Research Notes

Gray Whales and the Value of Monitoring Data in Implementing the U.S. Endangered Species Act

LEAH R. GERBER,*‡§ DOUGLAS P. DEMASTER,† AND PETER M. KAREIVA*

*National Center for Ecological Analysis and Synthesis, University of California at Santa Barbara, 735 State Street, Suite 300, Santa Barbara, CA 93101–3351, U.S.A.

†National Marine Mammal Laboratory, Alaska Fisheries Science Center, National Oceanographic and Atmospheric Administration, 7600 Sand Point Way NE, Seattle, WA 98115, U.S.A.

§Washington Cooperative Fish and Wildlife Research Unit, School of Fisheries, Box 357980, University of Washington, Seattle, WA 98195, U.S.A.

Abstract: *Many scientists lament the absence of data for endangered species and argue that more funds should be spent acquiring basic information about population trends. Using 19 years of abundance estimates for the eastern North Pacific gray whale (*Eschrichtius robustus*), we sampled subsets of the original survey data to identify the number of years of data required to remove the population from the U.S. Endangered Species Act's (ESA) list of endangered and threatened wildlife. For any given duration of monitoring, we selected all possible combinations of consecutive counts. To incorporate variability in growth rates, we extracted a maximum likelihood estimator of growth rate and confidence interval about that growth rate on the assumption that the population changes can be approximated by a simple diffusion process with drift. We then applied a new approach to determine ESA status for each subset of survey data and found that a quantitative decision to delist is unambiguously supported by 11 years of data but is precariously uncertain with fewer than 10 years of data. The data needed to produce an unequivocal decision to delist gray whales cost the National Marine Fisheries Service an estimated U.S. $660,000, a surprisingly modest expense given the fact that delisting can greatly simplify regulatory constraints. This example highlights the value of population monitoring in administering the ESA and provides a compelling example of the utility of such information in identifying both imperiled and recovered species. The economic value of such data is that they provide the foundation for delisting, which could ultimately save much more money than the collection of the data would ever cost.*

Ballenas Grises y el Valor de Datos de Monitoreo en la Implementación de el Acta de Especies en Peligro de Extinción de los Estados Unidos

Resumen: *Muchos científicos lamentan la ausencia de datos para especies en peligro y argumentan que se deberían gastar mas fondos en la adquisición de información básica referente a tendencias poblacionales. Utilizando estimaciones de abundancia de 19 años para la ballena gris (*Eschirichtius robustus*) en la región oriental del Pacífico Norte, muestreamos subjuegos de los datos originales para indentificar el número de años requeridos para remover a una población de la lista de vida silvestre en peligro del Acta de Especies en Peligro de los Estados Unidos (ESA). Para cualquier longitud de monitoreo dada, seleccionamos todas las posibles combinaciones de conteos consecutivos. Para incorporar la variabilidad en las tasas de crecimiento extraímos un estimador de probabilidad máxima de la tasa de crecimiento y el intervalo de confianza sobre esa tasa de crecimiento bajo el supuesto de que los cambios poblacionales pueden ser aproximados por un proceso de difusión simple con deriva. Posteriormente aplicamos una aproximación nueva para determinar el estatus de ESA para cada submuestra de datos y encontramos que una decisión cuantitativa para desenlistar es soportada sin ambiguedad por 11 años de datos, pero precariamente incierta con datos provenientes de menos de 10 años. Los datos necesarios para producir una decisión inequívoca para desenlistar la ballena gris cuesta al Servicio Nacional de Pesquerías Marinas aproximadamente $660,000, un gasto sorpresiva-*

‡*email gerber@nceas.ucsb.edu*

Paper submitted September 21, 1998; revised manuscript accepted March 31, 1999.

mente modesto dado el hecho de que el desenlistar puede simplificar enormemente las limitaciones regulatorias. Este ejemplo resalta el valor del monitoreo en la administración de la ESA y provee un ejemplo complejo de la utilidad de este tipo de información en la identificación de especies tanto en peligro como recuperadas. El valor económico de estos datos es el de proveer la fundación para desenlistar, lo cual podría ultimadamente salvar mucho mas dinero de lo que la colecta de datos podría costar.

