Defining a “population” under the Endangered Species Act*

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Abstract

The original form of this article was submitted on March 31, 1995 as the Direct Service Industries’ comments to draft regulations proposed by the U.S. Fish and Wildlife Service (FWS) and the National Marine Fisheries Service (NMFS, now NOAA Fisheries). The two agencies wanted to define “distinct population segments” under the Endangered Species Act (ESA) so that they would have a consistent definition for their regulatory decisions. Unfortunately, administrative convenience and political accommodation replaced science in the definition. The two agencies also gave different names to the same contrived groupings. The U.S. Fish and Wildlife Service considers a “discrete vertebrate population segment” to be a species under the ESA while the National Marine Fisheries Service calls the equivalent group an “evolutionarily significant unit”. The draft regulations were adopted as permanent and have been in place ever since.

Introduction

For most people (taxonomists, systematists and resource agency staffers excepted) a species is a unique grouping of living organisms capable of reproducing more of themselves. Perhaps this is the concept held by those who wrote the Endangered Species Act (ESA). However, it was determined by the resource agencies responsible for implementation of the ESA that “species” was too coarse a taxon. The result is a policy that considers populations (that is, local assemblages of individuals within a species at a defined location) as species under the ESA. In order to apply this redefinition the agencies needed a policy to identify these populations. This policy uses three elements to be considered in decisions regarding the status of distinct population segments as endangered or threatened under the ESA. The first two elements – **discreteness** and **significance** – can be discussed in scientific terms. The third element “**is the population segment, when treated as if it were a species, endangered or threatened**” represents circular reasoning and should have be dropped from further consideration by the resource agencies.

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In this article I discuss the scientific meaning of the discreteness and significance elements, provide the references to pertinent published research which support my conclusions, and comment on the policy relative to the National Marine Fisheries Service's (NMFS) Pacific salmon policy.

My two conclusions are: the policy cannot be scientifically justified or defended, and it will impede meaningful attempts to resolve existing or future problems.

The policy's fundamental assumption that all vertebrate species can be separated into biologically or ecologically meaningful *distinct population segments* has not been justified. This justification does not appear either in the published policy nor in the peer-reviewed scientific literature. To a large extent, this assumption fails because the issue of the relatives influences of nature versus nurture remains unresolved. In addition, grouping of individuals or population segments can be based on appearance, behavior, or genetics. Each of these characteristics would be more or less important in assigning individuals to each group, depending upon the species.

Discreteness

This element is the more important of the two. By definition (policy), if a population segment is not discrete it does not fall under the ESA. The idea is that this element can be satisfied by meeting either of two criteria: being *markedly separated* from other populations of the same taxon, or it is *delimited by international boundaries*.

Markedly separated

Whether a population segment is markedly separated from other populations of the same taxon depends on the definitions of *species* and *subspecies*. For a complete discussion of these concepts (without being overwhelmed by technical jargon), I recommend the article by McFetridge (1994; citation at the end of this article).

Classifying animals into species is the biological field of study called taxonomy. Taxonomy is imperfect and imprecise; arbitrary because it is not experimental but observational. Whether by gross observation or by measuring physical characteristics of animals, we can distinguish differences. For example, a deer, an elk, and a moose will be recognized as different by most people. The significance of these differences has meaning only under the Biological Species Concept (BSC) as defined by Mayr (1940). The BSC says "that groups of actually or potentially interbreeding populations that are reproductively isolated from other such groups are a species." That is, a species is the smallest unit of reproductive isolation.

There are two critical consequences for the proposed policy based on this definition. The first consequence results from the fact that reproductive isolation has many mechanisms. These mechanisms may be physiological (that is, elephants and mice cannot interbreed because of structural and physiological differences), spatial (the animals are not in the same place), temporal (they are not capable of reproduction at the same time), or behavioral (one species does not recognize and respond to breeding behavior of another species). The second critical consequence is that no level of populations smaller than the species has any scientific support. Most importantly, this means that the smallest scientifically defensible distinct vertebrate population segment is the species.

