

Conserv-Vision Conference Proceedings

The University of Waikato



A CELEBRATION OF 20 YEARS OF CONSERVATION BY
NEW ZEALAND'S DEPARTMENT OF CONSERVATION

Conference Proceedings edited by:

Dr Bruce Clarkson, Dr Priya Kurian, Todd Nachowitz, & Dr Hamish Rennie

© 2011 ROLAND J. FOSTER AND HARVEY C. PERKINS

Article Title: "We were careful to not call it a species": a social scientific interpretation of species concepts, taxonomy and conservation

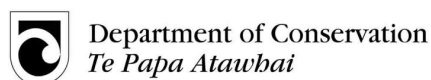
Authors: Foster, Roland J. and Harvey C. Perkins

Publication Date: 15 March 2011

Source: Proceedings of the Conserv-Vision Conference, University of Waikato, 2-4 July 2007

Published by: The University of Waikato, Private Bag 3105, Hamilton, New Zealand

Stable URL: www.waikato.ac.nz/wfass/conserv-vision



“We were careful to not call it a species”: a social scientific interpretation of species concepts, taxonomy and conservation

Roland J. Foster and Harvey C. Perkins

Department of Social Science, Parks, Recreation, Tourism and Sport

Faculty of Environment, Society and Design,

Lincoln University

Canterbury, New Zealand

email: <roland.foster@lincolnuni.ac.nz>, <Harvey.Perkins@lincoln.ac.nz>

Abstract

Priorities for international nature conservation are based on species as the fundamental unit of distinctiveness, and taxonomic status can profoundly influence the allocation of conservation resources. But there is still considerable dispute among biologists about how species should be defined, particularly between advocates of the biological species concept and the phylogenetic species concept. The number of species recognised in any particular taxa can vary significantly depending on which concept is used by the taxonomist, and this has the potential to increase the number of threatened species and alter areas recognised as having high biodiversity. The taxonomic “reality” of species has altered through time as competing species concepts have held sway among taxonomists. The paper relies on a social scientific artefactual constructionist approach to investigate the materiality of scientific practices and suggests that the “reality” of species is enacted by the “inscription devices” utilised by the scientists, which must be compatible with a broad scientific “hinterland”. This hinterland incorporates practices that are scientific, political and ethical, reinforcing the conclusion that the definition and elaboration of species concepts has biological, philosophical and social dimensions.

Key words: artefactual construction, avian, conservation, *Eudyptula albosignata*, New Zealand, species concepts, taxonomy.

Introduction

This paper contributes a social scientific interpretation of current debates about species concepts, taxonomy and conservation. It has its origins in a study of an eco-tourism proposal on Banks Peninsula, Canterbury, New Zealand, and associated attempts to characterise white-flippered penguins as a distinctive entity to enhance its conservation status. Our analysis of those attempts has connected us with the practices of biodiversity conservation which uses species concepts to order international conservation effort through *The IUCN Red List of Threatened Species* (Baillie et al. 2004). While the notion of species appears straightforward there is still considerable debate among scientists over exactly how a species should be defined, and to what extent species can be considered objectively “real” entities. This paper highlights some of the conservation implications of competing species concepts and argues that the “reality” of species is not purely a biological question, but also has philosophical and social dimensions.

Exploring the “reality” of “species” in taxonomic science

Biologists, philosophers and constructionist social scientists have different understandings of what constitutes the “reality” of species. Biologists are split between those, in the minority, who argue that the “reality” of species in evolution, and in ecological and biodiversity studies, has been overestimated (Mallet 2001:428); and the majority, including most philosophers of science, who are convinced that species “are **real** by-products of natural processes and not misguided fabrications of our own invention” (Mayden 1997:384, emphasis in original). As Cracraft (2000) suggests, although biologists do not see species in the same way that they see, for example, a squirrel, this does not prevent them from inferring that species are discrete “real” entities, and consequently that this reality can be discovered by science. Mallet (2001) agrees that, to a naturalist, species are usually somewhat objectively definable in local communities, but argues that difficulties arise when attempts are made to extend this local objectivity over space and evolutionary time. This is compounded by biologists “arguing fruitlessly among themselves as to the nature of the important reality that underlies this illusory spatiotemporal objectivity” (Mallet 2001:428). For Mallet (2001), the difficulty of agreeing on a unified species concept is because species lack a single interpretable biological “reality” over geological time and across their geographic range.

A number of social science perspectives share affinities with Mallet’s (2001) stance and reject the conventional understanding of science that posits “a progressive unfolding of more accurate representations of a real, independent, and pre-existing natural world” (Braun and Castree 1998:170). There are a number of strands in such work (Demeritt 1998 & 2002, Hannigan 2006), and each is concerned with “situating knowledge socially or ... advancing an understanding of reality or specific entities as socially produced, rather than as simply given

with fixed ontological properties” (Demeritt 2002:771). Law and Lien (2010) distinguish between two major strands of science studies research; the first they describe as empirical epistemology, which says “there’s a reality out there” (2010:2) that is a focus of different perspectives, for instance of penguin textbook writers, penguin field surveyors or penguin ecotourists, but the assumption is;

[D]eep down, behind the interactions and the interpretations this way of thinking assumes that reality ... is a somewhat stable object – or class of objects – that is somewhat beyond human control. It is taken for granted that there’s a [penguin] reality out there (2010:2).