Introduction

The eastern North Pacific gray whale *(Eschrichtius robustus)* is one of the first species to have been removed from the U.S. Endangered Species Act's list of endangered and threatened wildlife (U.S. Department of Commerce 1994). In spite of an unusually long time series of population data which indicated that the population was increasing in abundance, the decision to delist the population was contentious. Eastern North Pacific gray whales, which breed along the west coast of North America, were severely depleted by commercial whaling, such that the population declined to as few as 4000 individuals in the late 1800s (Rice et al. 1984). The abundance of the eastern North Pacific gray whale has been monitored approximately biannually since 1967 (19 counts in 30 years) from a shore station in California (Fig. 1; Reilly 1992). Surveys, conducted December through February off the coast of California during the southbound migration, use a combination of two independent shore-based observers, aerial surveys, and a thermal sensor to detect whales passing at night (Rugh et al. 1993). These surveys and other data indicate that, since its protection in 1946, the population has recovered to a level near its estimated pre-exploitation size (Reilly 1992).

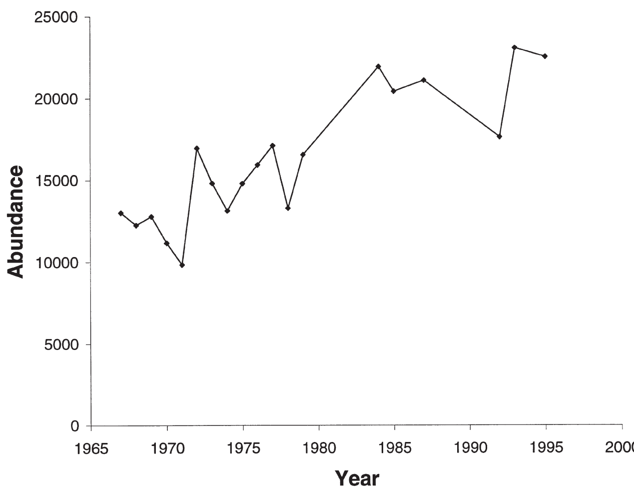

Figure 1. Nineteen-year time series of abundance for eastern North Pacific gray whales. Each data point represents an abundance estimate made from the National Marine Fisheries Service shore-based surveys off the coast of California.

Having time-series data of abundance estimates over 15 years is rare for long-lived vertebrates and even more rare for endangered species. Some examples of threatened species with 15 or more years of census data include the Kirtland's Warbler (*Dendroica kirtlandii*), the Laysan Finch (*Telespyza cantans*), the Whooping Crane (*Grus americana*), and the grizzly bear (*Ursus arctos horriblis*) (Dennis et al. 1991). The wealth of data available for the gray whale provides us with an excellent case study for determining decisions we might have reached were we to have fewer data, recognizing that fewer data are the norm for most endangered species (Tear et al. 1993; Schemske et al. 1994). To these data we then applied recently developed quantitative criteria for deciding whether to classify species as endangered, threatened, or delisted (Gerber & DeMaster 1997; Gerber & DeMaster 1999).

Methods

There are several quantitative approaches for deciding if data indicate that a species should qualify as "recovered" such that it may be considered for removal from the list of endangered and threatened wildlife. Our approach focuses on two critical aspects of a population: population size and trends in population size that comprise both average tendencies to increase or decrease and variability about these tendencies due to intrinsic variability in population growth rates. To characterize patterns of population growth, we used the National Marine Fisheries Service's (NMFS) shore-based estimates of abundance and first subsampled randomly from contiguous surveys to create progressively impoverished data sets (19, 15, 13, 11, 10, 8, and 5 years of abundance estimates). For any given survey duration, we selected all possible combinations of survey data. Thus, for 19 years of available data there were 15 different ways of sampling 5 consecutive years, 12 different ways of sampling 8 consecutive years, and so on. Then, we subjected each subsample to exactly the same analyses, recognizing the possibility of different results because the count data would be different for different subsamples. To incorporate variability in growth rates, we extracted a maximum likelihood estimator of growth rate and confidence interval about that growth rate (Dennis et al. 1991) on the assumption that the population changes can be approximated by a simple diffusion process with drift. As long as density-dependence is not strongly evident in the data, this simple diffusion approximation to population change is known to work well (Dennis et al. 1991). Because several attempts by whale biologists have failed to reject the null hypothesis regarding density-dependent population growth in the time series of gray whale abundance data (Breiwick 1994, 1995; Wade & DeMaster 1996), we used a simple diffusion approximation to translate survey data into assessments of net population change.