To briefly illustrate why this is important, consider the legal and management confusion of trying to work with subspecies, hybrids, or distinct vertebrate population segments. Arguably, there is no biological difference among these terms. However, what happens if the reproductive isolation mechanism fails and two different subspecies or species interbreed to produce a hybrid (*e.g.*, mule deer and white tail deer or rainbow and cutthroat trout)? Is the hybrid another subspecies? Could a population of these hybrid individuals be a distinct vertebrate population segment considered for listing under the ESA? These questions should be raised about the policy as adopted. Not answering these questions could prevent meaningful efforts to increase the size of species' populations for a long time.

In a population of any given species, individuals differ in physical appearance; no two animals are exactly alike. "Therefore, we may say, a population of a species is largely distinct but it is impossible to assign any individual to a population with absolute certainty" (McFetridge 1994, page 14). This means that an individual seen by itself, and away from its context (for example, in a photograph), cannot always be unambiguously assigned to a distinct vertebrate population segment.

This is neither a new idea nor one which has been demonstrated to be false. Wilson and Brown (1953) quote from a 1949 study by Moore that "there is no generally accepted and easily applied criterion for recognizing subspecies." Since that time, no one in the scientific community has described such criteria. This federal policy appears to attempt by administrative declaration what biological scientists have not been able to accomplish in 50 years of taxonomic, anatomical, evolutionary, and population genetics research.

It is both credible and easy to make the scientific case that all animals are hybrids to some degree because all parents are slightly different from each other in both appearance and genetics. This weakens the attempt to develop a scientific case that there is a consistent, measurable basis for subspecies or any other grouping smaller than species.

It is absolutely essential that the fishery services understand and accept the differences between managing populations in different geographic areas so as to maintain genetic diversity and declaring them to be definably different taxonomic entities.

International boundaries

Then there is the problem of the second discreteness criterion: *delimited by international governmental boundaries*.

Vertebrate species do not respect political boundaries. They respond to habitat, climate, and biological interactions (predation, competition) and will seek places to survive. Managing such populations based on the man-made concept of an international boundary is a reflection of political reality rather than scientific reality. Not having a policy which separates the two realities reduces effectiveness in both arenas.

This same criterion focuses on exploitation differences. How can differences in exploitation in separate governmental jurisdictions be the basis for distinguishing biological population segments? If exploitation is the same on both sides of a governmental boundary does this mean there are no distinct vertebrate population segments? I hope this is not the intent of the policy. It is possible that this language could be construed as promoting exploitation or using harvest policies as a criterion for listing a species. It is my opinion that this criterion is purely politically motivated and not based on sound biological or ecological principals.

Significance

If a population segment is demonstrably distinct, then its significance needs to be evaluated to determine whether or not it is needed to conserve genetic diversity.

Species evolve because populations are isolated by space or time. Animal species have ranges of varying size. In general, throughout the species' range the physical and biological environment varies. Some areas are optimal for the species' survival, some areas are less well suited, and other areas are marginal. In general, populations in the optimal areas have the greatest adaptability to survive environmental change. That is, they contain individuals with collectively the genetic makeup to successfully exploit a wide range of habitats and environmental conditions. On the other hand, those populations in marginal or extreme habitats tend to become more narrowly adapted to the specific, local environmental conditions. This results in those populations having a reduced ability to survive changes in their environment.

There are implications of this ability to adapt to change for listing, reclassifying, delisting, or managing species populations under the ESA. These implications are particularly germane to the significance element of the fisheries agencies' policy.

For each animal species, populations may have differences in appearance and genetics which reflect their location within the distributional range. Usually, animals from populations in optimal habitats could be relocated to marginal habitats with relatively high chances for continued survival and increase in number. Migration is how animal species exploit new habitats or relieve overpopulation pressures. Within a limited number of generations, these transplants could assume the physical and genetic adaptations to the environment shown by the previous populations in that habitat. Conversely, the probability of successfully moving individuals from one marginal habitat to another, different, marginal habitat would be low because of environment-specific adaptations that are highly specialized. Often, this probability is low enough for the attempted transplant effort to fail.