The second, empirical ontology, proposes instead that “realities are enacted in relations” (2010:2) and that penguin-realities, for instance, are done in penguin-related practices. The approach known as artefactual construction or actor-network theory is particularly useful here because it concentrates on the *materiality* of scientific practices, arguing that reality is constructed in those practices (Demeritt 1998, 2002).

This approach has been elaborated by British sociologist John Law (2004) (following Latour and Woolgar 1986) in his studies of the ways scientists undertake the processes of scientific activity. Law (2004) argues that “inscription devices” are a key way of producing usable data out of materials that take other forms. While inscription devices are often machines in the laboratory, out in the field they might involve maps, aerial photographs, weighing scales, score cards, sampling schemes, and identification tags (Latour 1999). In general terms, an inscription device is “a set of arrangements for labelling naming and counting” (Law 2004:29). The importance of inscription devices is that they can “transform material substance into a figure or a diagram which is directly usable by [scientists]” (Latour and Woolgar 1986:51).

Inscription devices are important in all aspects of taxonomy. Studying, for instance, the morphology of penguins involves taking a series of measurements of individual birds, which are then combined to show differences and similarities between the various populations that have been sampled, which are then often statistically manipulated (see Kinsky and Falla 1976). A similar process happens with DNA analysis of the same penguin populations whereby traces of penguin mitochondrial DNA are extracted from feathers or muscle tissue, then amplified by polymerase chain reaction using a Perkin Elmer 2400 thermal cycler. These sequences are then analysed using “maximum likelihood analysis” to produce a phylogenetic tree which shows the genetic relationships between populations (see Banks *et al.* 2002:32).

Latour and Woolgar (1986) argue that the process of producing these traces melts into the background, the materiality of the process gets deleted and that;

It is not simply that phenomena depend *on* certain material instrumentation; rather, the phenomena *are* thoroughly constituted by the material setting of the laboratory. The artificial reality, which participants describe in terms of an objective entity, has in fact been constructed by the use of the inscription devices (Latour and Woolgar, 1986:64).

It is important to distinguish what is being constructed or enacted here; Law argues that scientific knowledge is constructed in scientific practices. This, it should be noted, is not at all the same thing as saying it is constructed by scientists ... But the process of building scientific knowledge is also an active matter. It takes work and effort. The argument is that it is wrong to imagine that nature somehow impresses its reality directly on those who study it if they just set aside their own biases (Law 2004:19).

So, scientists use inscription devices to produce scientific knowledge, which then gets turned into texts in the form of scientific papers. This being so, what is to stop scientists making any claim they feel like making? Law (2004) argues that scientists are not free to make any statement they like, without inscriptions of the appropriate provenance, or supporting statements that will back up their initial assertions, because both natural and social science are not just literary exercises. If statements are to last they need to draw upon what Law (2004:28) describes as an "appropriate hinterland".

The hinterland consists of other related statements, which need to be consistent with the initial assertion, as well as a network of appropriate inscription devices. To determine the strength of a statement, in relation to its inscription devices, one might ask "do the practices in which these are embedded produce figures that can be compared and tend to reinforce one another? If the answer is 'yes' then the authority of the statement increases. If it is 'no', then the statement is likely to enter the limbo of the might-have-beens" (Law 2004:28-29). Law (2004) argues that it is the character of this hinterland and its practices that determines what it is to do science, or to practise a specific branch of science.

Texts also include statements derived from beyond the laboratory, such as papers and reviews written by scientists elsewhere, which are played off against one another, in order to produce statements that carry authority (Law 2004). Some statements are unconditional and form the bedrock of a particular paper, which can also be seen as the scientific paradigm that researchers are working within (Latour 1987). For instance, the founding statement in Banks *et al.*'s (2002) study of relationships among little penguins is that "animal mitochondrial DNA is maternally inherited and does not recombine (Hillis *et al.* 1996). Mitochondrial DNA clades within many species have been shown to be geographically localised (Avice 1994)" (Banks *et al.* 2002:29-30). The second sentence, however, includes the phrase "have been shown", which has less authority, and is what Latour and Woolgar (1986) call a "modality". These are qualifications that turn up within the text, and may be aimed at strengthening one's own position vis-à-vis another technique, or alternatively, to undermine the credibility of another paper (Law 2004). For example, the statement "depending on gene region selected, sequencing can detect variation between populations that allozyme analysis may fail to detect" (Sunnucks 2000, cited in Banks *et al.* 2002:30), appears to do both these tasks in the same sentence.

Law (2004:28) suggests that a lot of the time, “scientists are comparing statements of differing degrees of strength, selecting and playing them off against one another in the process of trying to create unqualified statements ... if all goes well it may become possible to make statements that assert unqualified claims about substances and realities, pin these down, fix them, and make them definite”. This process is ongoing so that as statements are stabilised they can be said to be “demodalised” so that “*yesterday’s modalities become tomorrow’s hinterland*” (Law 2004:32 emphasis in original). In the case of DNA analysis, for instance, the Perkin Elmer 2400 thermal cycler is an example of a large body of earlier research on genetic sequencing that has become routinised. Law (2004) argues that the limits of scientific knowledge and reality are therefore set by particular and specific sets of inscription devices. To understand the importance of these inscriptions and the character of the hinterland in systematics and taxonomy, it is necessary to briefly outline the historical origins and philosophical arguments within biology over what constitutes a species.

