Assessing the Impact of Endangered Species Act Recovery Planning Guidelines on Managing Threats for Listed Species

by

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ABSTRACT

Since its inception in 1973, the Endangered Species Act has been met with both praise and criticism. More than 40 years later, the Act is still polarizing, with proponents applauding its power to protect species and critics arguing against its perceived ineffectiveness and potential mismanagement. Recovery plans, which were required by the 1988 amendments to the Act, play an important role in organizing efforts to protect and recover species under the Act. In 1999, in an effort to evaluate the process, the Society for Conservation Biology commissioned an independent review of endangered species recovery planning. From these findings, the SCB made key recommendations for how management agencies could improve the recovery planning process, after which the Fish and Wildlife Service and the National Marine Fisheries Service redrafted their recovery planning guidelines. One important recommendation called for recovery plans to make threats a primary focus, including organizing and prioritizing recovery tasks for threat abatement. Here, I seek to determine the extent to which SCB recommendations were incorporated into these new guidelines, and if, in turn, the recommendations regarding threats manifested in recovery plans written under the new guidelines. I found that the guidelines successfully incorporated most SCB recommendations, except those that addressed monitoring. As a result, recent recovery plans have improved in their treatment of threats, but still fail to adequately incorporate threat monitoring. This failure suggests that developing clear guidelines for monitoring should be an important priority in future ESA recovery planning.

DEDICATION

To my parents for encouraging me to find and pursue my passions.

To Adriene for being my own little endangered species.

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CHAPTER 1

INTRODUCTION

The Endangered Species Act has been a controversial law since its passage, garnering criticism ranging from large NGOs to private landowners (Knickerbocker 2005; Doremus 2010). An important contention by critics, including conservation organizations like the National Wildlife Federation, is that the US Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) are too lax in their enforcement of the provisions of the Act and its regulations (Kostyack & Rohlf 2008; James & Glitzenstein 2011). Other critics, including some members of Congress (CBS DC 2014), argue that the law is too stringent, unceremoniously putting the needs of beetles and birds above the desires and successes of humans. These critics suggest that the underlying premise of protecting all plants and animals is no longer feasible, thus the law is need of revisions (Hartl 2014). In light of these conflicting views on the Act, studies on the Act's management and implementation can help to elucidate key contentious issues. Here, I seek to determine the efficacy of current management practices under the Endangered Species Act, specifically in the recovery planning process, by analyzing clarity and depth of recently drafted recovery plans.

Despite criticisms, many legal scholars and conservationists revere the Endangered Species Act of 1973 as one of the most powerful and substantial U.S. environmental laws (Goble 2009). Part of this reverence stems from the perceived successes of the Act. Some sources indicate that species that would otherwise be extinct are still alive today because of protections offered by the ESA (Taylor et al.

2005; Suckling et al. 2012). Critics nonetheless point toward the large discrepancy in the number of species listed each year as compared to already-listed species that are never delisted (Doremus & Pagel 2001; Gerber 2003). Furthermore, because a recovery plan must be written for all threatened and endangered species (unless it would not aid recovery, which is almost never the case), these plans may be seen as burdensome and difficult to construct (Crouse et al. 2002). However, recovery plans are important because they include criteria that dictate what constitutes recovery of the species, management actions that should be taken by implementing agencies, and key threats to the species that must be mitigated (Taylor et al. 2005). With these positions in mind, it is clear that a better track record of species recovery under the Act would substantiate claims about the Act's effectiveness.

In light of these issues, in 1998 the Society for Conservation Biology (SCB) sought to identify ways to improve the recovery planning process, as mandated by section 4(f) of the Act. With support from the USFWS and in partnership with faculty and graduate students at 19 universities across the country, the SCB embarked on a massive review of 181 representative species' recovery plans – about 20% of the total number of plans at the time (NCEAS 2002a). The goal of the study was to determine which features of recovery plans contribute to an improving status for species, as determined by USFWS biannual reports to Congress, and to find potential discrepancies and inconsistencies common among plans (Brigham et al. 2002; Campbell et al. 2002; Clark et al. 2002). The resultant study was the most comprehensive review of endangered species recovery plans ever completed, the findings of which were published in a special issue of

Ecological Applications (Vol. 12, No. 3) in 2002. On many accounts, the study found that recovery plans were improving with time (Clark et al. 2002). For instance, Gerber and Hatch (2002) found that more recently drafted plans included more quantitative data, Morris et al. (2002) found that plans were using population viability analysis more effectively, and Harvey et al. (2002) discovered that plan revisions were effectively incorporating updated information. Despite these improvements, the study determined that there were still areas that needed improvement.

Along with other subsidiary findings, the study called for four major improvements to the recovery planning process: 1) improve the treatment of threats to species, 2) encourage diverse authorship of plans and allow the priority of plans to play a larger role in decision-making, 3) use personnel more effectively by rewriting recovery planning guidelines and assigning responsible parties to recovery actions and 4) integrate key biological information more effectively while avoiding taxonomic bias between plans (Table 1; Clark et al. 2002).

In response to these recommendations, the USFWS identified ten action items that could reasonably be addressed more effectively by the Services (Crouse et al. 2002). These action items included improving the internal consistency of plans, strengthening species-specific details, and improving monitoring efforts, among others. In 2004, in direct recognition of the SCB study's recommendations and the action items, the USFWS and NMFS overhauled their recovery planning guidance document (which has since been edited minimally) (Table 1; NMFS 2010).

