Developing a Criterion for Delisting the Southern Sea Otter under the U.S. Endangered Species Act

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Abstract: *Recent surveys of recovery plans indicate that criteria, such as population sizes, for delisting species from the U.S. Endangered Species Act (ESA) are often unrealistically low by scientific standards. We describe the delisting criterion for the threatened southern sea otter (*Enhydra lutris nereis*) developed by the Southern Sea Otter Recovery Team. A major oil spill is the most serious threat to this sea otter population. After extensive modeling of oil spills, the recovery team concluded that it was not scientifically defensible to develop a delisting criterion in terms of a single probability of extinction over a specified time period. Instead, the team decided to define a size at which it would consider the population endangered and to consider the population threatened as long as a major oil spill might reduce it to that size. The effective population size (*N_e*) for endangered status was set at 500, estimated to be about 1850 otters. Using a spill the size of the* Exxon Valdez *spill (250,000 bbl), the oil spill model was iterated to generate a frequency distribution of the number of sea otters contacted by oil, from which the team estimated that less than 800 otters would be killed by 90% of the simulated spills. Thus, the delisting criterion was set at 1850 + 800 = 2650 individuals. There have been several proposals to improve the Endangered Species Act by providing quantitative guidance, in the form of specific probabilities of extinction within some time frame or specific criteria like those used by the World Conservation Union as to the levels of extinction risk represented by the terms "threatened" and "endangered." Experiences of the Sea Otter Recovery Team indicate that guidelines should not be overly rigid and should allow flexibility for dealing with specific situations. The most important consideration is to appoint a recovery team that is both technically well qualified and unconstrained by pressures from management agencies.*

Desarrollo de un Criterio Para Desenlistar la Nutria Marina del Sur Bajo el Acta de Especies Amenazadas de los Estados Unidos

Resumen: *Estudios recientes de planes de recuperación indican que los criterios (tamaño de poblaciones) para desenlistar especies del Acta de Especies Amenazadas de los Estados Unidos son usualmente poco realistas de acuerdo a estándares científicos. Describimos los criterios para desenlistar la nutria marina amenazada (*Enhydra lutris nereis*) desarrollado por el Equipo de Recuperación de la nutria del mar del sur. Un derrame grande de petróleo es la amenaza más seria para estas poblaciones de nutrias. Después de un modelado extensivo de derrames de petróleo, el equipo de rescate concluyó que no era científicamente defendible el desarrollo de criterios para desenlistar en términos de una probablilidad única de extinción sobre un periodo de tiempo específico. En su lugar, el equipo decidió definir un tamaño al cual se consideraría la población amenazada en base a que un derramme grande podría reducirla a dicho tamaño. Los criterios para amenaza fueron fijados a un* N_e *de 500, estimado a ser de aproximadamente de 1850 nutrias. Usando un derrame del tamaño del Exxon Valdez (250,000 barriles) el modelo del derrame del petróleo fue diseñado para generar una distribución de frecuencia del número de nutrias marinas alcanzadas por el petróleo, del cual el equipo estimó que menos de 800 nutrias morirían en un 90% de los derrames simulados. Por lo tanto, el criterio para desenlistar fue fijado en 1850 + 800 = 2650 individuos. Han existido diferentes propuestas para elaborar el acta de especies amenazadas mediante la provisión de orientación cuantitativa, en forma*

Manuscript submitted September 19, 1995; revised manuscript accepted July 11, 1996.

de probabilidades especificas de extinción dentro de un marco de tiempo o criterios específicos como aquellos usados por IUCN, hasta los niveles de riesgo de extinción representados por los términos "amenazado" y "en peligro." Experiencias del equipo de recuperación de nutrias marinas indican que los lineamientos no deben ser demasiado rígidos y deberían permitir flexibilidad para enfrentar situaciones específicas. La consideración más importante es el recalcar que el equipo de recuperación es técnicamente bien calificado y no está restringido por agencias de manejo.

Introduction

The U.S. Endangered Species Act (ESA) specifies that the recovery plan developed for each species shall include "objective, measurable criteria which, when met, would result in a determination. . .that the species be removed from the list" (ESA Section 4, §16 U. S. C. 15.33 (f) (1)). Thus, delisting criteria should specify conditions under which a species is no longer considered threatened and should indirectly specify acceptable levels of extinction risk. Because neither the act nor the implementing agencies (the U.S. Fish and Wildlife Service [USFWS] and the National Marine Fisheries Service) specify the level of risk at which a species shall no longer be considered threatened, the authors of each recovery plan must make an independent judgment as to this level of risk.