On the origin of “species concepts”

While the 18th century Swedish naturalist Carl Linnaeus (1707-1789) is credited with the invention of hierarchical taxonomy and binomial nomenclature, the terms “genus” and “species” were adopted and codified from an essentialist Aristotelian philosophy, in which each “species” had a “form” or “essence”, and variation within a species was due to imperfections in the actualisation of that form (Mallet 2001). Individual species were defined by their “essences” which were different from all other species’ essences because each species form was separately created by God. Linnaeus achieved pre-eminence among taxonomists, despite this essentialist philosophy, because he was also one of the few 18th century systematists who “wrote down precisely what he was doing and what he thought he should do” (Claridge *et al.* 1997:3). Precise criteria and rules became increasingly important as imperial exploration in the 19th century dramatically increased the number of species needing classification, and caused taxonomy to split between field naturalists and museum taxonomists (Claridge *et al.* 1997).

Up until the time of Linnaeus, most taxonomists were familiar with the entities they were working on as living organisms in the field, but with the increase in imperial exploration during the later 18th and 19th centuries vast amounts of material from all over the world arrived at museums as dead specimens (Claridge *et al.* 1997, and see Boelens and Watkins 2003 for an illustration of the scope of imperial bird collecting). Taxonomists working in museums were thus forced to rely purely on morphology (the form of things), with little knowledge of the habits and habitats of an organism, to distinguish separate species. This reinforced the tradition “that species, and indeed higher taxa, must be based on morphological characters recognisable in preserved specimens” (Claridge *et al.* 1997:4). The difficulty with this approach

is, however, that it relies on the subjective assessments of individual taxonomists. This is epitomised by Regan's (1926) well-known statement that "a species is a community, or a number of related communities, whose distinctive morphological characters are, in the opinion of a competent systematist, sufficiently definite to entitle it, or them to a specific name" (cited in Claridge *et al.* 1997:4).

In contrast, field naturalists recognised that species could have some biological reality irrespective of morphological distinctiveness (Claridge *et al.* 1997). Charles Darwin, who was part of the naturalist tradition, recognised that species did not have an essential form, and that the distinction between intra-specific and inter-specific variation was false (Mallet 2001). Darwin (1859) observed that variation itself was among the most important characteristics of living organisms because it allowed species to evolve. Darwin also recognised that essentialist species would be hard to give up and argued that;

we shall have to treat species in the same manner as those naturalists treat genera, who admit that genera are merely artificial combinations made for convenience. This may not be a cheering prospect; but at least we shall at last be freed from the vain search for the undiscovered and undiscoverable essence of the term species (1859:485 cited in Mallet 2001:428).

For Darwin, species were little more than varieties and only acquired a greater reality when the morphological intermediates between them died out leaving a morphological gap (Mallet 2001). Darwin's reluctance to give precise definitions for species contrasts with the increasing attention on what exactly constituted a species in the early 20th century.

Modern species concepts

While at least 20 modern species concepts have been proposed, many have only minor differences between them, and much of the debate among biologists has been between proponents of the *biological species concept* and those proposing some version of the *phylogenetic species concept* (Mayden 1997, Wheeler and Meier 2000). The most widely known of species definitions, the "biological species concept", popularised by Ernst Mayr (1942), combined earlier ideas of Poulton and Dobzhansky about the importance of interbreeding at local scale with an extension over geographic scale to cover replacement series of actually or potentially interbreeding subspecies (Mallet 2001). This proposes that "biological species [are] groups of interbreeding natural populations that are reproductively isolated from other groups" (Mayr 2000:17). With the widespread adoption of the biological species concept by biologists and taxonomists, in the mid 20th century, many prior-named species were demoted to subspecies, and numerous geographical varieties or races were classified as "polytypic" species. For example, the number of bird species recognised dropped by 50 per cent when ornithologists took this view (Zink 2004).

Rather than placing emphasis on whether populations could interbreed, the phylogenetic species concept aims to classify species according to their evolutionary relationships, and with the rise of DNA analysis, allows these relationships to be expressed in the form of a binary branching tree or phylogeny (Mallet 2001). The phylogenetic species concept is by no means monolithic and there are several competing versions, but they are based on the notion that species form when a single interbreeding population split into two branches or lineages that do not exchange genetic material (Mallet 2001). One of the most influential definitions of the phylogenetic species concept was proposed by Cracraft (1989:29) where “[A] phylogenetic species is an irreducible (basal) cluster of organisms, diagnosably distinct from other such clusters, and within which there is a parental pattern of ancestry and descent”. Cracraft’s (1989) definition has become particularly influential in avian taxonomy where diagnostic characters have been used to reassign many taxa long thought of as subspecies to the level of full species (Mallet 2001).

