Species and Cultural Conservation in New Zealand: Maori Traditional Ecological Knowledge of Tuatara

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Abstract: *Traditional ecological knowledge can be highly informative and integrated with complementary scientific knowledge to improve species management. This is especially true for abundant species with which indigenous peoples have frequent interactions (e.g., through harvest), but has been studied less frequently in isolated or declining species. We examined Maori traditional ecological knowledge of tuatara (*Sphenodon *spp., reptiles that resemble lizards but are the last living representatives of the order Sphenodontia) through semidirected interviews of elders of Te Atiawa, Ngati Koata, and Ngati Wai Iwi (similar to tribes), the guardians of several islands currently inhabited by tuatara. Maori are indigenous to New Zealand, having settled 800 to 1000 years ago. Tuatara are endemic to New Zealand, have declined in numbers since human settlement, and are now restricted to 37 offshore islands. The detail and volume of tuatara traditional ecological knowledge were less than that recorded in studies of more abundant or accessible species. In addition, traditional knowledge of the cultural significance of tuatara was more common and detailed among the elders than traditional knowledge of tuatara biology or ecology. The traditional knowledge collected, however, provided the first evidence of seven former sites of tuatara occupation, suggested five additional sites tuatara may currently occupy, contained novel hypotheses for scientific testing, and described tuatara cultural roles that have not been reported previously. We conclude that, in at least some cases, traditional ecological knowledge may persist as species decline and may serve as a valuable source of ecological information for conservation.*

Keywords: indigenous knowledge, New Zealand, reptile conservation, *Sphenodon*, TEK

Conservación Cultural y de Especies en Nueva Zelanda: Conocimiento Ecológico Tradicional Maori de la Tuatara

Resumen: *El conocimiento ecológico tradicional puede ser muy informativo y puede ser integrado a conocimiento científico complementario para mejorar el manejo de especies. Esto es especialmente cierto para especies abundantes con las que los indígenas tienen interacciones frecuentes (e.g., por medio de la explotación), pero ha sido estudiado menos frecuentemente en especies aisladas o en declinación. Examinamos el conocimiento ecológico tradicional Maori sobre el tuatara (*Sphenodon *spp., reptiles que asemejan lagartijas pero que son los últimos representantes vivos del orden Sphenodontia) mediante entrevistas semidirigidas con ancianos de Te Atiawa, Ngati Koata, and Ngati Wai Iwi (similares a tribus), los guardianes de varias islas actualmente no habitadas por el tuatara. Los Maori son nativos de Nueva Zelanda que se establecieron hace 800-1000 años. El tuatara es endémico a Nueva Zelanda y ha declinado en número desde el establecimiento de humanos; actualmente está restringido a 37 islas. El detalle y volumen de conocimiento ecológico tradicional sobre tuatara fue menor al registrado en estudios de especies más abundantes o accesibles. Adicionalmente, el conocimiento tradicional de los ancianos sobre el significado cultural del tuatara fue más común y detallado*

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que el conocimiento tradicional de la biología o ecología del tuatara. Sin embargo, el conocimiento tradicional registrado proporcionó la primera evidencia de siete sitios previamente ocupados por tuatara, sugirió cinco sitios adicionales a los que ocupa actualmente el tuatara, contenía hipótesis novedosas y describía papeles culturales del tuatara que no habían sido reportados previamente. Concluimos que, en por lo menos algunos casos, el conocimiento ecológico tradicional puede persistir aun si las especies declinan y puede servir como una valiosa fuente de información ecológica para la conservación.

Palabras Clave: CET, conocimiento indígena, conservación de reptiles, Nueva Zelanda, *Sphenodon*

Introduction

Traditional ecological knowledge (TEK) is knowledge acquired through extensive and long-term observation of an area or species and passed down through generations (Huntington 2000). Although TEK is not restricted to indigenous individuals (Huntington 2000), indigenous TEK is often highly localized and collected over hundreds to thousands of years (Turner et al. 2000; Kimmerer 2002). A broad range of ecological and evolutionary concepts is found in TEK. For example, the O'odham and Comcáac peoples of Arizona (U.S.A.) and Sonora (Mexico) recognize predator and prey, ectoparasite and host, forager and forage, mimic and model, and dweller and dwelling ecological relationships (Nabhan 2000). Traditional ecological knowledge is not limited to those species that are actively harvested by or economically valuable to indigenous communities (Nabhan 2000; Kimmerer 2002).

Like scientific ecological knowledge, TEK is based on observations of the natural world, suggests hypotheses about how the natural world works, is tested, is shared with a community, is interpreted within a cultural context, and is used as a basis of resource management (Berkes et al. 2000; Kimmerer 2002). Unlike science, however, TEK is tested through experience and application to the livelihood and survival of indigenous peoples (Huntington 2000) and transmitted orally through stories, song, art, and ceremony (Berkes et al. 2000; Turner et al. 2000).

