analysis of these diaries is also proving to be of great value for improved ecological understanding. In many cases statistical analyses of birders data agree with the overall trends detected by the scientific monitoring of bird abundance, and with the birders own perspectives of what has been happening. This offers a mechanism whereby individual birders and their families can learn about the tools science has to offer and in some cases reveal or quantify trends or changes on their *manu* that they were unaware of. For example, statistical analysis of fluctuations in the birders' harvest rate in relation to the 'Southern Oscillation Index' (a barometric air pressure index of El Ninõ / La Ninã weather fluctuation) revealed a surprising pattern: harvest rate declined just before an El Ninõ weather pattern set in [LYVER and MOLLER 1999; LYVER et al. 1999]. It is not surprising that TEK failed to detect such a lagged correlation with a remote climate variable, which is measured in the central Pacific by climatologists communicating to a totally different community. But a scientific partnership with the birders quickly revealed a promising lead requiring further investigation: that *tītī* declines are being driven by climate change. This potential new explanation would not have been identified by TEK or scientists working in isolation.

Another example of the potential benefits of TEK and science working together is the use of harvest rate as a tool to monitor population trends [KITSON 2002; MOLLER et al. in subm.]. We have placed a lot of research emphasis on investigating the birders own monitoring methods. This approach shows great potential despite a number of issues that must be overcome, such as the non-linearity of the relationship between harvest rate and chick density [KITSON 2002]. One advantage of this approach is that it avoids the need to use time consuming, costly and technical scientific monitoring tools, while another is it has the benefit of directly involving the birders in the monitoring. More fundamentally, it provides a bridge between science and TEK, a focus for both knowledge holders to peer review each others' interpretations.

4.5. TEK and Science Findings Do Not Always Agree on Pattern

In some cases hypotheses generated from TEK have not been corroborated by scientific investigation—even for simple observations of pattern. For example TEK from some birders indicated that the chicks from the west coasts of islands are bigger than those on the east coast, but this claim was not supported by research [CHARLETON 2002]. Such a divergence could be due to problems with either the science or the TEK methods. The science team may have failed to observe such an effect due to poor experimental design or limited time and resources. Equally, as most birders only have detailed TEK specific to one location, they may be less informed on larger scale spatial issues. It should also be noted that not all birders interviewed thought the west versus east size effect occurred. Science often emphasises spatial replication whereas knowledge of long-term local resource users working in a restricted area may be based on very strong temporal replication. However, wildlife science also often fails to achieve adequate replication [TILLMAN 1989] and some experiments are especially weak because they are not carried out over a sufficient length of time to obtain reliable inferences [MOLLER and RAFFAELLI 1996; RAFFAELLI and MOLLER 2000].

4.5.1. Do We Need Better Filters for TEK and Science?

The above example also highlights the need to filter good TEK and science from bad. Our investigation of east versus west chick size differences was only conducted in a single year, so we have very weak evidence that such a pattern does not generally occur. Limited spatial and temporal variation severely reduces the power of most scientific investigations published today, especially when the science has been directed at a long-lived, large and widely ranging species of interest to communities or wildlife managers [RAFFAELLI and MOLLER 2000]. Romesburg [1981] feared that scientific wildlife management may collapse under the weight of 'unreliable knowledge' generated from folklore and reinforced by repetition and authority rather than evidence. Romesberg's concerns about wildlife science partly stemmed from his belief that scientists broke a series of international rules that are universally agreed upon. These help to filter out 'good science' from 'bad science' and enable results to be repeated and corroborated.

It may be that TEK has a similar set of rules by which it can be filtered, scrutinised and improved. If such rules exist, the dilemma is that they are rarely declared or made explicit. A general consensus may exist within each local community about reliable and unreliable TEK, but no newcomer or outsider to that community can consult a prescription for how that filtering happens or whether it even exists. Presumably young customary users are taught how to evaluate TEK at the same time as they learn specifics about hunted species, habitats and change, but this has not been investigated.

Our best approach was to request information from *kaumātua* within the *tītī* harvest community relating to how the customary users filter their own community's knowledge. For example, when we discussed the purported difference between the size of chicks on the east and west coasts with *kaumātua*, it was made apparent that this is not a universal observation and was highly questionable in many cases. This sparked animated discussion between researchers and the TEK holders about how to filter good TEK from bad. The birders used four indicators of whether they considered a TEK construct valid. All concerned the identity of the person transmitting the construct:

1) who taught you—the best source of information was elders from within your own family;
2) your level of experience—someone with more birding experience was considered a more reliable source of information than an external source;

3) how current your knowledge is—birders who had been birding recently were considered to have more relevant and reliable information; and
4) how trustworthy you were considered in other aspects of your life—the status and respect you had developed from within the community.