For the purposes of classifying a population's risk of extinction, we used the approach described by Gerber and DeMaster (1999) for humpback whales. Specifically, we considered two attributes: (1) population size and (2) population growth rate corresponding to the lowest 5% of the frequency distribution of likely growth rates ($\lambda_{0.05}$). In particular, for each time series corresponding to a subset of the total data set, we first asked whether there was a >5% chance that the population would fall below 500 during the next 10 years (threshold level for endangered status; Gerber & DeMaster 1999). If the answer was yes, then the population should be listed as endangered. If the answer was no, we determined whether the population should be listed as threatened. To do this, we adopted a longer time horizon and asked if there was a >5% chance of the population falling below 500 during a 35-year time period. If the answer was yes, then the population was categorized as threatened. If the answer was no, then the population should be delisted altogether. The census population size of 500 was based on ancillary data from the conservation biology literature and on the consensus of a panel of whale experts (Ralls et al. 1996; Gerber & DeMaster 1999). For different species the threshold might be 1000 or 5000, and the time frame could be altered as well. The time frame considered is a policy decision that needs to be made by the appropriate management agency. We assumed time frames of 10 and 35 years because they were suggested by a panel of NMFS scientists as the longest over which the agency could reasonably engage in planning. In addition, the percentile value from the distribution of lambda could be changed depending on how much risk one was willing to assume. Finally, to make the above calculations, we needed to specify some initial population size. As our starting population size, we used the last abundance estimate from the subsampled time series. In lieu of simply taking the observed last count, we decided to be more conservative and use the lower bound of the 95% confidence interval about the last population count. For each subsample of data, we not only calculated $\lambda_{0.05}$ (Fig. 2) but also the implications of the specific subsample for the above listing criteria (Fig. 3).

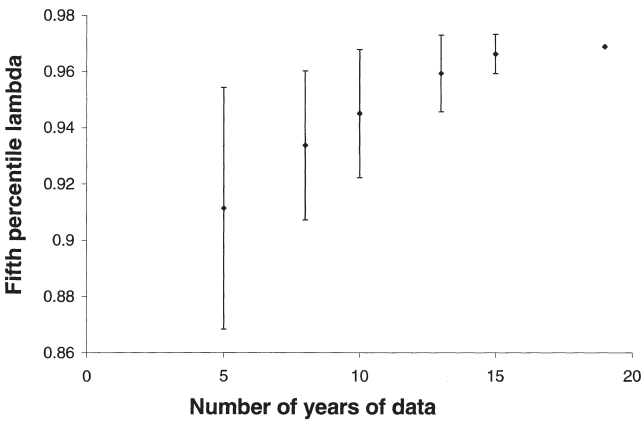

Figure 2. Mean and 95% confidence interval (CI) for fifth-percentile lambda values for each data subset. The 95% CI represents the mean fifth-percentile lambda value plus or minus the standard deviation times 1.96. The number of samples for each monitoring duration include 15 for 5 years of monitoring, 12 for 8 years of monitoring, 10 for 10 years of monitoring, 7 for 13 years of monitoring, 5 for 15 years of monitoring, and only 1 sample for the complete 19 year data set (hence no confidence interval).

Results and Discussion

Three results of our analyses are striking. First, in no cases did the results lead to a decision to list gray whales as endangered, and for every subsample of population-count data in excess of 10 years the results lead to a decision to delist the species (Fig. 3). This is reassuring and indicates that the decision to delist was likely robust to any deviation caused by the vagaries of sampling slightly

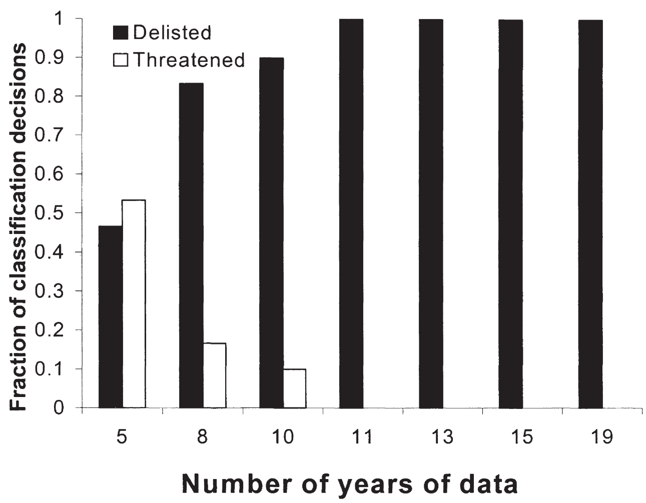

Figure 3. Endangered Species Act classification decisions to list eastern North Pacific gray whales for each data subset. None of the 63 sampled datasets indicated that gray whales should be listed as endangered, regardless of the length of the monitoring period.