Science may have much to learn from TEK because TEK can be a source of novel ecological information (Kimmerer 2002; Lyver 2002; Gilchrist et al. 2005). Scientists have sometimes reported discoveries long known among indigenous people, such as the intoxicating effects of thornapple (*Datura wrightii* Regel) alkaloids on nectar-feeding hawkmoths (*Manduca* spp.; Grant & Grant 1965; Nabhan 2000) or the effects of grizzly bear (*Ursus arctos horribilis*) foraging on the growth and persistence of glacier lilies (*Erythronium grandiflorum* Pursh; Tardiff & Stanford 1998; Turner et al. 2000). Because it is older than most monitoring programs, TEK may provide insight into past ecosystem states. For example, Dena'ina Athabaskans of Lake Clark, Alaska recall when a dry streambed was once a sockeye salmon (*Oncorhynchus nerka*) spawning creek (Stickman et al. 2003). Indigenous people have had lasting impacts on ecosystems through species introductions (Hurles et al. 2003), selective cultivation of wild plants (Deur 2002), and nutrient inputs (Douglas et al. 2004). Knowledge of this history could be crucial to scientists trying to understand current ecology of "wild" populations and landscapes.

Scientists and practitioners of TEK share a common goal of species conservation and it is crucial that they work together to conserve both species and cultures. Species extinction rates are currently 1000 to 10,000 times higher than in the past (Singh 2002), and there is a growing awareness that indigenous languages and TEK of the world are also rapidly disappearing. It is projected that 90% of the world's languages will be extinct or nearly so within the next 100 years (Cox 1997; Stork 1999). Transmission of TEK between generations has been reduced in many communities as well because it is no longer perceived as necessary for survival (Gadgil et al. 2000). Weaving science and TEK together has improved understanding and conservation of many species from bonefish (*Albula* spp.) in Kiribati (Johannes & Yeeting 2001) to reindeer (*Rangifer tarandus*) in northern Sweden (Sandström et al. 2003).

We recorded the TEK of Maori elders and cultural specialists of the tuatara (*Sphenodon* spp.). Our objectives were threefold. First, we aimed to learn more about tuatara biology and ecology. Second, we hoped to document the cultural significance of tuatara to Maori. Finally, we sought to determine if Maori TEK of tuatara had persisted while tuatara became more isolated and less abundant over time.

Natural History of New Zealand and Tuatara

New Zealand is a South Pacific nation composed of two main islands surrounded by many small islands. It has been isolated from neighboring land masses for approximately 80 million years (Hay et al. 2003). Long-term isolation and a lack of native mammalian predators promoted a high level of endemism in New Zealand, particularly of reptiles and flightless birds (Daugherty et al. 1993). New Zealand was the most recent major land mass to be permanently settled by humans (Gibbons 2001; Hurles et al. 2003), and its indigenous people, the Maori, settled New Zealand approximately 800 to 1000 years ago (Hurles et

Figure 1. Mature adult male tuatara, Sphenodon punctatus*. Individual was 21 years old, 462 mm from snout to end of tail, and 685 g.*

al. 2003), at least 600 years before European colonization (Holdaway 1989).

Tuatara are endemic to New Zealand and, although they superficially resemble large lizards, are the last living representatives of an entire order of ancient reptiles, the Sphenodontia (Daugherty et al. 1990; Daugherty & Cree 1990; Fig. 1). They are considered a living fossil, having changed little morphologically in over 220 million years (Daugherty & Cree 1990). Tuatara have many unusual biological attributes including a rudimentary "third eye" or pineal gland on the top of the head, lack of a male copulatory organ, and temperature-dependent sex determination (Daugherty & Cree 1990; Nelson et al. 2004). Tuatara live in burrows, often with nesting muttonbirds (e.g., Fairy Prion [*Pachyptila turtur*], Diving Petrel [*Pelecanoides urinatrix*], Sooty Shearwater [*Puffinus griseus*]), which are seabirds harvested by Maori for subsistence (Daugherty & Cree 1990; Cree 1993; Gaze 2001; Lyver 2002). Tuatara feed on the eggs and chicks of muttonbirds sharing their burrows (Cree 1993; Gaze 2001).

Both Maori and European settlers introduced predatory mammals to New Zealand (e.g., rats, cats, pigs, dogs, and mustelids) that resulted in the extinction of many endemic species (Holdaway 1989; Cree 1993). Subfossil evidence suggests that tuatara were once found throughout New Zealand (Crook 1975). Tuatara were extirpated from the main islands in the early 1900s and are currently found on only 37 offshore islands (Daugherty & Cree 1990; N. J. N., unpublished data; Fig. 2). Two species of tuatara are currently recognized: *Sphenodon punctatus* and *Sphenodon guntheri* (Daugherty et al. 1990). The latter has only a single naturally occurring population that is listed as vulnerable by the World Conservation Union and endangered by the New Zealand Threat Classification System.