Now, 10 years after the initial revision of the guidelines, it's pertinent to determine whether these guidelines are actually fostering implementation of the SCB recommendations. In this analysis I determine: 1) the extent to which the recovery planning guidelines were integrated into the 1999 SCB study recommendations, and 2) the extent to which recovery plans written under these new guidelines have embraced the recommendations on threats provided by SCB. I focus specifically on threats because Lawler et al. (2002) found that information about and actions to address threats were severely lacking. Compared with all other SCB recommendations, the USFWS/NMFS guidelines most strongly emphasize the importance of addressing threats for the recovery of species (NMFS 2010). This emphasis is supported by the conservation literature, as many scientists recognize the key role that threats play in species endangerment (McClenachan et al. 2012; Croxall et al. 2012) and the need for scientists to be able to communicate clearly about these threats (Salafsky et al. 2008). This recognition and communication can lead to better threat management and abatement, which is a critical step towards species recovery (Carwardine et al. 2012).

Using the same methods as the SCB study, I collected key characteristics of endangered species recovery plans written since 2006 to identify changes in the recovery planning process. These analyses compare current data on plan attributes with both data and recommended improvements from the SCB study. In order to analyze the quality of current recovery planning under the ESA, as determined by the 1999 SCB findings and subsequent recommendations, I examined the treatment of threats in recent (2006-2012) recovery plans for endangered species. By using the treatment of threats as a case study, my goal is to assess the extent to which the recovery planning guidelines have embraced key recommendations from the 1999 SCB study and whether recovery plans are implementing these recommendations.

CHAPTER 2

METHODOLOGY

The SCB Study

I follow methods used in the 1999 SCB study (described in Hoekstra et al. 2002a). In general, the goal of the SCB study was to survey recovery plans and extract key information with which to assess the quality of the plans. The SCB study centered on a data collection instrument that included over 2500 specific questions about the information included in recovery plans (available at NCEAS 2002b). These questions were written as explicitly as possible and solicited answers meant to reduce subjectivity and standardize the scope of the recovery plan review. The instrument covered the gamut of areas addressed by recovery plans, including prompting reviewers to answer questions on descriptive data about species (i.e., listing data, habitat type, taxonomic group, etc.), biological information (i.e., threats, population size, behavior, etc.), recovery actions and criteria, and other key information about the species (Kareiva et al. 1998; Harding et al. 2001).

Most questions required a standardized numeric response (i.e., ‘0’ for no, ‘1’ for yes; for primary ecotype – ‘1’ for tropical rainforest, ‘2’ for tropical deciduous forest, etc.), with negative response codes to indicate when and why information was missing for each question (i.e., ‘-1’ for information cannot be determined, ‘-2’ for information is not applicable to the species). Some questions called for numeric answers to indicate a total quantity, (i.e., total number of pages or authors), while others asked for qualitative, descriptive answers. In this way, the instrument allowed for identification of relevant information in recovery plans, with each question signifying diverse information included in the plan. Questions were answered using only information explicitly stated in the recovery plan itself or from the species' listing document; no outside information was used (except for determining the species' current status).

The instrument and its questions were developed within a graduate student seminar, tested on recovery plans and refined, and finally reviewed by academics, USFWS biologists, policy-makers, and conservation and business organizations (Hoekstra et al. 2002a). Once the instrument was finalized, 19 public and private universities, with 325 total researchers, participated in the coding of the plans. The researchers were mostly graduate students, organized into seminars of reviewing groups that received input from the USFWS, with principal investigators leading each seminar. To choose which recovery plans to use in the study, all pre-1998 recovery plans were stratified for taxon, scope, and revision status and then randomly selected. In the end, 135 plans were analyzed, representing ~20% of plans drafted up until 1998.

Each seminar answered all questions in the instrument for ten plans over the course of a semester. The data collected was then entered into an online database for analysis. Once the database was compiled for all 135 plans representing 181 species, 85 plants and 96 animals, two workshops were held where major patterns and trends were discussed, and groups were formed around key study areas (i.e., threats, recovery criteria, plan consistency, etc.). Collective results were then published as a special issue of *Ecological Applications* (Vol. 12, No. 3, 2002).

Review of Recovery Planning Guidelines

The first step of this study was to determine if the SCB recommendations had been incorporated into the USWFS recovery planning guidelines redrafted in 2004, with the most recent version released in 2010. I first compiled a list of all key recommendations made from each of the 20 papers published under the SCB study (available at NCEAS 2002c). Recommendations made by SCB were considered to be "key" if they were strongly emphasized in a publication, explicitly recognized by the USFWS (Crouse et al. 2002), or included as final recommendations in the SCB summary paper (Hoekstra et al. 2002a). I then reviewed the recovery planning guidelines and found relevant sections that correlated with each SCB recommendation. If a recommendation had multiple sections or passages, the most relevant and prominent section was chosen (Table 1). I only considered recommendations to be explicitly recognized if parallel passages in the guidelines were actionable and specifically addressed how to incorporate the item into recovery plans.