Plans may be written by agency employees, independent experts, or recovery teams of varied composition. A survey of the composition of recovery teams appointed by the USFWS found that 77% of team members were either employees of the USFWS or the state government (Miller et al. 1994). Thus, it is not surprising that variation in the backgrounds of plan authors has resulted in varied judgments regarding acceptable levels of risk. Recent surveys of recovery plans have concluded that delisting criteria, such as population sizes, are often unrealistically low by scientific standards (Tear et al. 1993, 1995). For example, almost one-third of the original plans had delisting criteria set at or below the population size existing at the time the plan was written (Tear et al. 1993), and 73% of the plans for vertebrates "set population goals so low that the species would remain in a vulnerable state even if recovery goals were achieved" (Tear et al. 1995).

The Southern Sea Otter Recovery Team consisted of scientists with varied expertise, including sea otter biology, the ecology of nearshore communities, toxicology, physiology, population dynamics, and conservation biology. Three of the eight members were employees of the federal government, but none worked for the USFWS; one worked for the California Department of Fish and Game. Part way through the recovery team's deliberations, the USFWS provided the recovery team with a group of technical consultants to represent the "stakeholders" in the sea otter issue: the California Department of Fish and Game, the California Coastal Commission, the U.S. Coast Guard, the Western States Petroleum Association, Texaco, the Central California Council of Diving Clubs, the California Urchin Producers Association, the California Abalone Association, the Center for Marine Conservation, and the Friends of the Sea Otter.

We describe the delisting criterion this recovery team proposed for the southern sea otter (*Enhydra lutris nereis*) and the process by which it was developed. This case study is of particular relevance to general recovery planning issues, both because it exemplifies many of the recent suggestions in the scientific literature for improving the recovery planning process and because it documents the practical difficulties of carrying out other such suggestions. Our account should be helpful to those developing delisting criteria for other threatened species.

The Southern Sea Otter Population

The biology of sea otters has been reviewed in detail by Riedman and Estes (1990) and is summarized in the draft of the Southern Sea Otter Recovery Plan (Anonymous 1995). Sea otters are a keystone species in their nearshore environment (Power et al. 1996): by preying on herbivorous macroinvertebrates such as sea urchins, they promote the growth of kelp, which in turn has a variety of community- and ecosystem-level consequences (Estes 1996).

The southern, or California, sea otter population was hunted to near extinction for its luxuriant fur but has partially recovered since first receiving legal protection in 1911. Sea otters are relatively easy to count from shore, and the population has been surveyed by the same methods once or twice annually since 1982. These data, together with a reanalysis of earlier survey data (Estes et al. 1995), indicate that the population increased from several hundred animals in the late 1930s to approximately 1750 animals between 1973 and 1976, declined to a minimum of approximately 1250 animals in 1983, and then resumed growth (Fig. 1). The population currently contains about 2400 individuals, increases about 5% per year, and ranges along approximately 370 km of the central California coast (Fig. 2). A recently established colony at San Nicolas Island (Fig. 2) consists of about 17 individuals; its future prospects are uncertain.