Our study is timely for conservation of both Maori culture and tuatara. There is growing concern that Maori TEK may be lost over time with the death of elders. At the same time, heroic conservation actions are being taken to ensure the persistence of tuatara (Gaze 2001). Our focus on a rare species of conservation concern sets this study apart from many other TEK studies that focus on species that are abundant and are frequently encountered by indigenous people (Gadgil et al. 2000; Stickman et al. 2003; but see Nabhan 2000). There is no active or recent subsistence harvest for tuatara, they have been neither abundant nor accessible for at least 100 years, and there are no living Maori elders who have had active and regular involvement with tuatara throughout their lives. Specifically we asked, does TEK about a species persist as the species declines?

Methods

We quantified TEK through structured, semidirected interviews of 16 Maori elders and cultural specialists (hereafter collectively referred to as elders). Five women and 11 men ranging in age from their 30s to their 70s and representing iwi (tribes) from three different areas of New Zealand were interviewed. Te Atiawa and Ngati Koata iwi have territories in the Marlborough Sounds region of the south island of New Zealand (Fig. 2). Te Atiawa are guardians of North Brother Island, which is home to the only remaining natural population of *S. guntheri*. Ngati Koata are guardians of Stephens Island, which is home to the world's largest population of *S. punctatus*. Nga Puhi and Ngati Wai iwi have territories in the Hauraki Gulf area of the north island of New Zealand (Fig. 2). Ngati Wai are guardians of Little Barrier Island and the Mokohinau Islands. Of these islands only Little Barrier currently has a population of tuatara (*S. punctatus)*. Collaborating iwi selected elders with knowledge of their iwi's territory, history, and culture to be interviewed (seven from Te Atiawa, eight from Ngati Koata). We interviewed Whetu McGregor, an elder from Nga Puhi and Ngati Wai Iwi, based on her public record of activism in the conservation of tuatara and Little Barrier Island.

Our interview survey was developed collaboratively by university ecologists and iwi resource managers and included 45 questions that were either open form (respondent expressed their response in their own words) or open form combined with closed form (multiple choice presented with opportunity to add comments or additional categories). Survey questions asked about distribution, harvest, life history, behavior, habitat use, and cultural significance of tuatara.

Interviews were conducted between 26 February and 19 June 2004, lasted from 30 to 90 minutes each, and were recorded on a digital audio recorder and, if permission was granted, on video. Audio interview records were transcribed with the program WavPedal version 5.05 (Programmers' Consortium, Vienna, Virginia), and interview