Developing an Instrument

I used the key recommendations from the SCB study to reform the original SCB instrument to fit the needs of the current study. Many questions from the original instrument were utilized in this study's instrument, including categorized biological information, questions about threats and criteria, and questions about recovery actions and monitoring tasks. The most important difference between the instrument used in this study and the SCB study is that I was able to ask each question about individual actions, threats, and criteria. The SCB study generalized many questions to types of threats, monitoring actions, and criteria, whereas I applied the questions to each individual threat, action, and criteria, getting much more nuanced and individualized data. These differences abated certain comparisons between the present study and the original SCB study but allowed me to ask a more detailed swath of questions, to adequately address whether SCB recommendations had been integrated into the recent plans.

Questions from the guidelines were also incorporated into the new instrument. For instance, the guidelines recommend that threats be explicitly linked to recovery needs, so a yes/no question was inserted into the instrument to determine if this information was included for each individual threat. Additionally, recovery actions were tracked individually with explicit linkage to related threats. All information for answering recovery action questions was taken from the implementation schedule and the recovery action narrative.

The only metric that was not tracked individually was monitoring actions. Instead, the question of whether individual threats had a monitoring task was asked, and if so, relevant questions about the task were answered. If the threat had more than one assigned monitoring task, methods used by the SCB study (Schultz & Gerber 2002; Campbell et al. 2002) were employed, coding the "best" answer to each question. For instance, if the protocol for one monitoring task for the threat was not clearly linked to biology but the other's protocol was clearly linked, the threat was counted as having monitoring clearly linked with biology. If the monitoring tasks called for monitoring of different subjects (focal species, associated species, or habitat), the category with the most information was counted. Admittedly, this method may have skewed the monitoring data for subject of monitoring; however, in my opinion, not enough threats had multiple monitoring tasks to cause this to be a serious issue (approximately 1 threat for every 5 plans).

Data Collection

The SCB study found that multi-species plans had particular problems that were not manifest in single species plans (Clark & Harvey 2002). For this reason, and because of the extensive nature of multi-species plans, these plans were excluded from the current study. This exclusion may have caused a bias towards improved data, as multi-species plans, according to the SCB study, were more poorly written, and their data was included in many tests of the original SCB study. Additionally, the SCB study included plans for both threatened and endangered species, and the current study used only endangered species plans, so as to have a large enough, consistent sample size to make pertinent recommendations. As such, the results of this study may be limited to plans for endangered species only, though many plans for endangered species are redrafted from their threatened plans, if they were originally listed as threatened.

Lastly, in making time-based comparisons, the SCB study decided to analyze plans that were written two years after the ESA amendments of 1988. The two-year window was considered to be enough time for requirements to be incorporated into ESA management. In the same way, this study used only plans written during or after 2006, to allow for a two-year period after the guidelines were written for their incorporation into plan writing. Because the guidelines have since been edited three times (though not substantially), it is possible that more recent plans incorporate more recommended information. From the plans that fell into this sample, 28 were coded and analyzed using the re-crafted instrument.

As an example of how the instrument was used, in the threats section of most plans, threats are individually described. As a threat was discussed, questions about that threat's characteristics and management were answered. If the threat was described as a major threat that always affected the species, the question about threat magnitude was answered with a '2' for major and the question about frequency was answered with a '3' for continuous effects on the listed species. All questions in the new instrument were answered based on information explicitly stated in the recovery plans. As such, answers to these questions identified and quantified key components of recovery plans and provided data to be analyzed about recovery plan structure and content. The focus of this study was on threats and their treatment (including recovery and monitoring tasks), but data for all areas of the plan were collected.

Analysis

Whenever possible, I used the same tests and data type as the parallel analysis in the SCB study. This allowed for some results to be directly compared to the original SCB study. When relevant, I indicate in the results section whether or not the numbers should be considered directly comparable. Some data analyzed were percentages and some were total numbers; the type of data analyzed is explicitly stated in the results section. For all within-plan comparisons, the Wilcoxon signed-ranks test was used because the paired data (minor vs. major threats, direct vs. indirect threats, etc.) were non-normally distributed between plans. For all comparisons between animals and plants, an independent samples t-test was used. For all tests, a p-value of less than 0.05 was considered to be significant.

CHAPTER 3

RESULTS

SCB Recommendations in the Guidelines

Almost all key SCB recommendations are addressed in some way by the new guidelines, with the exception of investment in recovery coordinators and centralized databases, focus on using quantitative criteria, and monitoring (Table 1). Monitoring in particular is not a central focus of any part of the guidelines; instead, discussions of monitoring are sparsely dispersed throughout the guidelines in other relevant sections (such as in the sections on threats and recovery actions). There is not much information on how to determine what is to be monitored and monitoring protocols or on the use of species-specific biology to create specific monitoring tasks. Most other recommendations are more specifically addressed and given clear and descriptive details on how to adequately implement them.

Nature of Threats

There are a total of 302 threats identified for the 28 species. The average number of threats per species, 10.78, is equivalent to the average determined by the SCB study, 10.65 (1928 in 181 species) (Lawler et al. 2002). Like the SCB study, I found that animals have more threats, on average, than plants (t-value = 3.087, df = 26, $p < 0.001$); however, the difference was more substantial in my study, with the average difference being 4.6 threats versus the 1 threat difference found by Lawler et al. (2002). There is also a taxonomic bias found in the number of direct threats to species (Table 2). Animals are assigned an average of 7.15 direct threats, while plants are only assigned an average of 3.625 direct threats (t-value = 2.479, df = 26, p = 0.02). There is no difference in the number of indirect threats per species.