There are a number of criticisms of both these concepts; critics of the biological species concept argue that it is extremely difficult to demonstrate whether interbreeding is or would take place between allopatric (geographically separated) populations, and as Zink (2006:890) notes, “what constitutes ‘enough’ interbreeding for two taxa to be considered the same biological species varies immensely from authority to authority”. This situation is further complicated by species that interbreed where they overlap in a hybrid zone yet the parental types remain distinct (e.g. for North American field crickets, see Harrison 2002; for European toads and North American oak trees, see Mallet 2001). Harrison (2002:1082) observes that “examples of entities that interbreed to some extent, but tend to remain distinct even in the face of this interbreeding, are remarkably common, both in plants and in animals”. While interbreeding might seem a logical criterion there would appear to be plenty of organisms that make it difficult to operationalise.

On the other hand, one of the main difficulties with the phylogenetic species concept is deciding how much nuclear or mitochondrial DNA divergence between putative species warrants separate species status. For instance, Robertson and Nunn (1998) reviewed albatross taxonomy based on complete mitochondrial DNA cytochrome *b* sequences and split the previously accepted 13 albatross species into 24 species. Penhallurick and Wink (2004) reanalysed the sequences and rejected species status for species with less than two per cent divergence for any taxon pair and argued for the previous 13 species with the other 11 populations reduced back to subspecies status. Rheindt and Austin (2005), in a reply to Penhallurick and Wink (2004), point out the difficulty of choosing a particular percentage of divergence because of the difference in rates of molecular evolution among bird lineages. For instance, ducks can have as little as 0.1-0.5 per cent mitochondrial divergence between such distinct species as Northern Pintail (*Anas acuta*) and Mallard (*Anas platyrhynchos*). Rheindt and Austin (2005:185) suggest therefore that “if Penhallurick and Wink (2004) had conducted a

taxonomic revision of ducks, they might have ended up lumping the 35-40 currently recognised species of dabbling ducks (*Anas*) into a handful of species". Setting an arbitrary cut-off percentage to distinguish between any taxon pair by extrapolating from divergence distances of closely related but unequivocal species then depends on what is considered "unequivocal".

In an intriguing review of species concepts Pigliucci and Kaplan (2006), a biologist and a philosopher respectively, argue that the problem of defining what a species is cannot be solved by biologists alone because it is primarily a "philosophical question that requires empirical information (provided by science) to be settled, not a scientific problem with unwelcome philosophical characteristics" (2006:208). Based on a review of 10 of the major species concepts Pigliucci and Kaplan (2006) highlight four biological factors that they consider are most relevant for determining whether two populations of organisms belong to the same species: phylogenetic distance, reproductive (genetic) isolation, ecological/functional differentiation, and morphological differentiation. Each of these criteria admits degrees and each criterion is relevant for different purposes. The criteria form axes from an origin that would be a classic species (e.g. platypus) through to separate species (e.g. modern human and lowland gorilla). Pigliucci and Kaplan (2006) suggest that the "species-ness" of a population is given by its location in the multidimensional space determined by the four axes (and possibly others). Where two populations locate on each of these axes can be quite varied, however. For instance, *Phryma leptostachya* var. *leptostachya* (eastern North America) and *P. leptostachya* var. *asiatica* are morphologically and ecologically very similar flowering plants but are so phylogenetically distant that some botanists have suggested that they should be in separate genera (Wen 1999 cited in Pigliucci and Kaplan 2006). Conversely, two populations may have distinct morphological or ecological differences yet have minimal phylogenetic distance and reproductive isolation, such as "type 1" and "type 2" male of *Porichthys notatus* (midshipman fish), which are the same species but have massive sexual plasticity (Pigliucci and Kaplan 2006). When two populations cluster towards the origin on all axes they are unlikely to be considered a separate species, however as populations move away from the origin on each axis, recognition of separate species is more likely. We agree with Mallet (2001) and Pigliucci and Kaplan (2006) that proponents of the contrasting modern species concepts are essentially arguing that evidence from only one axis should be given more weight than any of the other axes, and consequently cannot solve the definition of what a species can be; but do these somewhat arcane arguments over what constitutes a species really matter to the business of conservation? We believe they do, and in support of our view, we will now discuss and interpret the debates currently surrounding the taxonomic status of white-flipped and little blue penguins, and then outline the emerging literature on the ethics and politics of taxonomy in conservation biology.

Enacting the taxonomic reality of a “species” of penguin

The taxonomy of the white flippered penguin (*Eudyptula albosignata*) and the little blue penguin (*Eudyptula minor*) in New Zealand and Australia, in many ways, displays the working out of the history of taxonomic fashion outlined earlier in this paper. It also highlights the ethical and political issues associated with species definition in conservation efforts. When it was first identified from a specimen collected off Akaroa Heads, in 1874 by the German naturalist Friedrich Finsch, the idea of subspecies had not been invented, so it was natural to name a bird that was morphologically different from the type specimen of little blue penguin (*Eudyptula minor*, identified in Dusky Sound by Forster in 1781) as a new species. *Eudyptula albosignata* retained species status for most of the next hundred years, until a comprehensive reanalysis of morphological characteristics of the entire *Eudyptula minor* complex was done by Kinsky and Falla (1976). They proposed that the white-flippered penguin (*E. m. albosignata*) be reclassified as one of five subspecies in New Zealand, with a sixth in Australia, within the *Eudyptula minor* complex. The next revision by Turbott (1990) interpreted analyses of allozyme data (Meredith and Sin 1988) and argued that “such a high degree of intra- and inter- population variability existed within *Eudyptula* that no subspecies could be recognised ... [and *Eudyptula* should be seen as] a single, morphologically variable species” (cited in Banks *et al.* 2002:29).