It is this context which I have used to evaluate this portion of the policy. The four criteria of the significance element are:

1. "Persistence of the discrete population segment in an ecological setting unusual or unique for the taxon."

2. "Evidence that loss of the discrete population segment would result in a significant gap in the range of a taxon."

3. "Evidence that the discrete population segment represents the only surviving natural occurrence of a taxon that may be more abundant as an introduced population outside its historic range."

4. “Evidence that the discrete population segment differs markedly from other populations of the species in its genetic characteristics.”

As pointed out in the previous section, the lowest taxon which can be supported or managed scientifically is the species. Therefore, as written, these criteria address inappropriate issues.

The first criterion can be construed as promoting the introduction of exotic species. For example, Africanized honey bees or zebra mussels. With no natural enemies or other controls on their populations, these exotics displaced indigenous native species (the bees) and/or become both costly pests and the focus of expensive attempts to exterminate them (the mussels). On the other hand, this criterion could also refer to a highly specialized population not in the historic range of the species or in a highly marginal environment. It is easy to imagine such a population evolving into a distinct new species. After all, “persistence in an ecological setting unusual or unique for the taxon” implies reproductive isolation by space and time.

The second criterion as written has no scientific meaning. The policy does not define *significant*. Nor does the policy explain why a gap in the range of a taxon is important. Furthermore, if a local population of a species has characteristics distinct from other local populations, it is most likely because of adaptation to the local environments. Therefore, it is also possible that replacement of this local population with individuals from other, more optimal portions of the species’ range would produce a gap filling population which evolves the same characteristics as the original inhabitants.

The third criterion also appears to be a stretch of administrative logic without a scientific foundation. What is a *natural occurrence* of a species? Reading this makes me wonder how many *un*natural occurrences of species we have wandering around. If there is a viable population of a species outside its *historic* range does that, alone, make it worthy of listing under the ESA? If the population is self-sustaining and has measurable genetic flexibility, then the population demonstrates its ability to survive despite human perturbance. Its historic range might now be a shopping mall or within the urban growth boundary of a metropolitan area.

Criterion four is a tautology. Genetic diversity by definition means differences within a species. This is what is observed among all animal species and among all individuals. This criterion also is based on *markedly* different genotypes. Is *markedly* more quantitative and scientific than *significant*? This fuzzy (subjective) language will only result in lawyers and judges making scientific decisions because the science cannot be supported. In the case of this administrative policy, and probably for realistic ESA management purposes, trying to define taxonomic levels finer than species cannot be scientifically supported. Further on this criterion, genetic differences produce appearance differences. Since neither appearance nor genetic differences can be taken unquestioningly as meaningful under the discreteness element, they cannot be so applied to the significance element.

Definitions and the NMFS' Fish Policy

The issues pointed out above are well illustrated by their application to Columbia River salmon by NMFS. In particular, salmonid fishes in the Columbia River basin illustrate these problems regarding distinctness.

Adult run timings (*i.e*., spring, summer, and fall chinook; summer and winter steelhead; early and late coho) are used to distinguish populations segments under the ESA, yet this trait is easily manipulated by man. Acquisition of hatchery brood stock, for example, has too often inadvertently selected for the earliest returning adults. Repeated over several generations, this has shifted the run timing (and possibly the genetic composition of Columbia River stocks) significantly. This change may be maladaptive to a naturally reproducing population. Therefore, apparent behavioral differences can be very flexible and respond to both natural and human influences.

Salmonids in the basin are managed as distinct *stocks*. Yet fertilized eggs from one hatchery have been used to supply eggs to other hatcheries throughout the basin. Since some adults do return to their natal hatcheries, it suggests that these *stocks* are not distinct units for listing under the ESA. Furthermore, strays and other hatchery-origin fish have interbred with populations of natural spawners, sometimes for many generations. If the hatchery fish had their ancestry from another part of the basin, but can produce viable offspring with local, "native" fish, it raises concerns about the utility of the distinct vertebrate population segment concept in carrying out the purposes of the ESA. The discreteness which is implied by using different "stock" designations is an artifact of human classification. It does not accurately reflect differences in the fish which must be preserved to conserve genetic diversity in the species themselves.