The recovery planning guidelines call for greater discussion of key biological characteristics and geographic scope of threats, as well as direct linkage of threats to endangerment, and the inclusion of threats tracking tables (NMFS 2010). I found that 84% of threats include information about how biological characteristics of the species make it vulnerable to threats, with an 89% median percentage across individual species. Geographic scope of the threat and how the threat is directly linked to endangerment are each described in 74% of all threats, with median percentages across species being 78% and 75%, respectively. Additionally, I determined that 72% of all threats are described with an explicit recognition of some uncertainty about the threat, with animal threats almost having significantly more recognition of uncertainty than plant threats (t-value =1.995, df = 26, p = 0.057). Only 57% (16/28) of plans include a threats tracking table.

Other characteristics were studied, including the severity, magnitude, frequency, timing, and directness of threats. The SCB study found that most threats were intense (44%), major (49%), chronic (76%), occurred in multiple time-frames (63%), and were both direct and indirect (37%) (Fig. 1; Lawler et al. 2002). I found that an equal percentage of threats have intense and moderate severity (28%), with 13% classified as light, and 14% classified as having an unknown severity. Similarly, major (35%) and minor threats (33%) are equally prevalent, while 12% of described threats are categorized as not actually being threats, and

10% of threats have an unknown magnitude. Like Lawler et al. (2002), I found that the majority of threats are chronic (78%, 48% repeated and 30% continuous; Fig. 1), while only 1% of threats are considered to be one-time threats. 8% of threats are explicitly cited as never affecting the species. Most threats occur over multiple timeframes (39%), with 21% considered to be anticipated threats, 20% current threats, and 7% historical threats (which includes many that are considered to now be non-threats). Lastly, most threats are direct threats (57%), while only 9% are indirect, 26% were both direct and indirect, 1% are unknown, and 7% have no directness indicated.

Documentation

Lawler et al. (2002) found that 39% of threats were lacking information on at least one of the 4 characteristics of threats (severity, magnitude, timing, frequency). I found that 44% of threats are missing information on at least one of the characteristics (Fig. 1), with severity missing the most often (17%), while only 1% are missing information on timing, which reflected the disparity found by Lawler et al. (2002) (30% to 5%, respectively). I found that 10% of species are missing either magnitude or frequency descriptions. Additionally, there are disparities between the documentation of major and minor threats, as well as documentation of direct and indirect threats (Table 2). Minor threats were found to be less well documented than major threats (median 3.6 out of 4 characteristics to 3.94, respectively) (Wilcoxon signed-ranks test $Z = -3.194$, p = 0.001). Indirect threats were also found to be less well documented than direct threats (median 3 of 4 characteristics to 3.65, respectively) (Wilcoxon signed-ranks test $Z = -2.174$, $p = 0.030$). No taxonomic biases were found for documentation of threats.

Addressing Threats

The SCB study found that 37% of all threats had no associated recovery task (Lawler et al. 2002; Schultz & Gerber 2002). I found that 19% of threats have no recovery task (Fig. 2), with a median of 1 threat per plan. The maximum percentage of threats that were not addressed in a single plan was 57% (8/14), while the median percentage of threats not addressed per plan is 12%. The median number of tasks that address threats per plan is 49, with the median number of actions for threats in a plan being 5. Lawler et al. (2002) found that 33% of all major threats have no assigned recovery task, and I found that only 8% of major threats had no recovery task (Fig. 2), with a median number of 7 tasks per major threat. Additionally, the taxonomic bias of animals having more associated tasks per threat than plants (Schultz & Gerber 2002) was not found (t-value = -0.177, df = 26, $p = 0.861$).

Lawler et al. (2002) found that both major and direct threats were addressed more than minor or indirect threats, respectively. I found that both of these disparities no longer exist in the recovery plans (Table 2). An equal percentage of major and minor threats are addressed (Wilcoxon signed-ranks test $Z = -1.020$, $p = 0.308$), and as many indirect threats are addressed as direct threats (Wilcoxon signed-ranks test $Z = -0.351$, $p = 0.726$; Fig. 2). However, both major threats and direct threats are addressed with more overall tasks than their counterparts (Table 2). Major threats are addressed with a median of 25 tasks per plan versus minor threats' 9 tasks (Wilcoxon signed-ranks test $Z = 3.176$, $p = 0.001$). As with major threats, direct threats are addressed more than indirect threats (23.5 tasks vs. 0.5 tasks; Wilcoxon signed-ranks test $Z = -4.395$, $p < 0.001$).

The number of tasks to address major threats (median 25) does demonstrate an increase in the number of total tasks to address major threats since the SCB study, which found that the median number of tasks for major threats was only 15 (Schultz & Gerber 2002). Additionally, I found that major tasks are not prioritized more than minor tasks (Wilcoxon signed-ranks test $Z = -1.794$, $p = 0.073$), whereas Brigham et al. (2002) found that plans were fairly consistent in prioritizing major tasks more than minor tasks.