This conclusion seems unsatisfactory to those who work closely with penguins around the Banks Peninsula coast. The local white-flippered penguins appear to have a distinctiveness which makes visiting little blue penguins from elsewhere readily discernible:

Occasionally birds turn up that are clearly not white-flippered penguins ... It’s quite noticeable that their voice is different. Everybody who has met them says that they talk a different language (Penguin scientist, interview transcription 20/8/1998).

We would probably say that from what we’ve seen there is enough difference, and we would be quite happy to say that they are a separate species from the little blue (Penguin fieldworker, interview transcription 13/12/2001).

This discernibility prompted international scientific colleagues to support proposals recognising the white-flippered penguin as a distinctive entity for conservation purposes, at the international penguin conservation assessment and management (CAMP) workshop held in Cape Town in 1996 (see Ellis 1999). As an Australian penguin scientist commented;

We helped [a particular scientist] to get the white-flippered penguin recognised as a taxon, but we were careful to not call it a species, because you have to do what you can to protect them (pers. comm. 21/6/2001).

The resultant listing of *Eudyptula minor albosignata* as one of three endangered penguin taxa recognised the penguin’s distinctiveness; however the listing also recommended the “taxonomic status of the *Eudyptula minor* complex should be investigated in detail ... to determine which geographic populations should be treated separately for conservation purposes” (Challies 1998:88). The listing could therefore be considered a “precarious

achievement" (Law 1994:101) because as Law notes "we can all dream up wish lists about the character of reality, but without support from other statements or inscriptions of the appropriate provenance they do not go very far" (Law 2004:28).

Challies' (2001) supporting statement at a penguin conference; "just to be controversial, the best advice on the white-flipped penguin's actual taxonomic status is from Allan Baker, who thinks it is clearly a species and has been for a substantial length of time" is of the appropriate provenance, but still lacks the evidence of inscriptions. It was only when Baker *et al.* (2006) published their article in *Proceedings of the Royal Society* outlining mitochondrial DNA analysis of the phylogenetic relationships between extant penguins, stating that "divergence of the white-flipped and little blue penguin dates to about 2.5mya (1.4-4.5mya)", and showing a phylogenetic reconstruction of white-flipped and little blue penguins on separate branches (Baker *et al.* 2006:14-15) that there appeared to be appropriate inscriptions. If this finding holds, the phylogenetic evidence would support morphological and ecological differences and strongly suggest that the white-flipped penguin is a separate species.

The Australian scientist's comment (above) that they were "careful to not call it a species" illustrates the hinterland of science in action, because he and his colleagues knew that claiming species status was likely to be contested. Similarly "just to be controversial" is a modality that acknowledges the presence of the hinterland and changes the statement into a tentative claim. It is only with Baker *et al.*'s (2006) statement that the white-flipped penguin's species status is demodalised; however if the practices embedded in the phylogenetic reconstruction do not include evidence from the related hinterland then that reconstruction may also be undermined.

In this case, Baker *et al.* (2006) ignored an earlier phylogenetic study by Banks *et al.* (2002), which had sampled all six of the putative sub-species populations of *Eudyptula minor*. The earlier study showed that there was significant phylogenetic divergence between Australian and New Zealand little blue penguins, but that there were also Australian little blue penguins along the Otago coast of New Zealand. The most likely evolutionary scenario suggested by Banks *et al.* (2002) to explain this unexpected pattern is that New Zealand *Eudyptula* penguins became extinct on the Otago coastline and the area was re-colonised from Australia approximately 95,000-238,000 years ago. These findings have been confirmed by later studies of 38 and 212 specimens respectively (Banks *et al.* 2008, Peucker *et al.* 2009). Indeed, Baker subsequently cites Banks *et al.* (2002) to argue that Australian and New Zealand little blue penguins both deserve species status (Tavares and Baker 2008).

The status of the white-flipped penguin, however, remains contested. Investigating the four dimensions suggested by Pigliucci and Kaplan (2006) of phylogenetic distance, reproductive isolation, ecological, and morphological differentiation suggests that there is limited support for even sub-species status. First, the most extensive phylogenetic study showed that 36

putative white-flipped penguins clustered into four different locations sharing affinities with Cook Strait, northern, Chatham Islands and southern blue penguins (Peucker *et al.* 2009). Second, Kinsky and Falla (1976) did not include white-flipped penguins from Motunau Island because they considered these included “representatives of both the Canterbury and Cook Strait subspecies as intermediates resulting from interbreeding between these two races” (Kinsky and Falla 1976:111). Third, the morphological distinctiveness that was responsible for the white-flipped penguin’s initial species status – the white anterior edge to the flipper, is not completely isolated to the Banks Peninsula and Motunau Island populations. Hocken (1997) found that up to 27 per cent of penguins in the Oamaru colony (outside *Eudyptula albosignata* range) had some form of “white-flippedness”. There is no straightforward way of weighting the relative importance of each of these dimensions of species-ness – it is a philosophical choice; however, human perception has tended to prioritise morphological distinctiveness.