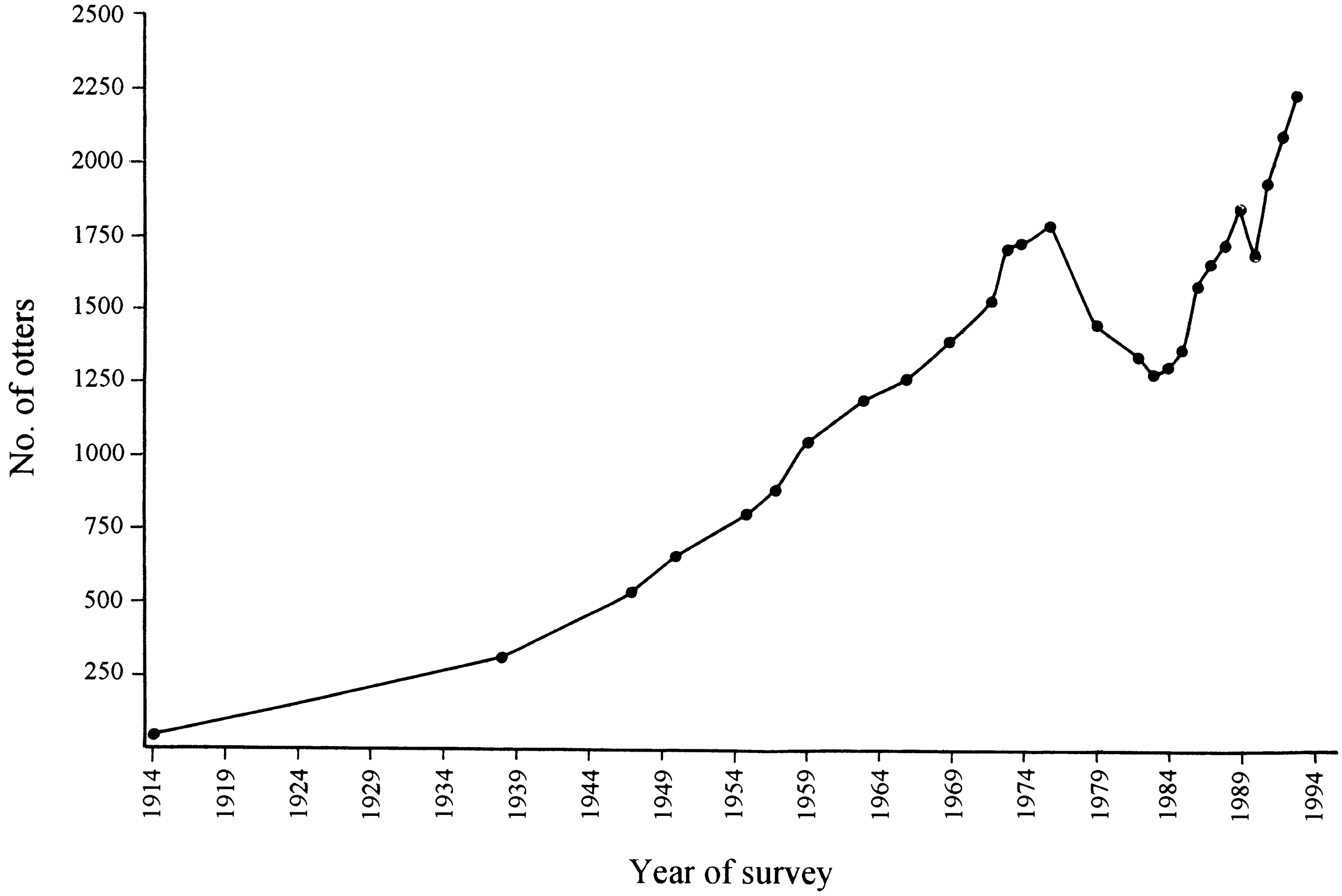

Figure 1. Growth of the California sea otter population, based on range-wide surveys by the National Biological Service and the California Department of Fish and Game. The decline in the population during the 1970s was due to incidental take of sea otters in gill and trammel nets.

The main threats to the population are habitat degradation, including oil spills and other environmental contaminants, and mortality caused by humans, including entanglement in fishing gear and shooting. Because sea otters depend upon their fur to maintain body temperature in their cold marine environment, they are very vulnerable to oil spills. A major oil spill from one of the tankers that travel along the California coast could kill large numbers of sea otters and is considered the most serious threat to the population.

The population is listed as threatened under the ESA and thus is automatically considered "depleted" under the Marine Mammal Protection Act (MMPA) of 1972 (16 U. S. C. §1361 [et seq.]). A depleted population is defined in the MMPA as one that contains fewer individuals than its optimum sustainable population (OSP) level, where OSP has been subsequently interpreted as a population level between 60% of carrying capacity and carrying capacity (Gerrodette & DeMaster 1990). Therefore, the threshold for classifying a population as depleted usually is considerably larger than the threshold for classifying a population as threatened.

Like many other threatened and endangered species, sea otters are the subject of political controversy due to differing human values. Nongovernmental conservation organizations tend to favor continued growth of the sea otter population, whereas those engaged in shellfish fisheries, who are in direct competition with sea otters for prey such as abalones and sea urchins, tend to favor curtailment of population growth. Because of the otter's vulnerability to oil spills, the species also poses a problem for those favoring additional oil production within its range.

A New Recovery Strategy

The USFWS's original recovery plan for the California sea otter (U.S. Fish and Wildlife Service 1982), developed in the early 1980s by state and federal biologists, called for the establishment of one or more new colonies to minimize the risk that an oil spill would simultaneously affect the entire population. In 1989 the USFWS established a recovery team to revise the plan. The re-