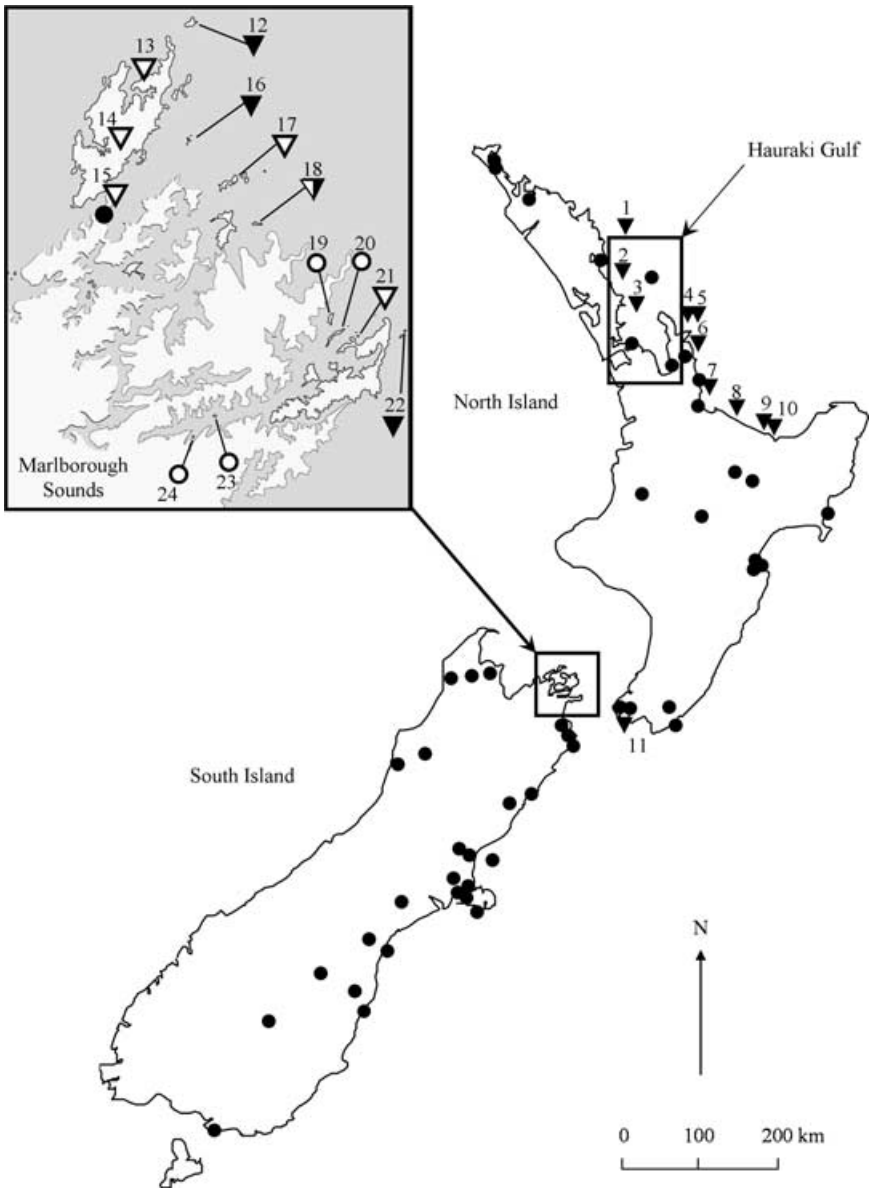

Figure 2. Distribution of tuatara in New Zealand. Closed symbols represent sites occupied by tuatara in the past based on subfossil remains (●, Crook 1975) and sites occupied by tuatara currently based on scientific surveys (▼, Gaze 2001). Open symbols represent past (○) and present (▽) sites of tuatara occupation based on traditional ecological knowledge (TEK). Numbers refer to the following sites: 1, Poor Knights Islands; 2, Hen and Chickens Islands; 3, Little Barrier Island; 4, Cuvier Island; 5, Mercury Islands; 6, Aldermen Islands; 7, Karewa Island; 8, Motunau Island; 9, Moutoki Island; 10, Moutohora Island; 11, Matiu-Somes Island; 12, Stephens Island; 13, Victory Island; 14, D'Urville Island; 15, French Pass; 16, Trios Islands; 17, Chetwodes Islands; 18, Titi Island; 19, Motuara Island; 20, Long Island; 21, Cooper's Island; 22, North Brother Island; 23, Allports Island; and 24, Mabel Island. Tuatara were translocated to Titi Island in 1995 (Gaze 2001), but TEK provides the only evidence to date that tuatara occupied Titi Island in the past. Thus, this island is coded with a half open, half closed symbol. Figure modified from Hay et al. (2003).

transcripts were checked for accuracy by interviewees. Audio, video, and transcript interview records formed a digital TEK archive for participating elders and iwi. The elders determined which part(s) of their interview could be shared with the public and their iwi through a flexible informed consent. Iwi trust councils also provided approval for sharing interview information with the public. Interview responses were compiled and summarized as relative percentages of responses for each question. Not all questions were answered by all respondents.

Results

The majority of participating elders had direct, personal experience with islands inhabited by tuatara (60%) and with tuatara themselves (93%). Most elders had lived in either the Marlborough Sounds or Hauraki Gulf areas since birth and had families whose history in the area extended 150 to 200 years into the past.

Tuatara Biology and Ecology

Nearly all respondents (87%) named at least one location where tuatara were found in the past (900 AD when Kupe explored New Zealand to within the last 50 years) and one location where tuatara are found currently (93%; Fig. 2). In general, locations were in the Marlborough Sounds and Hauraki Gulf areas that respondents were personally familiar with, and several sites were noted as having tuatara both in the past and present. Eighteen sites of past tuatara occupation were identified by the elders. The most commonly cited locations were Stephens Island (15%), D'Urville Island (15%), the Trios Islands (8%), French Pass

(8%), Cooper's Island (8%), and North Brother Island (6%). The elders also identified 11 locations where tuatara are found currently. The most commonly cited areas were Stephens Island (29%), North Brother Island (16%), and the Trios Islands (11%).

Nearly every elder named at least one characteristic of the types of habitats in which tuatara live (100%) or build their nests (73%). The most common habitat characteristics given (both living and nesting sites) were in burrows in the ground or under vegetation (21 and 31%), in closed or covered areas (9 and 10%), with muttonbirds (6 and 7%), and in sunny locations (4 and 10%). Additionally, elders indicated that tuatara live under or around buildings (6%) and in dry areas (6%) and that tuatara nest in soft ground (14%). Most elders agreed that tuatara like these places because they are warm (29 and 31%), protected (26 and 19%), and have a food source nearby (19 and 25%). The elders thought tuatara share burrows with muttonbirds because tuatara eat the birds and their young, gain shelter from the burrow, gain warmth from the birds, and are relieved of having to dig their own burrows. Most elders thought tuatara living (42%) and nesting (50%) habitat preferences had changed over the years due to introduced predators, habitat destruction, human habitation, and relocation of tuatara populations to different islands.

The majority of elders (57%) thought the maximum age of tuatara was between 150 and 300 years, whereas 29% thought tuatara live approximately 100 years and one elder thought tuatara live $\leq$100 years. Elders estimated the maximum body size of tuatara to range from 35 cm to 1 m. Twenty-one percent of the elders were not sure how big tuatara get, 35% thought tuatara grow to be >0.5 m, 21% thought tuatara grow to approximately 0.5 m, and 14% thought tuatara grow to be < 0.5 m. Most elders did not think that maximum tuatara body size (40%) or age (50%) had changed over the years.