Some implications of species concepts for conservation

Cracraft (2000) suggests that for most biologists the species concept they learnt at university seemingly fits what they do – population biology, behaviour, genetics, or ecology. He also argues that almost any species concept would be compatible with what they do because their work does not usually involve comparisons between taxonomic entities. Species are, however, the fundamental unit of biodiversity conservation, and there is an extensive literature attesting to how species concepts and taxonomy are affecting conservation (Hazevoet 1996, Cracraft 2000, Sutherland 2000, Gaston 2001, Lalas 2001, Agapow *et al.* 2004). Species concepts have a bearing on, among other things: 1) the specific status of diagnosable populations, 2) estimates of species diversity, 3) delineation of areas of endemism, 4) decisions on captive breeding, predator control etc., 5) which units will be given protection under legislation (Cracraft 2000). For instance, a study of the geographic distribution of avian endemism in Mexico found that the biological species concept and phylogenetic species concept produced drastically different maps of species richness endemic to single biotic regions, and consequent conservation priorities (Petersen and Novarro-Seguenza 1999).

In a review of 89 studies where organisms had been classified by both the biological species concept and the phylogenetic species concept, Agapow *et al.* (2004) found that 48 per cent more species were recognised under the phylogenetic species concept, with an associated decrease in population size and range. This has led some conservationists to argue that the recognition of too many additional species would draw too much time and money from currently recognised species and would destabilise taxonomy (Collar 1996, Sutherland 2000). An alternative view is that taxonomic neglect promotes extinction of distinctive endemics because subspecies are so often ignored by biologists and conservationists (Hazevoet 1996), and that the phylogenetic

species concept enables conservationists to precisely identify the basic units of conservation, which should result in a more efficient use of resources (Sangster 2000). This leads, however, to the question of whether groups and areas that have had phylogenetic analysis deserve greater attention than those that have yet to attract the attention of a splitting taxonomist (Lorimer 2006, Sutherland 2000).

It is widely recognised that the level of conservation concern is heavily dependent on taxonomic decisions, with subspecies usually only accorded local or regional conservation attention (Gamauf *et al.* 2005, Hazevoet 1996). This situation is exacerbated when conservation legislation only recognises species level diversity. The category of subspecies has caused considerable dissatisfaction, in part because, prior to the advent of statistical and genetic methods, subspecies names might refer to quite different types of entity; arbitrary points on clines, average differences between populations, zones of intergradation, or diagnosably distinct endemic island taxa, which are not of equivalent importance for conservation (Remsen 2005, Hazevoet 1996). The temptation among taxonomists is to elevate subspecies of restricted range to species level to intensify conservation efforts, which Gamauf *et al.* (2005) describe as the “conservation species concept”.

There are both scientific and ethical difficulties with elevating populations to species status, or retaining them as species, when that status does not have scientific backing. For example, the black turtle of the eastern Pacific (*Chelonia agassizii*) is phylogenetically indistinct from the widespread green turtle (*Chelonia mydas*), however phylogenetic analysis shows that population genetics were split into Atlantic and Indian/Pacific populations by the Panama land bridge (Karl and Bowen 1999). Despite this, the black turtle has retained species status for over a hundred years on the strength of shell colour and minor morphological differences, and the dire conservation status of the black turtle has also been invoked as an argument for preserving species status (Mrosovsky 1983, cited in Karl and Bowen 1999). For Bowen and Karl (1999) this situation highlights extremely important underlying issues in conservation biology, in particular, the misuse of scientific findings to promote conservation goals, and ultimately the deeper tension between science and advocacy in conservation; “should legitimate scientific results be withheld, modified, or ‘spun’ to serve conservation goals? Emphatically, we say no. Conservation goals will change with time, but scientific principles should not” (1999:1015).

From an ethical standpoint, in relation to the black turtle controversy, Schrader-Frechette and McCoy (1999) argue that “even if there are some grounds for expanding conservation biologists’ responsibilities for the common good ... scientists are not ethically justified in using any means whatsoever to achieve desirable consequences” (1999:1011). They also argue that conservation biologists do not appear to have the grounds for paternalism in the black turtle case because it involves value judgments (not merely professional expertise) about the importance of conservation and how to deal with uncertainty; and that there is also a

“prudential reason for being truthful and unbiased: the public will find out, and the misrepresentations will not be successful anyway” (1999:1012). The case of the white-flipped penguin appears remarkably similar to the black turtle; a longstanding morphological difference has been undermined by lack of phylogenetic distinctiveness, endangered status has been proposed despite the lack of evidence for species status, and scientific results have been modified and “spun” to serve conservation. We agree with Shrader-Frechette and McCoy (1999:1011) that “scientists are not ethically justified in using any means whatsoever to achieve [what they perceive as] desirable consequences”.