Before the new guidelines were written, incompletely understood threats were addressed by recovery tasks less often than fully documented threats (55% vs. 66%; Lawler et al. 2002). Now, less documented threats are addressed as often as well-documented threats (74% vs. 86% addressed; Wilcoxon signed-ranks test $Z = -1.734$, $p = 0.083$). Additionally, the percentage of threats of both types that are being addressed has increased since the SCB study (Fig. 2).

Monitoring

Brigham et al. (2002) found that only ~26% of threats had an associated monitoring task. In more recent plans, 51% of all threats have an associated monitoring task (Fig. 3), with a median of 44% of threats monitored in a plan. More major threats are monitored than minor threats (75% vs. 54%; Wilcoxon signed-ranks test $Z = -2.203$, $p = 0.028$), and more direct threats are monitored than indirect threats (56% vs. 32%; Wilcoxon signed-ranks test $Z = -2.122$, $p =$

0.034; Fig. 3; Table 2). The SCB study found that there was not much taxonomic bias between animals and plants in the amount of threats that were monitored and the number of monitoring tasks (Campbell et al. 2002; Schultz & Gerber 2002). My findings were consistent with this analysis; the percentage of threats with monitoring tasks did not vary between plants and animals for all threats (t-value = 1.309, df = 26, p = 0.308) or major threats (t-value = 0.839, df = 26, p = 0.409).

Campbell et al. (2002) found that 98.3% of all species proposed at least one monitoring task for focal species, 64.6% addressed habitat, and 49.7% addressed associated species, including monitoring tasks for criteria. I found that only 61% of all plans have focal species monitoring for threats, 71% have habitat monitoring, and 50% have associated species monitoring. My study was also able to determine how many and what percentage of monitoring tasks was dedicated to each type of monitoring. I found that 41% of tasks monitor focal species, 34% monitor habitat, and 20% monitor associated species. Animals were found to have a greater percentage of monitoring tasks dedicated to focal species monitoring than plants (42% vs. 13%; (t-value = 2.391, df = 25, p = 0.025; Table 2).

Schultz and Gerber (2002) found that 54% of species had at least one monitoring task for which biological information clearly influenced what was to be monitored and only 17% of plans had monitoring tasks with protocols that were clearly influenced by biological information. My approach was a bit different, as I asked questions specifically about threat monitoring and individual threat monitoring tasks. I found that 93% of all threats that are monitored have a clear biological basis for what is monitored, whereas only 50% of monitored threats link protocol for monitoring clearly with biological information. For 35% of threats, it is entirely unclear how monitoring protocols are influenced by biological information. The influence of biology on monitoring protocols is even less prevalent in animals, with an average of 40% of monitored threats having clear biological linkage to protocols, as opposed to 72% in plants (t-value = -2.608, df = 25, p = 0.015; Table 2).

Threat-linked Criteria

I found that across all plans, the median percentage of threats addressed by at least one criterion is 89%. However, plant threats are more often addressed by recovery criteria than animal threats (91% of threats addressed vs. 74%; t-value = -2.121, df = 26, p = 0.044; Table 2). I also found that, when a threat is addressed by a criterion, 31% of the time that criterion is quantitative, 33% of the time it is qualitative, 28% of the time it is both quantitative and qualitative, and 8% of the time its measuring metric is not indicated.

CHAPTER 4

DISCUSSION

The recovery planning guidelines generally integrate the recommendations made by the Society for Conservation Biology in its 1999 landmark study, including strong support for assessing threats. The USFWS strongly embraced these recommendations; the guidelines are clear that threats should be prioritized and adequately addressed in as much detail as possible by plans. This focus in the guidelines has led to measurable improvements in the incorporation of important scientific information into recovery plans.

Nature of Threats

More than 70% of threats include information on geographic location, biological characteristics that make the species susceptible to threats, and clear descriptions of how threats affect species endangerment. With there being uncertainty about 4 out of every 5 threats, certain information may always be missing. This general uncertainty makes the broad inclusion of key characteristics for the majority of threats even more impressive. However, direct linkage of threats to endangerment seems to be a critical piece of evidence for both determining what should be considered a threat and determining why and how a threat should be managed. Although 75% of threats have this linkage, a clear description of why each threat is considered to be a harm to the species could be included more prevalently for more threats, so as to adequately describe the threat and defend its management.

The relative frequency of different magnitudes, severities, and directness of threats has changed since the SCB study. With the heavy focus on threats in the guidelines, more minor, less severe, and more indirect threats may be included more than in previous years, though the number of total threats has not changed. Prioritization and management were also focused on in the USFWS guidelines, and it's possible that threats are being classified in different ways so as to help prioritize management decisions. It is also possible that subjectivity in classification of threats may have caused disparities between the SCB study and the present study. If subjectivity is to blame, it would indicate that more explicit descriptions of threat severity, magnitude, frequency, timing, and directness should be included to mitigate confusion and allow for more easily prioritized management.

Though the relative frequencies of features for threats are different, the overall documentation of threats remains the same. One interpretation of these results is that certain pieces of information for individual threats may always be missing simply because it cannot be determined, as indicated by the recognition of uncertainty for a majority of threats. However, the other interpretation of these results may indicate a problem area in recovery planning. Knowledge of threat characteristics is important for species protection and recovery (Crain et al. 2009) and more recovery actions should be dedicated to determining missing information. With only 51% of all threats assigned a monitoring task and higher documented tasks having more recovery actions, it's reasonable to suggest that the gathering of information about threats has not been made a priority in recovery planning since the SCB study. This could explain why documentation numbers have not improved.