Seventy-three percent of elders named at least one food item in the tuatara diet. The most common food items listed were insects (57%; including wetas, bugs, and beetles), muttonbirds and their eggs (17%), and "anything they can capture" (9%). Similarly, 79% of elders named at least one predator of tuatara. The most common predators given were introduced mammals (55%), adult seabirds (18%), and hawks (14%). Most of the elders thought that tuatara diet (40%) and predators (50%) had changed over the years due to relocation of tuatara to different islands, extinction of native food species, and the introduction of mammalian predators.

Cultural Significance of Tuatara

Most elders were not sure what the word tuatara meant (50%) and were not aware of any origin stories of the tuatara (53%). Twenty-nine percent of the elders said the name tuatara refers to the creature's rough skin and spiny

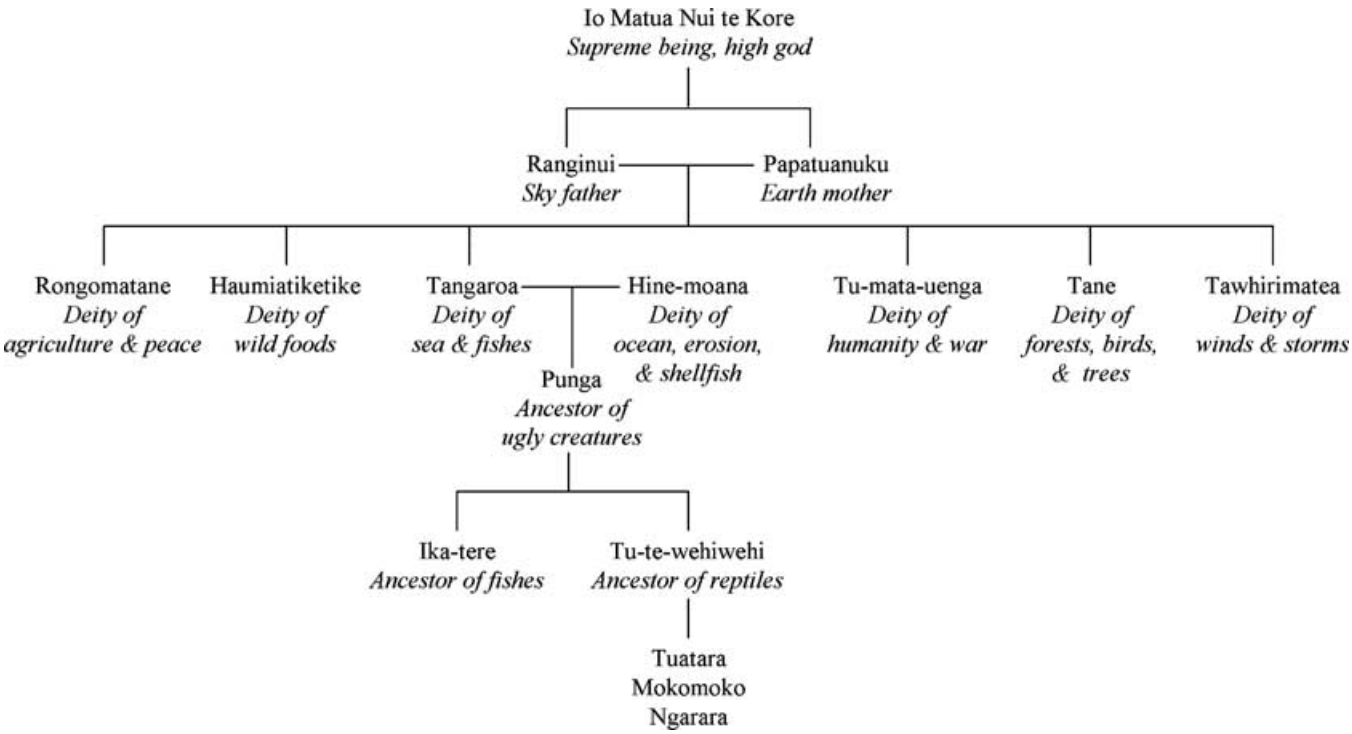

Figure 3. Whakapapa, or traditional Maori genealogy, of tuatara as related by one elder we interviewed (modified with additional information from Roberts et al. [1995] and Orbell [1995]).

back. One elder suggested the name means "here before Tara" (an early Maori explorer) and refers to the ancient nature of tuatara. The elders did not refer to the tuatara by any other name.

Twenty percent of the elders explained the origin of tuatara as either a creation of Ioa Matua Nui te Kore (the Supreme being, high god) or, more commonly, a descendent of Tu-ta-wehiwehi (the ancestor of reptiles; Fig. 3). One elder recounted the whakapapa, or traditional genealogy, of tuatara, which includes a story explaining the origin of reptiles (also called mokomoko and ngarara; Fig. 3). In this story the brothers Ika-tere and Tu-te-wehiwehi disagree as to whether they should flee to the sea or forest to escape the wrath of their great uncle. Tu-te-wehiwehi flees to the forest and warns his brother "Your children will be food for men." Ika-tere, ancestor of the fishes, flees to the sea and replies "And yours will be the ugliest things on the face of the earth." This story explains why elders identified tuatara and other reptiles as children of Tu-te-wehiwehi.