These forms of 'external checks' are analogous to those that are applied by science to check the 'authority' of a scientist. But science also attempts to step beyond authority as the only signal of reliability. In fact the authority of the messenger is considered to be a secondary indicator of reliability and new discoveries or paradigms are more likely to come from non-authorities [CHALMERS 1976].

It is hard to tell if the above rules are sufficient for assessing TEK, party because the judgements are subjective, and also because these 'external checks' may be of limited use if conditions change e.g. if an external process such as climate change affects the system. Another risk from this approach is the potential creation of a 'weak link in the chain'. If an individual gains authority but passes on poor information based on an atypical observation or interpretation, she or he may leave a legacy of misinformation that remains for generations to come. The idea is less likely to be challenged and corrected if the only criterion used to evaluate its reliability is the authority of the messenger. Weeding out unreliable TEK must also happen, but an explicit methodology for this process has not yet been developed.

4.6. The Importance of Learning Why Pattern Occurs

Our team's experience of working with the Rakiura Māori community is that while the science and TEK often find agreement in pattern, there may be less agreement on why these patterns occur. Science researchers and birders agree more about what is happening than why it is happening. Some parts of science are merely descriptive, especially at the beginning of an investigation, so descriptive science and TEK are likely to agree more often on what does or does not happen. However, the scientific investigation of mechanism may often lead to disagreement between TEK holders and scientists.

While TEK has been shown in some cases to rival or even exceed that of western scientific counterparts in describing pattern [GUNN et al. 1988; DEURDEN and KUHN 1998], there are few examples of TEK providing insights into ecological processes [LYVER 2002a], information that is typically considered a necessity for science-based wildlife management. Focus on what happens rather than testing why or how it happens may lead to weaker predictions of ecological processes. We tentatively conclude that good science has stronger potential and capacity to identify mechanism and processes leading to pattern than can TEK. If we understand mechanism and process, we still may be able to predict change from a new external perturbation such as climate change. When there is a systematic departure operating at a spatial and temporal scale beyond "the memory of the TEK system", an understanding of what used to happen will not help predict what will happen next. Debate and/or frustration within the community may emerge. Key TEK holders may lose some of their 'authority' if their knowledge no longer seems to apply. This frustration is already being exhibited by the birding community; e.g., elders no longer knowing what is happening (*Tītī Times* Issue 13) and similar examples can be found from other communities worldwide, such as Inuit communities [THORPE et al. 2002; JOLLY and KRUPNIK 2002].

There are several international examples where the patterns recognised by TEK are explained by metaphysical or profoundly religious means [BERKES 1999]. These are more extreme examples of the way scientific and TEK interpretations of mechanism will diverge. In the *tītī* example, the disagreement on mechanism has concerned perfectly plausible competing hypotheses based on biophysical and ecological processes.

The putative relative strength of the scientific approach to reveal the underlying mechanism causing ecological pattern could ultimately result in disagreement between the researchers and the community engaged in co-management. Conflict has been minimised by considerable effort from both the science team and the community to understand each other's methods and approaches. The community has gained a better understanding of the process by which science works along with its limitations. The science team has learnt a lot about the undoubted accuracy and subtlety of TEK.

4.6.1. Unequal Focus on Events and Different Measures

TEK may focus on what people see as important rather than obtaining a systematic coverage of what could be causing ecological pattern. This could result in problems of bias due to emotional subjectivity. For example, it has been noticed that extreme bad events appear to be recalled and discussed more than extreme good events, and individual oral histories appear to be punctuated by extremes more than trends in norms. The *tītī* harvesters repeatedly mention distressing breeding failures in 1961, 1993 and 2002, although extremely good years, such as 1973 and 1998, are not mentioned to the same extent. The importance of extreme events on wildlife populations and their human impact has been highlighted elsewhere [BERKES 2002]. However it is the trend in norms that is most likely to affect long-term sustainability of the *tītī* harvesting. Extreme events such as chick failure may influence population trajectories, but systematic changes to more crucial population parameters such as adult survival [HAMILTON and MOLLER 1995; HUNTER et al. 2000b] are likely to be more important.