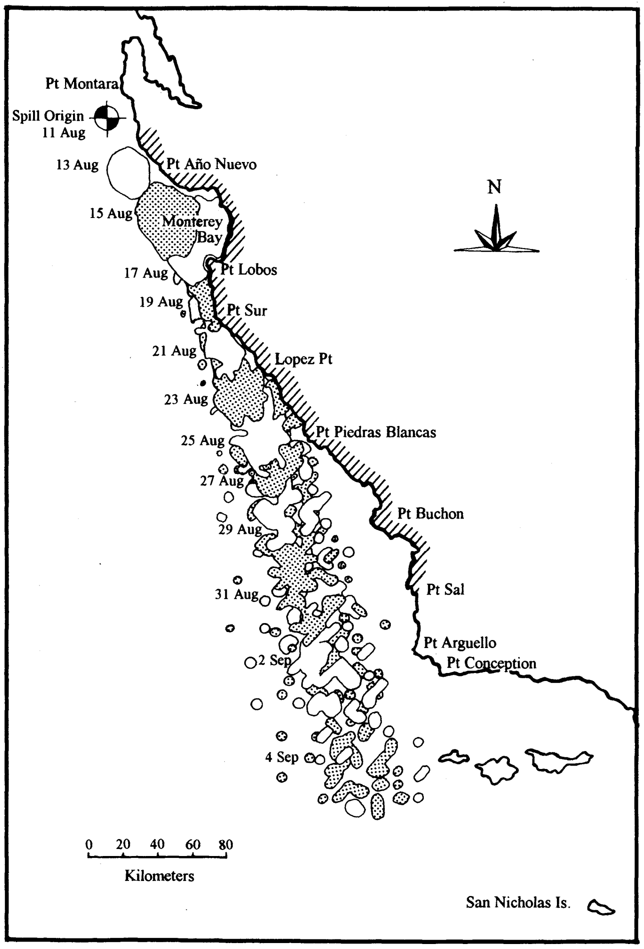

Figure 2. Area contacted by the 90th percentile case among 200 simulated 250,000-bbl oil spills. Based on Ford and Bonnell (1995). Diagonal hatching indicates the range of sea otter population.

covery team, after reviewing the history and status of California sea otters, recommended a new recovery strategy of passively allowing the mainland population to continue growing in size and increasing in geographical range until it reached a level that would ensure its persistence in the event of a major oil spill or a series of small spills (Anonymous 1995).

The proposed new strategy was based on several events that occurred after the original strategy was developed. First, in 1982 when the establishment of new colonies was recommended, the sea otter population was not growing; the reason for its lack of growth was unknown. Shortly thereafter it became evident that large numbers of sea otters were being killed as the result of incidental entanglement in gill and trammel nets (Estes et al. 1995). Subsequent restrictions on net fishing reduced the number of these losses, and the population began to grow again.

Second, the translocation to San Nicolas Island proved much more difficult than expected. From 1987 to 1991 the USFWS removed 139 sea otters from the mainland population and released them at the island. Most of the otters left the island, some of them returning to their capture locations. In 1995 there were only about 17 otters at the island, a colony size that has persisted since about 1992 (Anonymous 1995).

Third, the 1989 *Exxon Valdez* oil spill in Alaska confirmed many of the worst fears about the consequences of such events for sea otters. The spill was uncontrollable and spread over 670 km—a length greatly exceeding the present length of coastline occupied by both the mainland sea otter population in California and the small colony at San Nicolas Island (Fig. 2). At least several thousand Alaskan sea otters were killed by the spill (Garrott et al. 1993; DeGange et al. 1994). Furthermore, efforts to rehabilitate oiled otters were of little or no value to the Alaskan population (Estes 1991).

The recovery team concluded that the San Nicolas colony did not provide a reasonable safeguard against a major spill and that the fastest way to achieve recovery of the southern sea otter population was to let the mainland population grow without removing additional animals to establish new colonies.

Modeling Oil Spill Risks

Because oil spills are considered the greatest risk to the southern sea otter population, the recovery team sought to define this risk as accurately as possible. The USFWS assisted by contracting with independent experts for extensive modeling of oil spills along the California coast (Ford & Bonnell 1995) and the development of models that related otter survival to time and distance from the origin of the *Exxon Valdez* spill (Brody et al. 1996).

Ford and Bonnell (1995) considered the expected number of oil spills along the California coast over the next 30 years, the relationship between spill size and the number of otters contacted by oil, and the likely number of otters contacted by spills occurring at different points along the coast and at different distances offshore. They used the computer model OSRISK to perform the spill trajectory analysis. OSRISK accepts wind and surface current information from external sources and combines them with geographic data describing animal distribution (in this case obtained from range-wide sea otter surveys conducted by state and federal biologists) and oil spill behavior. It further simulates an oil spill occurring under a specific set of conditions, taking into account wind conditions, surface currents, and a variety of other factors of lesser importance.

The expected number of oil spills greater than 1000-bbl along each of the four tanker routes off the central and northern California Coast over the next 30 years ranged from 0.1 to 3.1. The relationship between spill size and the number of otters contacted was nonlinear:

despite a 32-fold increase in spill volume, only two to three times as many otters would likely be contacted by a 1,000,000-bbl spill as by a 31,250-bbl spill. The largest likely spill off California was estimated at 350,000 bbl, based on the size of tankers using the San Francisco Bay and south coast tanker routes. Spill trajectories varied greatly with the weather conditions prevailing during the spill; many spills went out to sea without contacting otters. The effect of the distance offshore at which the spill occurred varied with the point along the coast at which the spill occurred. The greatest risk to otters was from spills in the northern part of the range, with a spill off Point Año Nuevo contacting the largest number of otters.

Faced with these complex results, uncertainties concerning the various assumptions required by the model, and the seemingly endless possibilities for modeling oil spills, the recovery team began to question the feasibility of accurately determining the risk posed by oil spills to sea otters over the next 30 years. It seemed more feasible to estimate the distribution of the number of sea otters that would be contacted by a major spill by iterating the model with a constant spill size and randomly selected real-time input parameters. But this approach forced the recovery team to choose a single spill size to represent a "major" spill. The recovery team asked the modelers to simulate spills of 250,000 bbl because (1) a spill of this magnitude had occurred in sea otter habitat (the *Exxon Valdez*) and (2) although larger spills were possible in California, the distribution of estimated spill volumes indicated that they were highly unlikely.