The majority of elders thought that neither Maori nor Europeans used to harvest tuatara (Maori 67%; European 69%) or tuatara eggs (Maori 73%; European 64%) for subsistence purposes. Reasons given for this include fear of tuatara, reverence and respect for tuatara, little meat on adult tuatara, small size of tuatara eggs, and the presence of ample alternative food sources (e.g., muttonbirds). Several elders added that tuatara may have been eaten by Maori as ritual, however, either to show bravery or gain knowledge.

Whetu McGregor described how her family and Ngati Wai Iwi used tuatara during the traditional summer muttonbird harvest on the Mokohinau Islands of the Hauraki Gulf.

> I used to go out with my family. . .to harvest muttonbirds. The tuatara were quite plentiful on the island and the harvesters. . .would put them next to their skin in their clothes. . .They would be able to harvest all day with the tuatara keeping their body cool. That was a very special reptile to [Maori harvesters]. . .Without it, you couldn't harvest.

The muttonbirders, primarily the women, collected tuatara from burrows in the morning and returned them to their burrows in the evening with a thank you prayer.

We asked how tuatara are used and what they signify in Maori songs, proverbs, stories, and carvings. Most elders said tuatara are not found in songs (43%) or proverbs (50%) and none of the elders could recall any songs or proverbs involving tuatara specifically. In contrast the majority of elders related stories of Cook Strait sites inhabited by tuatara (62%) and had observed tuatara in traditional carvings and tattooing (80%). We recorded four stories of the Maori explorer Kupe and the Cook Strait area and four traditional meeting houses with tuatara carvings.

In Maori stories and carvings, tuatara often represent guardians, signify calamity and death, or warn that something monstrous is about to occur and, thus, are used as a social control. For example, carvings of tuatara can be found on boxes containing bones of the dead, and women would sometimes tattoo reptiles (presumably some of which represent tuatara) near their genitals. Ropata Taylor, a member of Te Atiawa Iwi, said:

> [Tuatara] were often used in our stories as boundaries. As perimeters that signify tapu (sacred or restricted) and indicate. . .that if you cross that boundary, there is mana there. There's an authority, there's a power, and there's going to be repercussions.

Seventy-one percent of the elders related additional ways in which tuatara figure prominently in Maori culture. Tuatara were sometimes kept as pets (20%), but some iwi considered tuatara a taniwha (reptile-like water monster), bad omen, or manifestation of the malevolent supernatural being Whiro. In addition, islands inhabited by tuatara were tapu themselves in part because of the presence of tuatara. Practically, this limited peoples' experience with tuatara islands. For example, tradition restricted even viewing North Brother Island to only the highborn or those that had previously sailed past the island, depending on the iwi.

The elders related that tuatara are regarded as guardians of the stream of knowledge and that role is evident in their biology. The tuatara's third eye is evidence that tuatara can see another dimension, the long life of tuatara allows accumulation of knowledge, and the early arrival of tuatara in New Zealand means they have been accumulating knowledge since very early times. The lack of a male copulatory organ in tuatara was viewed by one elder as evidence that tuatara were sent to Earth by Io Matua in a hurry and unfinished.

Persistence of Tuatara TEK

In general traditional knowledge of tuatara cultural roles was more extensive and detailed than traditional knowledge of tuatara biology or ecology. The majority of the elders' knowledge came from personal observation (49% biological; 48% cultural) and stories handed down from their elders (29% biological; 40% cultural). Popular and scientific media and interaction with scientists comprised 17% of their biological TEK sources but only 7% of their cultural TEK sources.

The majority of elders (65%) thought tuatara TEK was being lost to some extent over time. Nevertheless, 24% of the elders thought it unlikely that Maori ever had much TEK of tuatara because of the secretive nature of tuatara and the isolation, protection, and tapu nature of tuatara and the islands they inhabit.

All the elders expressed support for tuatara conservation and dispersal throughout New Zealand. The majority of elders (86%) were agreeable to tuatara being taken out of New Zealand under strict conditions. The elders expressed support specifically for continued total protection of tuatara, breeding and translocation programs, island and habitat restoration, careful management and research, public education, iwi participation in management, and a desire to see tuatara left in peace.

Discussion

Tuatara Biology and Ecology

Traditional knowledge and scientific knowledge of tuatara biology were largely similar (e.g., tuatara diet and predators) but also differed from each other in a number of important ways. There is currently no scientific evidence (e.g., subfossil remains) to suggest that tuatara once occupied seven of the sites listed by the elders as places where tuatara were found in the past (Victory, Titi, Motuara, Cooper's, Long, Allports, and Mabel Islands; Cree 1993; P. Gaze, personal communication). Thus, TEK provides the only evidence to date that tuatara inhabited these islands. Caution is required in interpreting these data as Cooper's Island (called Motungarara in Maori meaning "lizard island") was the only site mentioned by more than one elder.