The disparity in documentation between major and minor threats and direct and indirect threats is more troublesome (Table 2). This finding suggests that more resources are dedicated to finding key information about major and direct threats, in which case minor and indirect threats may be taken less seriously than is necessary. Alternatively, better understood threats may be considered higher magnitude, suggesting that some threats that are currently classified as minor would actually be considered major threats if more information was known about them. More effort should be invested into documenting threats of both minor and major magnitudes, to ensure that accurate assessment of true magnitude is being made. Additionally, because the synergistic nature of threats was not explicitly considered, it may be even more crucial that minor threats be considered, as their overall impact may be greater than their individual magnitude indicates.

Though the number of threats for each species has remained the same since pre-1999, it appears that the difference between threats attributed to animals and plants has grown. There are several possible reasons for this disparity, one of which may simply be statistical noise, as only 8 plant plans were studied. However, another equally plausible cause, which was somewhat apparent in the qualitative analysis, is that plant plans are generally less extensive; for instance, on average, plant plans were much shorter than animal plans (65.5 pages vs. 131 pages). Though taxonomic biases seem to have been mitigated in other key areas of recovery planning, the basic attribution of threats to species may be indicative of the sustained presence of biases (Table 2). This difference in the number of threats materializes directly in the number of direct threats assigned to species. Either there are actually more direct threats to animals than to plants or direct threats to plants are not being identified as readily and completely as those to animals. This disparity could be due to biases in the knowledge of threats for species or in the amount of information about threats being included in the plans.

Addressing Threats

With the implementation of the 2004 USFWS recovery planning guidelines, threats are being addressed more often by recovery tasks. Major threats are also addressed more often in recent plans than in plans written before the guidelines were redrafted, suggesting that the prioritization of threats in the guidelines has encouraged greater focus on actions for managing and understanding major threats. Recovery plans are more adequately addressing threats to plants, which are garnering equal numbers of recovery tasks as animals, and poorly documented threats.

Additionally, as many minor threats and indirect threats are addressed as major threats and direct threats, respectively, suggesting that recovery plan writers are granting more credence to minor and indirect threats. Major and direct threats are, however, addressed by more total tasks, yet major threat tasks are not prioritized any more heavily than minor threat tasks. This classification seems a bit inconsistent. From a managerial standpoint, it makes sense to address major threats with more tasks and to give them a higher priority; however, this study found that major threats were not explicitly prioritized as recommended by the SCB study (Table 1).

There seems to be no similar argument for addressing direct threats more than indirect threats. Though as many indirect threats as direct threats are addressed, the total number of tasks for indirect threats is still much fewer. Although there may be a difference in how direct and indirect threats can and should be addressed, the drastic difference in the number of tasks to address each does not seem justifiable. This disparity suggests that direct threats may be seen as more manageable, and thus are getting assigned more tasks, while indirect threats, which may be equally detrimental, are not receiving adequate attention. Although it is may be harder to address indirect threats (Horowitz & Jasny 2007; Halpern et al. 2008, 2009), it is nonetheless important to consider them (Darst et al. 2013), and this area of recovery planning could be improved.

While a majority of threats are addressed by a task, 19% of all threats are still not being addressed in any way. Even if there is not enough understanding about a threat to assign management tasks to it, at a minimum each threat should have an information gathering or monitoring task associated with it. Even for threats that cannot realistically be monitored or managed, i.e. tsunamis, tasks to create action plans or to increase genetic diversity in the case of a catastrophe should be explicitly linked with the threats that they help to abate. So, while there is obvious improvement in this arena, a continued focus on addressing all threats to some extent would further benefit the recovery planning process.

Monitoring

Compared to other metrics, monitoring is not well represented in the guidelines, garnering only sparse inclusion throughout the document. This dearth in the recovery planning guidelines has created noticeable disparities and a lack of improvement for some key SCB recommendations in recent recovery plans. Though the number of threats being monitored has doubled since the SCB study, there is still a lot of work to be done to improve monitoring of threats. Qualitatively, monitoring was not a major focus in more than one or two plans, either of threats or of criteria. Additionally, the question of monitoring the implementation of recovery actions was abandoned entirely because there were so few actions in place for monitoring the implementation of tasks.

Nearly half of all threats still have no associated monitoring task, which may translate to ineffective management actions and make adaptive management (Ruhl 2003) much more difficult. Major threats are monitored more often than minor threats and direct threats are monitored more than indirect threats (Table 2). Because these types of threats are also better documented, there are more monitoring tasks, including for information gathering, for better-documented threats. Even though major threats might require higher priorities for recovery tasks, there seems to be no reason why they should be monitored more often than minor threats. Similarly, direct threats and indirect threats should be monitored in equal amounts, so as to maintain a holistic view of how the species is being threatened and how adaptive management can be implemented.

Campbell et al. (2002) cautioned against the use of focal species monitoring to the detriment of other types of monitoring. Though the SCB study's monitoring questions were based on monitoring for the entirety of the plan and not just for threats, it appears as if monitoring of habitat and associated species has become more of a priority, as percentages for alternative types of monitoring of threats are more substantial than in the SCB study. However, plans have substantially less (61% of threats vs. 98.3% of all species) focal species monitoring. This may be reflective of the fact that many criteria involve focal species population numbers and status, and thus much of the focal species monitoring may be utilized more for criteria.