Ford and Bonnell (1995) ran 200 simulations of a spill this size that occurred at randomly selected sites within 25 nm of shore under real-time weather conditions with the start date selected at random. These simulated spills were ranked by the number of otters contacted (Fig. 3); the recovery team considered the 90th percentile case and the 100th percentile case in detail. The 90th percentile case (Fig. 2) was a spill occurring about 36 km northwest of Point Año Nuevo and driven by the real-time winds and currents of 11–31 August 1990. This spill drifted offshore on day 17, leaving most of the sea otter range south of Point Piedras Blancas untouched; it contacted 881 otters. The 100th percentile case was a spill occurring 36 km west of Point Año Nuevo and driven by real-time winds and currents recorded from 4–25 March 1991. This spill covered most of the sea otter range from Cypress Point to San Simeon Point and contacted 1820 otters.

The *Exxon Valdez* spill killed large numbers of otters but did not kill all the otters in all areas contacted by oil.

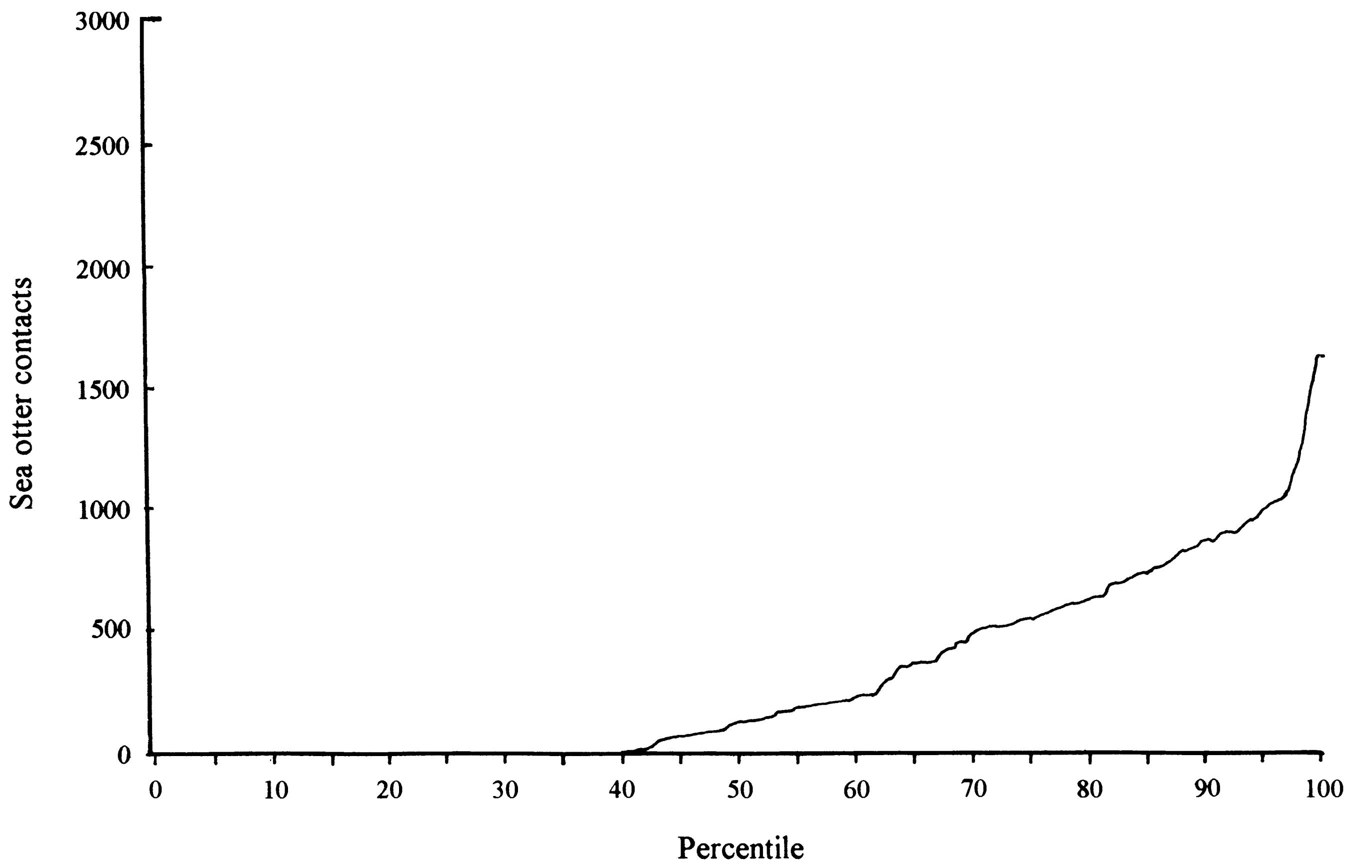

Figure 3. Distribution of the number of sea otters contacted by oil during 200 simulated 250,000-bbl oil spills along the California coast. Based on Ford and Bonnell (1995).