Similarly, five sites listed by the elders as places where tuatara can be found currently are not known by the New Zealand Department of Conservation to be occupied by tuatara (D'Urville, Victory, Chetwodes, Cooper's Islands, and French Pass) despite recent searches (P. Gaze & M. Aviss, personal communication). Thus, TEK appears to provide the only evidence that tuatara may still occupy these sites. Again, caution is required because all of these sites have introduced mammalian predators (M. Aviss, personal communication), which makes them inhospitable for tuatara (Gaze 2001), and only two of these sites (D'Urville and Cooper's islands) were mentioned by more than one elder. It is possible, however, that there are small, extant populations of tuatara yet to be confirmed through formal scientific surveys. Such a population was discovered living in the presence of rats on Little Barrier Island in 1991 (Cree 1993).

Additional differences between TEK and scientific knowledge also represent important opportunities for research. Most of the elders related that tuatara use the same burrow or similar habitats for both nesting and living. In contrast, behavioral studies on Stephens Island suggest that tuatara dig separate nest holes in habitats that are more open and sunny than the habitats in which they live (Cree 1993; Thompson et al. 1996). The elders also suggested that tuatara gain warmth from muttonbirds in their burrows, but this interaction has never been tested scientifically. Additionally, most of the elders described tuatara as being older (up to 300 years) and larger (up to one meter) than is currently known scientifically. The oldest known tuatara is 81-years old (with ages of 100 years or more likely; N. J. N., unpublished data), and the largest tuatara recorded are approximately 0.5 m long (Thompson et al. 1992). Thus, differences between traditional and scientific knowledge suggest that tuatara nesting behavior, use of muttonbirds for warmth, maximum age, and maximum size could benefit from additional research.

Cultural Significance of Tuatara

The elders related a great deal of information concerning traditional cultural roles of tuatara. Much of the TEK we recorded has been reported previously (Downes 1937; Phillips 1955; Orbell & Moon 1985; Orbell 1995; Reed 1999). Nevertheless, there are important differences between the traditional knowledge presented here and that found in the anthropological literature.

Historical records suggest that Maori feared reptiles because they could physically embody spirits (Orbell & Moon 1985), shared similarities with taniwha (Beattie 1920; Downes 1937; Reed 1999), and lived on land but were fish-like (Orbell & Moon 1985). Lizards appear to have been more feared than tuatara because they were thought to deliver disease and death (Downes 1937; Orbell & Moon 1985). Tuatara were still, however, often portrayed as vengeful, bloodthirsty, cannibalistic, man-eating, jealous creatures that served harmful spirits (Beattie 1920; Hongi 1922; Beattie 1994). The majority of elders we interviewed expressed respect and reverence toward tuatara rather than fear. This apparent contradiction may be due to a tendency for early writers and Maori to lump tuatara and lizards together simply as reptiles.

The elders denied that Maori ate tuatara for subsistence purposes, although this generalization is often found in the scientific literature. Maori subsistence hunts of tuatara have been recorded (Beattie 1920; Phillips 1955; Orbell & Moon 1985), and tuatara subfossil remains have been found in prehistoric middens (Crook 1975). Nevertheless, this study and Beattie (1994) found a lack of oral history of Maori subsistence on tuatara. Jim Elkington, a Ngati Koata elder, said, "Ngati Koata never ate tuatara. There was so much food around those days. Hell, we even ate each other. That was a better meal, so I'm told. We didn't have to eat tuatara." Several elders indicated it was likely people ate tuatara to show their bravery or gain knowledge, and there are similar stories of people eating lizards to show their authority or power (Orbell & Moon 1985).

To our knowledge, this is the first report of tuatara being guardians of knowledge and being used in muttonbirding. Tuatara are a cold-adapted reptile and typically have low body temperature (Daugherty & Cree 1990). Elders of Ngati Wai Iwi used to place tuatara in their shirts and against their skin to cool themselves while collecting

muttonbirds in summer. This story seems unlikely to some, but at least one historical report describes Maori nestling tuatara against their skin (Beattie 1994) and Ngati Wai elders that we did not formally interview describe similar interactions between muttonbirders and tuatara (J. [Sene] Ngawak, personal communication).

The apparent contradictions between the TEK reported here and that reported elsewhere may be due to differences among iwi in their relationship with tuatara or changes in attitudes over time (Ghimire et al. 2004). Our current understanding of Maori attitudes toward tuatara needs revising to accommodate this heterogeneity in TEK. Not all Maori fear tuatara, not all iwi subsisted historically on tuatara, and the cultural role of tuatara differs over time and among iwi.

Persistence of Tuatara TEK

Maori TEK of tuatara persisted despite increasing rarity and isolation of tuatara. Knowledge of tuatara biology, however, was not as widespread or detailed among the elders as knowledge of tuatara cultural significance. Similar studies report a greater volume and detail of TEK than that reported here. For example, 18 Dena'ina Athabaskan elders identified 48 sockeye salmon spawning sites and estimated contemporary distribution and decadal abundance since 1930 of multiple fish species in Lake Clark, Alaska (Stickman et al. 2003). Traditional knowledge of Sami reindeer herders in northern Sweden is similarly detailed and was used to construct a GIS database of seasonal reindeer distribution, movement, and forage base (Sandström et al. 2003).