Conclusion

While recently developed inscription devices are more able to detect variation within avian and other animal populations, the ways that variation is interpreted is dependent on the configuration of the scientific hinterland. The “reality” of species is not purely a biological question, but also has philosophical and social dimensions. Adopting an artefactual constructionist framework illustrates how the “reality” of species is constituted thoroughly by the inscription devices used in the practices of taxonomic science. This approach also shows how claims about the reality of particular species need to be congruent with the broad hinterland of taxonomic science, which has been continually changing since Greek philosophers first suggested the idea of species. But the hinterland of taxonomic science is not value-free. Changes to the hinterland are influenced in part by shifts in the interests, concerns and practices of the socially networked scientists who create and maintain the hinterland. They are also affected by broader cultural and political imperatives, in this case those associated with nature conservation. The practice of characterising some taxa as endangered, and the scientific, political and ethical manoeuvrings that are part of this practice, are an important element in the definition and elaboration of species concepts and the broader hinterland in which they are interpreted.

Acknowledgements

We thank Judi H. Miller of the School of Education, University of Canterbury, for her helpful comments on an earlier draft of this paper, and Adrian Paterson of the Faculty of Agriculture and Life Sciences, Lincoln University, for discussions about DNA analysis, and a copy of an early draft of a forthcoming article.

References

- Agapow, P., O. Beninda-Emonds, K. Crandall, J. Gittleman, G. Mace, J. Marshall and A. Purvis
2004. "The impact of species concept on biodiversity studies. *The Quarterly Review of Biology* 79(2), pp. 161-179.
- Baillie, J., C. Hilton-Taylor and S. Stuart
2004. *The IUCN Red List of Threatened Species: a global species assessment*. IUCN.
<http://iucn.org/ssc/red_list_2004> (accessed 20/6/07).
- Baker, A., S. Pereira, O. Haddrath and K. Edge
2006. "Multiple gene evidence for expansion of extant penguins out of Antarctica due to global cooling." *Proceedings of the Royal Society* 273, pp. 11-17.
- Banks, J., A. Mitchell, J. Waas and A. Paterson
2002. "An unexpected pattern of molecular divergence within the blue penguin (*Eudyptula minor*) complex." *Notornis* 49, pp. 29-38.
- Banks, J., R. Cruickshank, G. Drayton and A. Paterson
2008. "Few genetic differences between Victorian and Western Australian blue penguins, *Eudyptula minor*." *New Zealand Journal of Zoology* 35, pp. 265-270.
- Boelens, B. and M. Watkins
2003. *Whose bird? Common bird names and the people they commemorate*. New Haven: Yale University Press.
- Bowen, B. and S. Karl
1999. "In war, truth is the first casualty." *Conservation Biology* 13(5), pp. 1013-1016.
- Braun, B. and N. Castree
1998. *Remaking reality: nature at the millenium*. London: Routledge.
- Challies, C.
1998. "White-flipped penguin taxon data sheet" in S. Ellis, J. Croxall and J. Cooper (eds.) *Penguin conservation assessment and management plan*. IUCN/SSC Conservation Specialist Breeding Group: Apple Valley, MN 55124 USA.
2001. "Dynamics of pre-laying attendance and egg formation in the white-flipped penguin." Paper presented at *Oamaru Penguin Symposium*, 21-22 June 2001.
- Claridge, M., H. Dawah and M. Wilson
1997. "Practical approaches to species concepts for living organisms" in M. Claridge, H. Dawah and M. Wilson (eds.) *Species: the units of biodiversity*. London: Chapman & Hall.

Collar, N.

1996. "Species concepts and conservation: a response to Hazevoet." *Bird Conservation International* 6, pp. 197-200.

Cracraft, J.

1989. "Speciation and its ontology: empirical consequences of alternative species concepts for understanding patterns and processes of differentiation" in D. Otte and J. Endler (eds.) *Speciation and its Consequences*. Sunderland, Mass: Sinauer Associates.

2000. "Species concepts in theoretical and applied biology: a systematic debate with consequences" in Q. Wheeler and R. Meier (eds.) *Species concepts and phylogenetic theory: a debate*. New York: Columbia University Press.

Darwin, C.

1859. *On the origin of species by means of natural selection, or the preservation of favoured races in the struggle for life, 1st edition*. London: John Murray.

Demeritt, D.

1998. "Science, social constructivism and nature" in B. Braun and N. Castree (eds.) *Remaking reality: nature at the millennium*. London: Routledge.

2002. "What is the 'social construction of nature'? A typology and sympathetic critique." *Progress in Human Geography* 26, pp. 767-790.

Ellis, S.

1999. "The penguin conservation assessment and management plan: a description of the process." *Marine Ornithology* 27, pp. 163-169.

Gamauf, A., J-O. Gjershaug, N. Rov, K. Kvaloy and E. Haring, E.

2005. "Species or sub-species? The dilemma of taxonomic ranking of some South-East Asian hawk-eagles (genus *Spizaetus*)." *Bird Conservation International* 15, pp. 99-117.

Gaston, A.J.

2001. "Taxonomy and conservation: thoughts on the latest Birdlife International listing for seabirds." *Marine Ornithology* 29, pp. 1-6.

Hannigan, J.

2006. *Environmental sociology, second edition*. London: Routledge.