4.6.2. TEK May Lack Independent Observations

Harvesting behaviour probably feeds back on natural patterns. For example, removing chicks from breeding burrows may influence the behaviour of the breeding adults in that area, potentially affecting the breeding success of these adults. If the two processes are in some form of feedback loop, then changes to the harvest methods or rates will affect the bird's ecology, making it very difficult to disentangle the two processes and understand them fully. TEK observations may be biased or lack external checks, such as the non-treatment (control) comparisons and random sampling approaches that can give science its power of inference. TEK will be nurtured and retained mainly about areas where harvesting occurs, so an external yardstick to evaluate harvest impacts is impossible. This is another example of the way TEK has merit for describing what is happening but seems to lack the equivalent tools used in science for investigating beyond the descriptive stage, to look at mechanisms and processes.

4.7. Science Can Focus on Places or Times of Seasonal Cycles Not Covered by TEK

Restriction of TEK observations only to places and times of harvest may limit investigation of the system at crucial times or places. This restriction is most obvious in our study in the need to research the flight path and factors influencing survival of the adult *tītī* during their winter migration to the North Pacific. *Tītī* are a trans-equatorial, migratory species that spend more than half of the year away from New Zealand waters. The birders' TEK focused primarily on the harvest period in the breeding colonies and was therefore unable to provide much information that could help this investigation. By contrast, this sort of investigation is where science, with its international collaborative approach, can excel. Indeed, a survey of attitudes of the *tītī* harvesters towards science showed their intense interest in this more expanded spatial horizon [MOLLER and RUSSELL 2003]. Even the minority of birders who doubted the value of science, or saw it as threatening their *mātauranga*, urged that science be directed to factors influencing *tītī* when away from the breeding islands.

Application of science beyond harvest areas is an obvious and important complementarity that strengthens research partnerships. Our team is now building collaborative projects with international teams to study *tītī* movement and survival in the non-breeding season. Science will not always be easily extended to fill such gaps not covered by TEK. For some issues, TEK and *kaitiakitanga* have prevented the application of science at certain places and times. An example of this sort of limitation is the science team's restricted access to the Tītī Islands. The birders themselves are only allowed on the islands for approximately 11 weeks (from late chick provisioning until the end of fledgling). The islands are uninhabited by humans for the rest of the year. This access is restricted by law, but is also strongly reinforced by the lore and TEK. Whilst this protection ethic undoubtedly minimises the disturbance to the breeding adults and *manu* itself, which is typically fragile and susceptible to collapse, it also limits some of the avenues of research that the researchers wish to explore. Cultural prohibition to be on the islands during the egg and early chick phases has severely affected the information that could be recorded about the ecology of the *tītī*, which in turn has implications for the ability of the research to be able to provide the best possible estimates of population trends and harvest impacts.

Another example where TEK prohibited full application of science related to the researchers ability to accurately monitor the occupancy and breeding success within colonies. A 'burrowscope' (video camera mounted on the end of a tube inserted down burrows) is used to monitor breeding success. To 'calibrate' the burrowscope (measure the number of eggs or chicks missed or double counted), it was necessary to excavate a small number of burrows. Unfortunately, this disturbance would disrupt adults and, in some cases, kill chicks or eggs. This scientific need contradicted markedly with the strong *kaitiakitanga* that has taught birders to protect the ground and not to disturb the adults in any way [KITSON 2003].

Both of the above examples were solved by compromises. Out-of-season island access was granted on a number of non-harvested islands where monitoring sites could be established, even though access to traditional birding grounds was prohibited. The burrowscope was calibrated by letting the research team use building sites (ground that was to be disturbed anyway), small plots on non-harvested islands, and several small plots on *manu* where exploratory holes could substitute for complete excavation. These inspection holes were refilled using a traditional method for repairing collapsed burrows on the *manu*.

These two examples highlight an important lesson for scientists wanting to work across cultural boundaries—cross-cultural understanding and acceptance relates to how you do things, not just what you want to study. This is not surprising, because different cultures have different ethical constructs about appropriate and inappropriate research methodologies that scientists must adhere to if they are to have society's support.

4.8 Co-management of Research Does Not Come without Costs

One of the drawbacks of the collaborative approach is the extra cost both in terms of time and money to the research team and the community. The added administration and paperwork needed to ensure proper lines of communication place a considerable burden upon the researchers and the community, demanding many hours of extra work [MOLLER 2001b]. The added cost to the research team is counter-balanced in practical terms, to some extent, by support for the research from within the community e.g. sharing travel costs and accommodation.