The biases found between animal and plant focal species monitoring may reflect a larger overall trend in some "unimproved" taxonomic biases that were found (Table 2). The "biases" in the use of focal species monitoring in animal and plant species may make sense for the biology of each type of species; it may be more critical to monitor animals directly because of their interactions with one another and ability to move about a range. Taxonomic bias, in this instance, most likely has foundations in the biology itself and should not be a major concern for recovery planning. Even the total number of threats for species may reflect actual biological phenomena and true species status.

Lastly, perhaps the most glaring problem in the monitoring of threats is the lack of clarity on how and why monitoring will be done. Plans are doing a much better job at linking biological information with what is to be monitored than with how monitoring is to be done. Although my data could not be directly compared to the SCB data, the use of biological information to describe what should be monitored is being included for the majority of threats, while monitoring protocols must be more clearly described, particularly for animals. Only half of all threats that are monitored have monitoring protocols that clearly link biological characteristics to how monitoring will be done. In many cases, no description of how monitoring should be done is provided at all; for example, a task will call for the monitoring of attacks on the species by predators without describing how these attacks will be monitored.

Future Directions

Although the current study focused only on threats to species, data was collected on all facets of recovery plans. Further research could help to determine if other areas of plans have improved since the SCB study. Specifically, there has been a push to incorporate quantitative recovery criteria (Gerber & Hatch 2002; Schultz & Hammond 2003) and to improve prioritization and management of recovery actions by including adaptive management in plans (Crouse et al. 2002; Ruhl 2003). Additionally, with the current agreement by the USFWS to consider listing over 250 species by 2017 (USFWS 2011), research on how recovery planning could be more efficient and effective will play an important role in allowing listed species to gain protection and begin to recover. Lastly, further research in this area could inform structured decision-making (SDM) approaches in protecting species by improving species management and generation of species' recovery frameworks (Gregory et al. 2013).

Conclusions

The Society for Conservation Biology presented the USFWS with actionable, specific recommendations for the improvement of endangered species recovery planning. The USFWS directly acknowledged these recommendations (Crouse et al. 2002) and incorporated many of them into their recovery planning guidelines. This change to the guidelines has fostered improvement in several key areas, especially in the treatment of threats. Several taxonomic biases have been eliminated, threats are being more adequately described by biological information, more threats are being assigned recovery tasks, and minor threats are receiving more attention.

My results suggest important areas for future research and management. Major and direct threats are given more attention in plans, despite the actions to address them not being prioritized. In this case, more information and more assigned actions do not seem to be translating into improved prioritization and management. Perhaps one way to correct some of these issues is to emphasize the use of threats tracking tables in recovery plans. Although no quantitative differences could be found between plans with and without a threats tracking table, qualitative analyses of the plans indicate that the inclusion of a threats tracking table facilitates better understanding and organization of the threats section of the plan. Inclusion of information on threats, associated criteria, and associated actions into one table greatly improves the reader's ability to find and understand key information about threats, which could directly lead to improved management.

Finally, the overall monitoring of threats in recovery plans is still weak. Adaptive management for threats, which is specifically encouraged in the guidelines, cannot be adequately implemented without appropriate monitoring. Though the subject of monitoring tasks is more varied for threats, the number of monitoring tasks is lacking in the plans and task protocols remain unclear. This inadequacy in threat monitoring may reflect a larger problem in recovery planning. Further studies using the data acquired from recent plans should consider monitoring throughout the entirety of the plan, to determine if the dearth in threats truly reflects a greater problem in the recovery planning process.

Because the USFWS/NMFS recovery planning guidelines are still "interim" (USDI 2010), there is opportunity to restructure them to focus more substantially on monitoring. The successful incorporation of other key SCB recommendations could serve as a template for how to more adequately incorporate monitoring. Perhaps giving monitoring its own section in the guidelines and in recovery plans themselves would allow for more effective inclusion and prioritization of these tasks. These techniques were used to more adequately integrate other SCB recommendations for threats and have greatly improved many areas of the recovery planning process. Many biases and inadequacies in the treatment of threats in planning for endangered species have been eliminated thanks to the focus of the guidelines on addressing them. Overall, recovery planning is improving under the Endangered Species Act, and this improvement can directly lead to more effective management of endangered species.

CHAPTER 5

TABLES AND FIGURES

Figure legends

Figure 1: The percentage of all threats by characteristic. The characteristics of threats in each category, severity, magnitude, frequency, timing, directness, and total documentation (inclusion of all 4 categories of information for a threat), were determined. The chosen characteristics for each category were the most prevalent in the 1999 SCB study (Lawler et al. 2002). The blue bars represent the total percentages of threats in each category in the SCB study, while the red bars represent the total percentages as determined by the current study.

Figure 2: The percentage of different category threats addressed by recovery tasks. The blue bars indicate what the SCB study (Lawler et al. 2002) determined was the percentage of threats in each category that were addressed by a recovery task. The red bars indicate the current study's results. "Doc" indicates the documentation category, with complete documentation indicating threats had information on severity, timing, frequency, and magnitude.