Thus, another major area of uncertainty concerns the proportion of southern sea otters contacted by oil that would die due to oiling. Brody et al. (1996) estimated this proportion using data on the survival of sea otters held at rehabilitation centers during the *Exxon Valdez* spill. They developed two models of otter mortality: one described the relationship between otter survival and time since the spill, and the other the relationship between otter survival and distance from the spill origin. Survival increased with time and distance from the spill origin. Brody et al. (1996) used the distance model to simulate the impact of a spill the size of the *Exxon Valdez* spill (250,000 bbl) occurring at different locations along the California coast. A spill at the Monterey Peninsula had the greatest impact, exposing 90% of the population to oil and killing 50% of the individuals; this was a minimum estimate of mortality.

The recovery team discussed the implications of these modeling exercises at considerable length. In sum, the risk of oil spills to California sea otters has three important sources of variation: the expected number of spills, the volume of spilled oil, and the expected number of otters that would be contacted and killed by the oil. There is extensive uncertainty associated with all three. Approximately six oil spills larger than 1000 bbl in the range of the otter were predicted over the next 30 years. Estimated spill volume ranged up to 350,000 bbl, and spill volume correlated poorly with the number of otters contacted. Finally, the number of otters contacted in the various iterations of the simulation model ranged from none to almost the entire population, and the relationship between an otter being contacted by oil and its probability of mortality is highly uncertain.

Given all of this uncertainty, the recovery team came to the consensus opinion that any attempt to reduce this uncertainty to some probability of extinction within a specified time period by way of a conventional population viability analysis (PVA; Boyce 1992) was not scientifically defensible. The recovery team noted that when a PVA is applied to populations of long-lived vertebrates with populations in the low thousands that are consistently increasing and when the likelihood of a catastrophe is assumed to be negligible, the general result is mean persistence times of well over 1000 years. Furthermore, if the PVA model is modified by the assumption that catastrophes occur with some specified probability, then the results of such a PVA depend entirely on the specified probability and magnitude of catastrophes (Menges 1990; Mangel & Tier 1994).

Criterion Development

Simply put, the recovery team's charge was to provide the USFWS with a single number that would be used to make a decision about delisting the southern sea otter population. We went about this exercise just as any scientist would go about making a scientific inference, by attempting to achieve a reasonable balance between the likelihood of making a Type I and Type II error. That is, on the one hand we wanted the probability of the delisted population actually becoming endangered to be small. One way of achieving this would have been simply to set the delisting criterion at a very large number of otters, but—as is true for most endangered species (Scott et al. 1995)—this was not an option because of various socioeconomic constraints. Therefore, we needed to develop a number that could be scientifically justified, as far as possible, to those "stakeholders" who opposed further growth of the southern sea otter population.

The recovery team's general approach to developing a delisting criterion was to define a size at which it would consider the population endangered and to consider the population threatened until it had recovered to the point where a major oil spill was unlikely to reduce it below that size. This interpretation of the meaning of "threatened" was based on the ESA, which defines a threatened species as one "which is likely to become an endangered species within the foreseeable future." Thus, there were two main tasks in developing a delisting criterion: deciding upon the criterion for endangered status and estimating the number of otters that might be killed in a major spill.

The recovery team agreed that the endangered criterion should be based upon a standard proposed in the scientific literature. After discussing various possibilities, we chose a standard suggested by Mace and Lande (1991): a vertebrate population with an effective population size (N_e) of less than 500 that was subject to catastrophic population crashes should be considered endangered. The actual number of individuals required to achieve a given N_e is usually much greater than N_e itself (Frankel & Soulé 1981). We estimated the number of otters corresponding to an N_e of 500 by using the only existing estimate of the *Ne/N* ratio (0.27) for California sea otters (Ralls et al. 1983). Thus, the number of otters below which the population would be considered endangered was set at 1850 ($500 \times 1/0.27 = 1852$).

The most difficult and controversial step in deriving the delisting criterion was agreeing upon an estimate of the number of otters that might be killed in a major spill. An appreciation of the difficulties facing the recovery team can be gained by considering the distribution of otters contacted by oil among the simulated 250,000 bbl spills (Fig. 3). Even with a constant volume of spilled oil, the number of contacts ranged from zero to over 1800 individuals. Nearly half of the simulated spills did not contact the coast within the otter's range. Because the recovery team wished to establish a delisting criterion that corresponded to a relatively small (but not precisely specified) probability that the population would become endangered after delisting, it decided to select a percentile near the right end of the distribution shown in Fig. 3. But it was precisely this segment of the distribution that was the most poorly behaved (indicated by the steep ascent at the right tail of the distribution). For example, the difference in the number of otters contacted between the 90th and 100th percentile ranks is nearly 1000 individuals. The comparable differences for less conservative loss criteria (say between the 80th and 90th percentile ranks) was only about 200 individuals. Thus, one consequence of erring on behalf of the otters is the establishment of a delisting criterion that is extremely sensitive to very small changes in the chosen percentile.