Our experience is that researchers who engage in bottom-up community consensus approaches to research direction are subject to many personal and potentially emotionally difficult pressures. For example, it is hard for some individuals to cope with strident opposition from a minority of the community who disagree with the research taking place at all. Having around 500 lay people as the *tītī* team research directors can be disheartening when some of the opposition to the research is based on misunderstanding of what research is being conducted and why [MOLLER and RUSSELL 2003]. It is difficult to plan research when community decision-making can be slow and the outcomes unpredictable. Serving a community's needs and having the relevance of one's science underscored every step of the way is uplifting and adds motivation [MOLLER 2001b], but retaining personal confidence and energy for research in the face of the above difficulties can be dispiriting for researchers.

5. WHERE TO FROM HERE?

These lessons and observations have been gleaned from nine years of co-managed research. The *Kia Mau Te Tītī Mo Ake Tōnu Atu* Research Project is intended to continue for a further five years. In terms of working together, the most immediate imperative is to continue to transmit the research findings to the entire community as clearly as possible. This flow of information must be reciprocated for both partners to critically evaluate each other's findings. Continued production of the *Tītī Times* newsletter, as well as more meetings between the research team, the community, and individual birders to discuss the research findings and implications will be required. However we have recently recognised the need to have longer private consultations with each family in their own homes to discuss the details of the research. In the remaining years of the project it is also planned to build science capacity within the community to enable any potential future monitoring and harvest management objectives to be met by the community without the aid of university academics.

The Rakiura Māori environmental guardians alone must decide whether or not to act upon the research information provided. However, this decision-making process may ultimately be moderated by external social pressures. For example, there has been much debate on whether or not TEK can be relied upon to manage the customary use of natural resources in New Zealand [DICKISON 1994; MOLLER 1996; NZCA 1997; MOLLER 2001a]. Wider New Zealand society currently places more trust in science than TEK for resource management. This sentiment was echoed by some of the research directors, who consider that having the university team do the science adds a sense of objectivity and reliability to the findings that would have not have been possible had Rakiura Māori themselves done this research [LYVER 2002b; LYVER n.d.]. Therefore a co-managed approach is a promising compromise. It may help to quash external criticism and scepticism of resource management by Māori, yet ensure that the customary users themselves retain control of the management and research interpretations and evaluate predictions using their own TEK.

6. CONCLUSION: CO-MANAGED COALITIONS OF SCIENCE AND TEK GIVE THE BEST OF BEST OF BOTH WORLDS

One key lesson that is emerging from this collaborative approach is the importance of how results are obtained, and not just what is achieved. Comparing and contrasting science and TEK in the *Kia Mau Te Tītī Mo Ake Tōnu Atu* Research Project has been a highly beneficial and informative process, a point acknowledged by both the research team and the birding community [DAVIS 2001]. In addition to providing a wealth of information about the *tītī*, it has highlighted the relative merits and weaknesses of each knowledge system for managing the harvest of *tītī*. The research has shown that while both approaches clearly are valuable on their own, by working together they have augmented the research in ways that may not have even been considered otherwise. By grounding the research within the community it has also been possible to seek detailed feedback and advice from the resource stakeholders. Importantly, it has also been possible for the research team to demonstrate and show the birding community the merits of a scientific approach.

To properly use TEK, research must be grounded within the community. This brings increased delays and uncertainty, diverts time and energy from doing just the science itself, and forces new, less efficient ways of conducting science. Nevertheless, the real benefits of these strong co-management processes are high and well worth the costs [MOLLER 2001b]. Co-management becomes the link for accessing TEK that is embedded within the community and culture.

Our experience is clear: co-management is needed for science and TEK to work well together. Co-management may enable TEK to continue to grow and adapt to new ecological challenges, as it is hard to see how TEK could survive under a 'top-down' management system guided by science alone. Adaptation to ecological change by capturing the best of science and TEK is likely to be an important component of ecological and social resilience [BERKES et al. 2002; KITSON and MOLLER n.d.]. Any attempt to manage or research a resource without involving the user community must miss out on a significant contribution of knowledge and opportunity for collaboration for increased sustainability of that resource.