Research invalidates these definitions

In the first two sections of this article I presented the case for considering animals at the species level and not lower taxonomic refinements. I have included key references to published research to support my reasoning. It is appropriate in this section to consider the following information.

Fish biologists at the University of Washington (under the direction of Dr. Thomas P. Quinn) and the New Zealand National Institute of Water and Atmospheric Research have conducted research to measure the rate of evolution in salmon. The study focuses on a single group of Sacramento River fall chinook salmon which was transferred to New Zealand near the beginning of the last century.

Although the transferred fish were released from a hatchery in only one river, within about 10 years they had colonized that river system and dispersed up to 230 kilometers (144 miles) away among several different river systems along the same coast. These dispersed populations were (and still are) self sustaining. Populations within each system have developed unique characteristics which distinguishes each group from the others in genetic composition, appearance, and behaviors.

Not yet known is the amount of genetic plasticity (that is, inherent adaptability) in these populations or how this separation came about. In other words, we do not now know if the fish changed genetically (producing appearance and behavioral changes) in response to being in different river systems. Or, if the populations are in the different river systems because the original transplants had the genetic capability to thrive in all of them. From work with other species (including humans), it is most likely a combination of both explanations.

Early results of this research project provide evidence that these populations are now genetically distinct. This suggests that the time required for population adaptations and population segmentation may be in decades rather than centuries or longer. If these results are confirmed, they have major implications for the ESA, this administrative policy, and the effective management of Pacific salmonids.

If individuals from a source population can be successfully established in a totally different geographic location, then the prospects for success in geographically closer restockings should be even greater. For Pacific salmon this closer restocking has occurred in the movement of hatchery fertilized eggs around the basin. The salmon have a relatively short generation time (three to six years) and reproduce only once per generation. This life history pattern probably resulted in the evolution of a high degree of genetic plasticity (or adaptability) within the species. For the purposes of the ESA, therefore, there is no advantage to distinguishing populations at taxonomic levels lower than species. This is in addition to the lack of any scientific basis for making finer taxonomic distinctions.

Human alterations

Another component of scientific evidence bearing on the draft policy's appropriateness is human alteration of habitats and environments. Some degree of both phenotypic and genotypic variation among vertebrate populations may be due more to this manipulation than to natural evolutionary forces.

We humans have manipulated the phenotypic and genotypic makeup of our food animals and plants for a very long time. We have selectively bred individuals to increase certain desirable traits. If our selective breeding can be effective within a few generations, we should expect that our inadvertent selective pressures will also work at the same time scale. By this I mean that our activities can have the effect of selective breeding although this is not our specific or intended goal.

As an example of this unintended selective pressure, harvest policies and/or practices can easily and rapidly change Pacific salmon phenotypes (appearances). The mesh size of gill nets used in harvesting fish is very selective: smaller fish swim through the holes. Because only fish smaller than a certain size complete their journey, there is a decreasing size of adults returning to five hatcheries in Washington state. Over the past 20 years, the average size of returning adults has dropped 11.3 percent. At the extreme, average returning adult weight dropped from more than 6 pounds to less than 4.5 pounds.

Summary

The FWS and NMFS policy not not have been adopted. Of the three elements to be considered, discreteness depends on the existence of taxonomic levels finer than species; there is no scientific support for this idea. Significance (as defined by the four criteria in the draft policy) cannot be quantitatively determined. And the idea of artificially raising an arbitrary subspecies or hybrid to the specific taxonomic level is circular, capricious, and scientifically indefensible.

The NMFS policy of considering Pacific salmonids in terms of this policy has not resolved any issues nor brought species any closer to delisting under the ESA. The decisions based on "stocks" are arbitrary (or management) declarations analogous to *evolutionarily significant units* or *distinc*t *vertebrate population segments*.

References

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