The members of the recovery team were initially divided over whether to choose the 90th percentile or the 100th percentile from Fig. 3 as a basis for setting the criterion. Members also disagreed over whether or not to use the results of Brody et al. (1996), which suggest that only about 50% of otters in areas contacted by oil would die. Many assumptions were necessary to apply the approach developed by Brody et al. (1996). Further, the recovery team recognized that such an approach would provide a minimal estimate of mortality following a spill. Some team members believed that using a minimal estimate of mortality would not be sufficiently conservative, especially because mortality of otters in California might be greater than in Alaska because California's comparatively straight and exposed coastline offers many fewer refuges from spilled oil.

The recovery team achieved consensus by noting that using the 90th percentile spill and assuming 100% mortality (800 otters killed) was roughly equivalent to using the 100th percentile spill and assuming 50% mortality (910 otters killed). The recovery team chose the 90th percentile case because it would remain more stable over repeated sets of simulations and, preferring to err on the side of caution, chose to assume 100% mortality of sea otters contacted by oil.

Thus far, the recovery team had made three assumptions, all of which concerned the risk of oil spill. First, there is a nonnegligible probability that a major oil spill will occur in the range of the southern sea otter during the next 30 years. (This was the only assumption about the risk of an oil spill that the recovery team considered scientifically defensible; furthermore, it was the only such assumption with which no member of the Technical Consultants Group could disagree.) Second, there is a nonnegligible probability that as many as 800 otters would be contacted by oil during a major spill (based on the 90th percentile spill described above). Third, all 800 otters contacted by oil will die as a result. Based on these assumptions, the recovery team's estimate of the number of otters that might be killed in a major spill was 800 individuals.

The recovery team also made two assumptions regarding the sea otter population. First a 3-year running average of population size adequately incorporates the existing degree of uncertainty in estimating the abundance of southern sea otters. This assumption was based on an analysis of past survey data. The observed annual rate of increase for the southern sea otter population between 1982 and 1993 was approximately 5% per year, with a coefficient of variation of 0.09. During this 12-year period, the number of otters in year $i + 1$ relative to year i increased 10 times and decreased 2 times. Statistically, this is not unexpected given the observed coefficient of variation. Using a 2-year running average also resulted in two cases where the population "apparently" declined in one year relative to the next. Using a 3-year running average resulted in a population trajectory that increased monotonically.

Second, given current rates of population growth (Fig. 1), the southern sea otter population will reach a running average of 2650 individuals by the turn of the century, and the range occupied by the population is unlikely to increase by more than about 100 km during this period.

Based on these five assumptions, the recovery team developed the following final criteria: the southern sea otter population should be considered *endangered* under the ESA if the population declines to a level less than or equal to an effective population size of 500 (Mace & Lande 1991). Until better information is available, the recovery team recommends using a multiplier of 3.7 to convert effective population size to actual population size (Ralls et al. 1983), or 1850 animals. Therefore, the southern sea otter population should be considered *endangered* if the average population size over a 3-year period is less than 1850 animals. The southern sea otter population should be considered *threatened* under the ESA if the average population size over a 3-year period is greater than 1850 animals but less than 2650 animals. The southern sea otter population should be *delisted* under the ESA when the average population size over a 3-year period exceeds 2650 animals.

Consequences of Delisting

Removing the population from the list of endangered and threatened wildlife would end the special protection provided to southern sea otters under the ESA and would require the USFWS to evaluate the status of this population under the MMPA. That is, the USFWS would have to determine whether the sea otter population in California should be formally listed as depleted. At the time of delisting, the sea otter population in California will likely include approximately 2800 animals, whereas the lower end of its optimum sustainable population (OSP) level is thought to be several times that number. Therefore, unless the U.S. Congress changes the general definition of depleted in the MMPA or specifically changes the definition of depleted as applied to the southern sea otter, it is likely that this population will be classified as depleted under the MMPA. Once the population was classified as depleted, the USFWS would be required to prepare a conservation plan, which would specify the actions needed to recover the southern sea otter population to optimal levels.

Discussion

Although it was dealing with a comparatively well-studied population, the recovery team neither performed a population viability analysis nor set a delisting criterion in terms of the probability of extinction over some time period, such as the next 100 years. Population viability analysis models would have been dominated by assumptions regarding the frequency and magnitude of oil spills, which the recovery team concluded were impossible to estimate with any reasonable degree of confidence. Furthermore, current PVA models, although useful for estimating relative extinction risks, cannot reliably estimate the absolute extinction risk required to establish a delisting criterion based on the probability of extinction in some time period (Taylor 1995; Ralls & Taylor 1997).