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NOTES

1) The authors acknowledge the debate over the definition of such a value-laden term as 'Traditional Environmental Knowledge' (also often known as 'Indigenous Knowledge' [IK] or 'Traditional Knowledge' [TK]) and have chosen to adopt the working definition of Berkes *et al.* [2000], defining TEK as " a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment.
2) *Mātauranga* can be defined as a mixture of spiritual and natural history observations gleaned over centuries of living and working in the environment [Roberts et al. 1995].
3) *Kaitiakitanga* is a form of Māori conservation management or guardianship of spiritual values and resources [Roberts et al. 1995].
4) *Tītī* (sooty shearwaters; *Puffinus griseus,* 'Muttonbirds') are medium-sized burrowing petrels that breed in Australasia and South America. In New Zealand their present distribution is predominantly restricted (due to introduced predators) to southern offshore islands, although a few 'remnant' colonies remain on the coastal mainland. *Tītī* are a trans-equatorial migratory seabird species that are very common throughout the Pacific. They are long-lived slow breeding apex marine predators and as such are vulnerable to harvest. *Tītī* have been described as 'Keystone' species in many island reserves throughout New Zealand.
5) The project was initially planned to run for ten years; however this has now been extended for a further four years both in recognition of the time and effort required to initiate and carry out research in a co-managed way and the time required to gain useful ecological information about a long-lived seabird species.
6) The *Tītī Times* is a biannual newsletter produced by the research team containing a mixture of science, TEK, history, culture, news, views and current affairs relating to the *tītī* harvest. This newsletter is currently sent out to over 600 Rakiura Māori (both active and non-active birders) and 500 agencies, managers, scientists and other stakeholders.

REFERENCES

Berkes, F.

1999 *Sacred Ecology: Traditional Ecological Knowledge and Resource Management.* Philadelphia: Taylor and Francis.

2002 Making Sense of Arctic Environmental Change. In: Jolly D. and I. Krupnik (eds.) *2002 The Earth is Faster Now: Indigenous Observations of Arctic Environmental Change,* pp. 335–349. Fairbanks, Alaska: Arctic Research Consortium of the United States.

BERKES, F., J. COLDING and C. FOLKE
2000 Rediscovery of Traditional Ecological Knowledge as Adaptive Management. *Ecological Applications* 10(5): 1251–1262.
2002 *Navigating Social-Ecological Systems: Building Resilience for Complexity and Change.* Cambridge, United Kingdom: Cambridge University Press.
BORRINI-FEYERABEND, G.
1996 Collaborative Management of Protected Areas: Tailoring the Approach to the Context. Gland, Switzerland: International Union for the Conservation of Nature and Natural Resources.
CHALMERS A. F.
1976 *What is This Thing Called Science? An Assessment of the Nature and Status of Science and Its Methods.* St Lucia, Queensland: Cambridge University of Queensland Press.
CHARLETON, K. J.
2002 *Variation in Sooty Shearwater Burrow Entrance Density, Burrow Use and Chick Emergence: Science and Traditional Environmental Knowledge Approaches.* Dunedin, New Zealand: M. Sc. Zoology Department, University of Otago,
CRAIG, J., S. ANDERSON, M. CLOUT, B. CREESE, N. MITCHELL, J. OGDEN, M. ROBERTS, and G. USSHER.
2000 Conservation Issues in New Zealand. *Annual Review of Ecology & Systematics* 31: 61–78.
DAVIS, J.
2001 Te Kaha Te Hikoi O Te Tangata. In M.Howard and H. Moller (eds.) *He Minenga Whakatü Hua o Te Ao 'Sustaining the Fruits of the Land'.* Proceedings of a *Hui*, Murihiku Marae 25–27 August 2000. < http://www.otago.ac.nz/Zoology/hui/Main/default.htm>
DICKISON, M.
1994 "Can Traditional Maori Knowledge Be Considered Scientific?" *NZ Science Monthly* May 1994: 6–7.
DUERDEN, F. K. and R.G. KUHN
1998 Scale, Context and Application of Traditional Knowledge of the Canadian North. *Polar Record* 34(188): 31–38.
FISHER, R. J.
1995 Collaborative Management of Forests for Conservation and Development, Issues in Forest Conservation. Gland, Switzerland, International Union for the Conservation of Nature and Natural Resources.
GUNN, A., G. ARLOOKTOO and D. KAOMAYOK
1988 The Contribution of Ecological Knowledge of Inuit to Wildlife Management in the Northwest Territories. IUNC, Commission on Ecology and the Boreal Institute for Northern Studies. *Occasional Publication* 23: 22–30.
HAMILTON, S. and H. MOLLER.
1995 Can PVA Models Using Computer Packages Offer Useful Conservation Advice - Sooty Shearwaters Puffinus Griseus in New Zealand as a Case Study. *Biological Conservation* 73(2): 107–117.
HUNTER, C. M., H. MOLLER and J. KITSON
2000 Muttonbirder Selectivity of Sooty Shearwater (*titi*) Chicks Harvested in New Zealand. *New Zealand Journal of Zoology* 27(4): 395–414.
HUNTER, C. M., H. MOLLER and D. FLETCHER
2000 Parameter Uncertainty and Elasticity Analyses of a Population Model: Setting Research Priorities for Shearwaters. *Ecological Modelling* 134(2–3): 299–323.
HUNTINGTON, H. P., P. K. BROWN-SCHWALENBERG, K. J. FROST, M. E. FERNANDEZ-GIMENEZ, D. W. NORTON