Why might there be less TEK of tuatara? It is possible that Maori have never had detailed TEK of tuatara biology because they had no dependence on and did not harvest tuatara. There is often a correlation between dependence on a species and volume and detail of TEK of that species (Gadgil et al. 2000; Ghimire et al. 2004; Gilchrist et al. 2005). Nevertheless, indigenous communities often acquire substantial TEK that is not directly related to harvest (Nabhan 2000; Gilchrist et al. 2005). Thus, lack of subsistence or dependence on tuatara alone likely cannot explain why there is little TEK of tuatara biology.

Tuatara may not have been encountered often by Maori historically. Exploring Polynesians likely introduced Pacific rats (*Rattus exulans*) to New Zealand up to 1000 years before Maori settlement (Hurles et al. 2003). Thus, tuatara were possibly declining and rare on the mainland when Maori settled in New Zealand. Indigenous communities, however, often have TEK of rare and endangered species (Nabhan 2000), and the elders we interviewed represent iwi that have actively and historically spent time on tuatara islands. Thus, a lack of encounters with tuatara alone also cannot explain why there is little or widespread TEK of tuatara biology.

Because tuatara are tapu and live in tapu places, people may have purposefully avoided or been restricted from interacting with tuatara (Colding & Folke 1997; Lingard et al. 2003). It is not uncommon for TEK of a species to be limited to people of a specific social status or labor role (Turner et al. 2000; Ghimire et al. 2004) and several elders suggested that interaction with tuatara and access to tuatara islands may have been limited to spiritual leaders. Many species are currently protected by traditional cultural bans (Colding & Folke 1997; Lyver 2002; Lingard et al. 2003) and the tapu nature of tuatara may serve a similar purpose. Additionally, tuatara have been protected by law since 1895 (Cree 1993), and all islands currently inhabited by tuatara are protected reserves. Intense protection of tuatara, both through historical tapu and current legislation, has likely distanced Maori from tuatara and accelerated the loss of traditional knowledge of tuatara biology.

Most elders thought that more TEK of tuatara biology would have been known but has been lost because it is otherwise unlikely that tuatara would figure so prominently in Maori culture. Maori have been in New Zealand long enough to have gained substantial knowledge of native flora and fauna (Lyver 2002) and codify this knowledge culturally (e.g., as whakapapa; Roberts et al. 1995). Iwi collaborating on this study have been in their current territories for shorter periods of time (approximately 180 years) but are highly knowledgeable about many aspects of local ecology (e.g., muttonbirding and fishing locations). Lack of dependence on tuatara for survival, long-term rarity and isolation of tuatara, and protection of tuatara through tapu and legislation likely all contribute to the paucity of traditional knowledge of tuatara biology.

Implications for Conservation

Traditional ecological knowledge of rare and extinct species is sometimes distorted and difficult to interpret. This is likely because the mutually reinforcing connections between cultural and biological TEK are broken when a species is rarely or never encountered (Nabhan 2000). For example, tuatara are larger than life in Maori tradition due possibly to the cultural link between tuatara and taniwha, the latter of which are typically represented as huge in size (Orbell 1995). This does not mean that scientists must believe in sasquatch or taniwha to appreciate TEK. Although TEK is sometimes wrong (just like science), it may be one of the last sources of information on rare and extinct species and should neither be accepted nor rejected outright (Huntington 2000; Nabhan 2000; Gilchrist et al. 2005). For example, the Cheyenne of North America include mythical creatures, meteorological events, and insects in their traditional bird taxonomy (Moore 1986). This clearly does not conform to any scientific taxonomic category, but still encodes ecological knowledge of many bird species that has been collected through observation over thousands of years.

The results of our study have tangible outcomes for tuatara conservation. First, TEK presented the only

evidence of past and current tuatara occupation of several islands. This information will help managers prioritize islands for tuatara searches and translocations because translocation sites are selected based partially on evidence of former tuatara occupation (Cree 1993). Second, TEK suggested new avenues for scientific investigation into, for example, tuatara use of muttonbirds for warmth. Finally, our results affirmed that many Maori feel a strong personal connection with tuatara, are aware of the threats to tuatara, and have a strong desire to conserve tuatara.

We are currently experiencing a species and cultural extinction crisis with profound and correlated losses of species (Singh 2002), indigenous languages (Cox 1997; Maffi 1998; Stork 1999), and TEK (Sutherland 2003). If we wish to conserve TEK and cultural diversity, we must conserve species that figure prominently in culture and maintain links between traditional cultures and species. It should be encouraging that many elders thought it was not necessary for people to understand a species from a scientific perspective to appreciate or protect that species. Understanding a species from a cultural perspective can engender the same conservation ethic.

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