different years. Second, it also suggests that the decision to delist could actually have been made sooner than 1994, because at the time this decision was made there were 17 years of data, substantially more than the 11 years we determined were minimally needed. Third, as expected with any estimator of a population process, there was a convergence in the estimated $\lambda_{0.05}$ as the number of years examined increased, and there was decreased variance about each estimated lambda (Fig. 2).

At a practical level, the most striking result was the clear value of more data contributing to better decisions. It is obvious that more information should lead to decisions that are less likely to be serious mistakes. This effect is rarely quantified, however, because we seldom have enough data to perform the experiment of sampling progressively fewer data. Applying the quantitative classification criteria to 19 years of abundance data allowed us to conclude that eastern North Pacific gray whales are no longer in danger of extinction, at least based on the criteria used in our analysis. Given the available data, we have the rare opportunity to evaluate what decisions might have been made with less information, given the assumption that we made a "correct" decision with the 19 years of data on gray whale abundance. With as few as 5 years of data, the results are equivocal as to whether the species should be delisted or downlisted to threatened (Fig. 3). The next 6 years of data, however, which lead to a certain decision to delist, become more valuable. Although the exact number of years of monitoring required for a clear-cut decision to delist depends on the species and the details of listing criteria, in general we can expect that more years of monitoring will lead to more scientifically credible listing decisions (Fig. 3).

Often the request for more data is seen as the plea of unrealistic academics and scientists. Our analyses, however, show that acquiring more data is extremely pragmatic in the management context: it can save management agencies money and contention by facilitating more rational conservation decisions. Specifically, the cost of shore-based whale surveys averaged $60,000 per year, an estimate based on the cost to NMFS of the surveys in 1993–1994, 1995–1996, and 1997–1998 (D. DeMaster, personal communication). The value of data can be directly juxtaposed with this cost. Five years of whale surveys, which lead to enormous uncertainty, would cost on average $300,000, whereas 11 years of survey data, which provide statistically compelling support for downlisting, would cost an extra $360,000. The data needed to produce a decision to delist gray whales cost the NMFS an estimated $660,000, which is a surprisingly modest expense given the fact that delisting can greatly simplify regulatory constraints.

In light of the apparent bargain of collecting monitoring data versus the regulatory costs associated with maintaining a "recovered" species as endangered for an extended period of time, it would be interesting to compare the cost of monitoring to the cost of regulation required for listed species. Attaining a cost estimate for regulation imposed by the ESA's Section 7 is not straightforward, however, because such decisions are generally made on a case-by-case basis. Section 7 regulation may require mitigation of a variety of activities, including seismic activity, fishing, and offshore drilling. In general, the precautionary principle underlies all endangered-species decisions that have some degree of scientific uncertainty, but the level of certainty determines the extent to which the principle is to be applied or the extent of protection afforded (Cameron & Abboucher 1991). In particular, the principle is institutionalized in the consultation process of Section 7 of the ESA, which requires that no federal agency carry out activities that potentially harm listed species.

In the case of gray whales, the precautionary principle focuses on whether protective measures should be imposed only in cases where environmental damage is apparent or whether those proposing to conduct the potentially harmful activity must demonstrate the relative safety of their actions. Thus, hypotheses regarding actions that may influence the continued existence of the species must be supported by scientific evidence showing a causal link between the activity and the damage, but the evidence need not be conclusive. This definition implies that potentially detrimental activities are forbidden unless the proponent of the activity can prove that the threshold level of risk has not been achieved. Because of the case-by-case nature of this process for gray whales it is impossible to predict the precise economic cost of such restrictions. Nonetheless, it is clear that regulatory constraints are not as vigorous for species that are not listed under the ESA in the absence of the consultation requirement of Section 7 of the ESA.

Certainly, our results that show a convergence to a stable estimate of population growth with 13 years of monitoring (Fig. 2) indicate that additional cost savings could be realized by reducing survey frequency once it appears that the estimated lower bound on population growth has stabilized. For instance, it may now make sense to reduce gray whale surveys to every third or fourth year, cutting costs by one-third or more. Although less-frequent monitoring schemes would reduce our ability to detect future changes in trend, correctly designed monitoring at reduced levels would still garner enough information to signal changing future conditions without costing as much money.