and D. H. ROSENBERG
2002 Observations on the Workshop as a Means of Improving Communication between Holders of Traditional and Scientific Knowledge. *Environmental Management* 30: 778–792.

JOLLY, D., and I. KRUPNIK (eds.)
2002 The Earth is Faster Now: Indigenous Observations of Arctic Environmental Change. *Fairbanks, Alaska: Arctic Research Consortium of the United States.*

KITSON, J. C.
2002 What Limits the Number of Tītī (*Puffinus griseus*) Harvested by Rakiura Māori. *Human Ecology* 30(4): 503–521.
2003 *Looking after Your Ground: Sustainable Resource Management Practice by Rakiura Mäori Tītī Harvesters*. Ph.D. Dunedin, New Zealand: Zoology Department, University of Otago.

KITSON, J. C., and H. MOLLER
n.d. *Social Mechanisms for Sustainable Resource Management: Learning and Adaptation by Traditional Mäori Seabird Harvesters.* Manuscript.

LYVER, P. O'B.
2002a The Use of Traditional Environmental Knowledge by Rakiura Mäori to Guide Sooty Shearwater Harvests. *Wildlife Society Bulletin* 30: 29–40.
2002b Foundation for Research, Science and Technology Case Study Evaluation: the Kia Mau Te Tītī Mo Ake Tönu Atu Research Project. Unpublished Report to FRST.
n.d. *Power Devolution in New Zealand Environmental Management: A Review of Two Collaborative Partnerships.* Manuscript.

LYVER, P. O'B. and H. MOLLER
1999 Tītī Harvests by Rakiura Mäori: a Case Study of the Use of Mäori Traditional Environmental Knowledge for Sustainable Natural Resource Management. *Proceedings of Landcare Conference, Wellington 21–23 April, 1999.* Published on Landcare Research Web page: <http://www.landcare.cri.nz/conferences/manaakiwhenua/papers/index.shtml?lyver>

LYVER, P. O'B. H. MOLLER and C. THOMPSON
1999 Changes in Sooty Shearwater Puffinus Griseus Chick Production and Harvest Precede ENSO Events. *Marine Ecology Progress Series* 188: 237–248.

MOLLER, H.
1996 Customary Use of Indigenous Wildlife—Towards a Bicultural Approach to Conserving New Zealand's Biodiversity. In B. McFagen, and P. Simpson (comp.) *Biodiversity: Papers from a Seminar Series on Biodiversity*, Hosted by Science & Research Division, Dept. of Conservation, Wellington 14 June–26 July 1994.
2001a A Survey of Public Attitudes about Harvests of New Zealand Animals and Plants. In M. Howard and H. Moller (eds.) *He Minenga Whakatü Hua o Te Ao 'Sustaining the fruits of the land'.* Proceedings of a *Hui*, Murihiku Marae 25–27 August 2000. <http://www.otago.ac.nz/Zoology/hui>
2001b Co-management of a Bicultural Research Project: A Research Provider's Perspective. In M. Howard and H. Moller (eds.) *He Minenga Whakatü Hua o Te Ao 'Sustaining the fruits of the Land'.* Proceedings of a *hui*, Murihiku Marae 25–27 August 2000. <http://www.otago.ac.nz/Zoology/hui>

MOLLER, H., F. BERKES, P. O'B. LYVER and M. KISLALIOGLU
n.d. Combining Science and Traditional Ecological Knowledge: Monitoring Populations for Co-management. *Conservation Biology.* Manuscript.