The delisting criterion developed by the recovery team represents a collective judgment by a group of scientists of an acceptable level of extinction risk for the southern sea otter population. Although the level of risk deemed acceptable was a judgment, it was clearly a scientific judgment, based to a large extent on accepted principles and protocols of scientific inference. There was much more consensus among the recovery team members, who shared a common background in science, as to levels of acceptable risk than among members of the USFWS-appointed Technical Consultants Group, who did not agree as to whether the size of the worst-case oil spill chosen by the recovery team was too small or too large. Nevertheless, another group of scientists—or even the same group of scientists, given other circumstances—might have chosen a different level of extinction risk. For example, the judgment of the recovery team was influenced by the fact that when the sea otter population is delisted under ESA it will still be protected under the MMPA. The recovery team might have chosen a delisting criterion representing a lower level of extinction risk if the population would have been unprotected after delisting.

The World Conservation Union has adopted specific criteria for classifying species into its risk categories of critically endangered, endangered, and vulnerable (World Conservation Union 1994). The vulnerable category probably corresponds most closely with the ESA threatened category. It would have been possible to classify the southern sea otter population as vulnerable under one of the alternative criteria for this status: "Population characterized by an acute restriction in its area of occupancy (typically less than 100 km^2) or in the number of locations (typically less than 5)." It would not be possible, however, to delist the population under this criterion without carrying out translocations to establish new colonies at several locations, and the recovery team concluded that such translocations would not be in the best interest of southern sea otters.

There have been several proposals to improve the ESA by providing quantitative guidance, in the form of specific probabilities of extinction within some time frame or specific criteria like those used by World Conservation Union, as to the levels of extinction risk represented by the terms "threatened" and "endangered" (Rohlf 1991; Tear et al. 1993; Beedy 1995; Clark 1995; Mattson & Craighead 1995; National Research Council 1995). Providing such guidance could ensure that species are treated more uniformly and correct the tendency for delisting standards to be set too low by scientific standards (Tear et al. 1993, 1995). The experience of the Southern Sea Otter Recovery Team indicates that guidelines should not be overly rigid and should allow recovery teams some flexibility for dealing with specific situations.

The composition of the Southern Sea Otter Recovery Team satisfied many of the recommendations made by critics of past ESA implementation (Clark et al. 1995). The team included several but not all of the principal biologists who have studied the population (Snyder 1995), and expertise from outside the responsible agency (the USFWS) was well-represented (Reading & Miller 1995; Snyder 1995). Representatives of agencies and organizations with conflicts of interest were not voting members of the recovery team, but their input was available through the Technical Consultants Group (Snyder 1995).

The experience of this recovery team led us to the following conclusion: if a species is deemed sufficiently important to warrant appointment of a recovery team, the most important consideration should be to choose a group that is both technically well qualified and unconstrained by pressures from management agencies. Constraining such a team with rigid guidelines would be counterproductive.

Scott et al. (1995:214) recently suggested that recovery planning should proceed as a two-stage process, first considering the purely biological issues and then modifying these in light of "social, political, and economic realities." The USFWS in fact did this in the case of the southern sea otter by appointing a recovery team composed exclusively of scientists and later by appointing a group of technical consultants that represented the various stakeholders. Nevertheless, in this case the final recovery criterion developed by the recovery team was largely unaffected by the technical consultants because they did not have a unified view.

The recovery team did not include the range of expertise—policy experts, sociologists, psychologists, organizational consultants, and conflict managers—recommended by some (Clark et al. 1995; Kellert 1995). The team's relatively narrow breadth seemed appropriate for developing a biologically reasonable recovery strategy and a delisting criterion. The major societal issues regarding sea otters, such as conflicts with shellfisheries, are still to be resolved. The southern sea otter population is protected under both the ESA and the MMPA. Larger population sizes (e.g., 2-4 times larger) probably will be required to satisfy the mandates of the MMPA, which requires the maintenance of "optimum sustainable populations" of marine mammals. These societal issues will arise in the process of determining that the population is no longer depleted under MMPA. Further, it seems likely that the management of the southern sea otter in the future would benefit from bringing to bear a broader range of expertise in developing a conservation plan, once this population has been removed from the List of Endangered and Threatened Wildlife.

Acknowledgments

We thank the other member of the Southern Sea Otter Recovery Team—D. Duggins, M. Martin, C. Robles, U. Seal, and D. Siniff—for their contributions to the work of the Southern Sea Otter Recovery Team. We are also grateful to C. Benz of the U.S. Fish and Wildlife Service for his assistance to the team and to G. Mace for her comments on the manuscript.

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