A final point is the interplay between a shortage of data and the need for caution. When data are scarce, management decisions need to be conservative; when data are plentiful, management decisions can be less conservative. The uncertainty associated with sparse data is reflected by the fact that, for the 15 different 5-year data subsets, the majority of the datasets indicated that gray whales should not be delisted but should instead be downlisted to threatened. Conversely, as the datasets were expanded to include more years, the results gradually shifted to a 100% recommendation for delisting (Fig. 3). In any real-world decision, the right answer will not be apparent. The case of the gray whale, however, makes it clear that more data can better substantiate any decision, which means a lack of data should prompt cautious decision making and reluctance to delist a species. For those who argue that conservation biologists or government agencies are being too cautious in their restrictions on the taking of threatened species, there is an easy way out: collect more data and thereby substantiate that the population of concern is not at risk.

Acknowledgments

This work is based on research done in partial fulfillment of a doctorate in Wildlife Sciences, College of Forest Resources, University of Washington (L. R. G.). We thank P. D. Boersma, J. Estes, H. Possingham, P. Wade, G. VanBlaricom, and three anonymous reviewers for thoughtful reviews of this manuscript. Research was supported by the National Marine Fisheries Service, the University of Washington, the Washington Cooperative Fish and Wildlife Research Unit, and the National Center for Ecological Analysis and Synthesis (funded by the National Science Foundation, the University of California, Santa Barbara, and the State of California).

Literature Cited

Breiwick, J. M. 1994. Rate of increase of the California gray whale. Paper SC/46/AS18. International Whaling Commission, London.

Breiwick, J. M. 1995. Further notes on the rate of increase and density dependence of the California gray whale. Paper SC/47/AS6. International Whaling Commission, London.

Cameron, J., and J. Aboucher. 1991. The precautionary principle: a fundamental principle of law and policy for the protection of the global environment. Boston College International and Comparative Law Review **14(1):**1–27.

Dennis, B., P. L. Munholland, and J. M. Scott. 1991. Estimation of growth and extinction parameters for endangered species. Ecological Monographs **61(2):**115–143.

Gerber, L. R., and D. P. DeMaster. 1997. Endangered Species Act classification criteria for North Pacific humpback whales. Pages 203–211 in P.S. Hill and D.P. DeMaster, editors. Marine Mammal Protection Act and Endangered Species Act Implementation Program 1996. Processed report 97-10. Alaska Fisheries Science Center, Seattle.

Gerber, L. R., and D. P. DeMaster. 1999. An approach to Endangered Species Act classification of North Pacific humpback whales. Conservation Biology **13:**1203–1214.

Ralls, K., D. P. DeMaster, and J. A. Estes. 1996. Developing a criterion for delisting the southern sea otter under the U.S. Endangered Species Act. Conservation Biology **10:**1528–1537.

Reilly, S. B. 1992. Population biology and status of eastern pacific gray whales: recent developments. Pages 1062–1074 in D. McCullough and R. Barrett, editors. Wildlife 2001: populations. Elsevier Press, London.

Rice, D. W., A. A. Wolman, and H. Braham. 1984. The gray whale, *Eschrichtius robustus.* Marine Fisheries Review **46(4):**7–14.

Rugh, D. J., J. M. Breiwick, M. E. Dahlheim, and G. C. Boucher. 1993. A comparison of independent, concurrent sighting records from a shore-based count of gray whales. Wildlife Society Bulletin **21:** 427–437.

Schemske, D. W., B. C. Husband, M. H. Ruckelshaus, C. Goodwillie, I. M. Parker, and J. G. Bishop. 1994. Evaluating approaches to the conservation of rare and endangered plants. Ecology **75:**584–606.

Tear T. H., J. M. Scott, P. H. Hayward, and B. Griffith. 1993. Status and prospects for success of the Endangered Species Act: a look at recovery plans. Science **262:**976–977.

U.S. Department of Commerce. 1994. U.S. Federal Register **59:**31094.

Wade, P. R., and D. P. DeMaster. 1996. A Bayesian analysis of eastern Pacific gray whale population dynamics. Paper SC/48/AS3. International Whaling Commission, London.