MOLLER, H. J. de. CRUZ, D. FLETCHER, K. GARRETT, C. HUNTER, C. J. JONES, J. KITSON, P. LYVER, J.

NEWMAN, B. RUSSELL, P. SCOFIELD and D. SCOTT
1999 Kia Mau Te Tītī Mo Ake Tōnu Atu: Goals, Design and Methods. *University of Otago Wildlife Management Report* 117: 76 <http://www.otago.ac.nz/titi/default.html>

MOLLER, H., P. HORSLEY, P. O'B. LYVER, T. TAIEPA, J. DAVIS and M. BRAGG
2000 Co-management by Mäori and Päkehä for Improved Conservation in the 21st Century. In H. Perkins and Memon, A. (eds.) *Environmental Planning and Management in New Zealand,* pp. 56–167. Palmerston North: Dunmore Press.

MOLLER, H. and D. RAFFAELLI
1996 Predicting Risks from New Organisms: The Potential of Community Press Experiments. In D.J. Fletcher, L. Kavalieris and B.F.J. Manly (eds.) *Statistics in Ecology and Environmental Monitoring 2: Decision Making and Risk Assessment in Biology.* Otago Conference Series, pp. 131–156. Dunedin, New Zealand: University of Otago Press.

MOLLER, H. and B. RUSSELL
2003 Kaitiakitanga O Kā Tītī I. A Māori Community's View of a Science Project to Protect a Customary Wildlife Harvest. *University of Otago Wildlife Management Report* 2003: 801–802.

NEW ZEALAND CONSERVATION AUTHORITY
1997 *Maori Customary Use of Native Birds, Plants and Other Traditional Materials*—Interim Report and Discussion Paper. Wellington, New Zealand: New Zealand Conservation Authority.

POSEY, D. A.
1996 Traditional Resource Rights. *International Instruments for the Protection and Compensation for Indigenous Peoples and Local Communities.* Gland, Switzerland: IUCN.

RAFFAELLI, D. and H. MOLLER
2000 Manipulative Field Experiments in Animal Ecology: Do They Promise More Than They Can Deliver? *Advances in Ecological Research* 30: 300–338.

ROBERTS, M., W. NORMAN, N. MINHINNICK, D. WIHONGI and C. KIRKWOOD
1995 Kaitiakitanga: Mäori Perspectives on Conservation. *Pacific Conservation Biology* 2: 7–20.

ROMESBURG, H. C.
1981 Wildlife Science: Gaining Reliable Knowledge. *J. Wildl. Manage.* 45(2): 293–313.

SAGAR, P. and D. HORNING
1997 Mass-related Survival of Fledgling Sooty Shearwaters Puffinus griseus at The Snares, New Zealand. *Ibis* 140: 329–339.

SCOFIELD, P. and D. CHRISTIE
2002 Beach Patrol Records Indicate a Substantial Decline in Sooty Shearwater (*Puffinus Griseus*) Numbers. *Notornis* 49: 158–165.

TAIEPA, T., P. O'B. LYVER, P. HORSLEY, J. DAVIS, M. BRAGG and H. MOLLER
1997 Co-management of New Zealand's Conservation Estate by Mäori and Päkehä: a Review. *Environmental Conservation* 24 (3): 236–250.

THORPE, N., S. EYEGETOK, N. HAKONGAK, and KITIKMEOT ELDERS
2002 Nowadays It Is Not the Same. Inuit Qaujimajatuqangit, Climate and Caribou in the KitiKmeot Region of Nunavut, Canada. In D. Jolly and I. Krupnik (eds.) *2002 The Earth is Faster Now: Indigenous Observations of Arctic Environmental Change.* Fairbanks, Alaska: Arctic Research Consortium of the United States.

TILLMAN, D.
1989 Ecological Experimentation: Strengths, and Conceptual Problems. In G.E. Likens (ed.) *Long-term Studies in Ecology.* New York: Approaches and Alternatives, Springer.

VEIT, R. R., J. A. MCGOWAN, D. G. AINLEY, T. R. WAHLS and P. PYLE
1997 Apex Marine Predator Declines Ninety Percent in Association with Changing Oceanic Climate. *Global Change Biology* 3: 23–28.

WILSON, E.
1979 Tītī Heritage. *The Story of the Muttonbird Islands.* Invercargill: Craig Printing Co Ltd.