Harrison, R.

2002. "Species concepts" in M. Pagel (ed.) *Encyclopedia of Evolution*. Oxford: Oxford University Press, pp. 1078-1083.

Hazevoet, C. J.

1996. "Conservation and species lists: taxonomic neglect promotes the extinction of endemic birds, as exemplified by taxa from eastern Atlantic islands." *Bird Conservation International* 6, pp. 181-196.

Hocken, A.

1997. "Plumage and bill morphology variations in a population of the blue penguin (*Eudyptula minor*)." *Notornis* 44, pp. 259-263.

Karl, S. and B. Bowen

1999. "Evolutionary significant units versus geopolitical taxonomy: molecular systematics of an endangered sea turtle (genus *Chelonia*). *Conservation Biology* 13, pp. 990-999.

Kinsky, F. and R. Falla

1976. "A subspecific revision of the Australasian Blue Penguin (*Eudyptula minor*) in the New Zealand area." *National Museum of New Zealand Records* 1, pp. 105-126.

Lalas, C.

2001. "Taxonomy of blue penguins: does it matter?" Paper presented at *Oamaru Penguin Symposium*, 21-22 June.

Latour, B.

1987. *Science in Action*. Cambridge: Harvard University Press.

1999. *Pandora's hope: essays on the reality of science studies*. Cambridge: Harvard University Press.

Latour, B. and S. Woolgar

1986. *Laboratory life: the construction of scientific facts, second edition*. Princeton: Princeton University Press.

Law, J.

1994. *Organising modernity*. Oxford: Blackwell.

2004. *After method: mess in social science research*. London: Routledge.

Law, J. and M. Lien

2010. "Slippery: field notes on empirical ontology." Available at <<http://www.sai.uio./english/research/projects/newcomers/publications/working-papers-web/Slippery%20revised%2013%20WP%20version.pdf>>. Accessed 29/9/2010.

Lorimer, J.

2006. "What about the nematodes? Taxonomic partialities in the scope of UK biodiversity conservation." *Social and Cultural Geography* 7(4), pp. 539-558.

Mallet, J.

2001. "Species, concepts of" in S. Levin *et al.* (eds.) *Encyclopaedia of Biodiversity, Volume 5*. London: Academic Press, pp. 427-440.

Mayden, R.L.

1997. "A hierarchy of species concepts: the denouement in the saga of the species problem" in M. Claridge, H. Dawah and M. Wilson (eds.) *Species: the units of biodiversity*. London: Chapman & Hall.

Mayr, E.

1942. *Systematics and the origin of species from the viewpoint of a zoologist*. New York: Columbia University Press.

2000. "The biological species concept" in Q. D. Wheeler and R. Meier (eds.) *Species concepts and phylogenetic theory: a debate*. New York: Columbia University Press.

Pigliucci, M. and J. Kaplan

2006. "Species as family resemblance concepts: the (dis-)solution of the species problem?" in Pigliucci and Kaplan (eds.) *Making sense of evolution: the conceptual foundations of evolutionary biology*. Chicago: The University of Chicago Press.

Penhallurick, J. and M. Wink

2004. "Analysis of the taxonomy and nomenclature of the Procellariiformes based on complete nucleotide sequences of the mitochondrial cytochrome *b* gene." *Emu* 104, pp. 125-147.

Petersen, A. and A. Novarro-Sigüenza

1999. "Alternate species concepts as bases for determining priority conservation areas." *Conservation Biology* 13, pp. 427-431.

Peucker, A. J., P. Dann and C.P. Burridge

2009. "Range-wide phylogeography of the little penguin (*Eudyptula minor*): evidence of long distance dispersal." *The Auk* 126, pp. 397-408.

Remsen, J. V.

2005. "Pattern, process, and rigor meet classification." *The Auk* 122, pp. 403-413.

Rheindt, F and J. Austin

2005. "Major analytical and conceptual shortcomings in a recent taxonomic revision of the Procellariiformes – a reply to Penhallurick and Wink (2004)." *Emu* 105, pp. 181-186.

Robertson, C. and G. Nunn

1998. "Towards a new taxonomy for albatrosses" in C. Robertson & R. Gales (eds.) *Albatross biology and conservation*. Chipping Norton: Surry Beatty and sons.

Sangster, G.

2000. "Taxonomic stability and avian extinctions." *Conservation Biology* 14(2), pp. 579-581.

Schrader-Frechette, K. and E. Mc Coy

1999. "Molecular systematics, ethics, and biological decision making under uncertainty." *Conservation Biology* 13(5), pp. 1008-1012.

Sutherland, W.

2000. *The conservation handbook: research, management and policy*. Oxford: Blackwell Science.

Tavares, E. S. and A.J. Baker

2008. "Single mitochondrial gene barcodes reliably identify sister-species in diverse clades of birds." *BMC Evolutionary Biology* 8, 81. Available from:
<<http://www.biomedcentral.com/1471-2148/8/81>>.

Zink, R. M.

2004. "The role of subspecies in obscuring avian biological diversity and misleading conservation policy." *Proceedings of the Royal Society* 271, pp. 561-564.

2006. "Rigor and species concepts." *The Auk* 123(3), pp. 887-891.