Figure 3: The percentage of different category threats addressed by monitoring tasks. The blue bars indicate what the SCB study (Brigham et al. 2002) determined was the percentage of threats in each category that were addressed by a monitoring task. The red bars indicate the current study's results. There are no data from the SCB study for percentages of major, minor, direct, or indirect threats addressed by monitoring tasks.

Table 1: Society for Conservation Biology 1999 Study Recommendations and Parallel, Related Text in the 2010 USFWS/ NMFS Recovery Planning Guidelines.

	SCB recommendations	USFWS/NMFS guidelines
Crafting the plan	New recovery planning guidelines.[a]	Direct appeal to SCB recs[1]
	Guidance on drafting optimal recovery plans.[a]	Example recovery outline, example recovery strategy, and explicit plan writing instructions[2]
	Bolster internal consistency with checklists of questions[a]	Calls for improvement in internal consistency[1]
		Specific questions for various assessments including biological, threats, and conservation[3,4,5]
	Improve and standardize revision process.[b,c,d]	Describes how to use and update plans and when to revise[6]
	Reflect species-specific needs and information in plan length and structure.[d]	Focus on recovery plans as guidance documents, not regulatory documents[7]
		Maintain plan flexibility and address specific circumstances[8,9]
		"Recovery planners should view this as an opportunity to use their creativity and ingenuity to craft the most effective and practical recovery program for each species in their care" (1.2-3).[8]
	Clearly define and justify management actions, recovery goals, and monitoring programs.[a]	Describes considerations and uses for management actions[10,11,12]
		Prioritize actions in recovery strategy[13]
		"Measuring the effectiveness of the plan via monitoring actions should be included in the recovery program, and these monitoring actions should be assigned a priority equal to the activity that is being monitored" (5.1-20).[14]
	Keep authorship small yet diverse.[d,e,f]	Improve diversity of contributors, while maintaining

		small, manageable, expert-based teams[1,15,16]
Plan implementation	Improve effect of prioritization on plan structure and implementation.[b,c,g]	Prioritize species plans and actions within plans for implementation and revision.[1,17]
	Invest more in recovery coordinators[c,e]	Identify responsible parties and facilitate coordination.[18]
		If necessary, employ coordinator.*[19]
	Small, diverse committee to coordinate implementation.[a]	Includes responsible parties and possible coordinator, but no calls for committee*[16,18,20]
	Invest more in centralized databases[c,e]	No inclusion**
	Maintain current, publicly available database of high-quality estimates of status trend.[a]	None**
	Track investment of resources and effectiveness on species recovery[a]	"Within the recovery action narrative, recovery actions should be stepped down to discrete actions that can be funded, permitted, or carried out independently" (5.1-22).[11]
Use of biological information	Integrate and use biological information.[h]	More effectively connect biological information with recovery criteria and actions[1]
		Includes biological assessment questions to be answered[3]
		"By identifying the sources and magnitude of our uncertainties, we can build better criteria and more accurately target those aspects" (5.1-18).[21]
	Collect and integrate missing biological information[a]	Include careful assessment of biology, status, and threats.[22]
	Link species biology with other important features of the recovery plans, such as recovery criteria, goals, actions, and implementation. [d,h,i,j]	Make criteria specific and measurable[22,23]
		Make realistic criteria that are defensible and grounded in good science[23]
	When possible, use quantitative criteria.[j]	No focus on quantitative criteria**
		Criteria must be measurable and objective, they need not all be quantitative[21]
	Define management actions and goals that are more biologically justified (in plan revisions).[b]	"Identify any biological constraints or needs of the species that need to be

		considered in planning and management" (5.1-10).[24]
	Use species-specific biology to select monitoring protocols[g,h,i]	Inadequate discussion of use of biology to determine appropriate monitoring protocols**[11]
	Collect information necessary to effectively monitor species.[g]	Little information on how collected information will/should influence monitoring**[11]
	Incorporate Population Viability Analyses[k]	Encourages use of new science and theories[1] "PVA should not be viewed as a replacement for criteria based on threats, but as a supplement to them" (5.1-18).*[21]
Monitoring	Monitoring must be a priority.[a]	Only 1.5 pages of guidelines*[1,11]
	Increase monitoring of species status, threats, and implementation of recovery tasks.[g,h]	"Monitoring is needed to address a number of different aspects of a recovery program. These include species status and trends, threats, plan implementation, the effectiveness of recovery actions, and progress towards meeting recovery criteria." (4.5-1).[11,25]
	Develop an implementation monitoring system[a]	Create at least a basic monitoring framework and include an action to create post-delisting monitoring plan[1,11,25]
Threats	Address how threats can be mitigated and alleviated.[h,l]	"Identification of, and strategies for dealing with, the threats… should be central to the recovery plan and program" (1.3-1).[26,27]
	Invest in understanding factors that threaten species.[l]	"Outline the characteristics of a species that make it vulnerable to, and that would allow it to recover from, environmental, demographic, and human-caused threats" (1.3-1).[26]
	Include and prioritize tasks to directly address threats, especially major ones.[a,h,l]	Include threats tracking table and threats assessment[27] Discusses how to identify threats and uncertainties[28] Link threats directly to criteria[21] "Recovery actions must include specific actions to control each of the identified threats to the species" (5.1-22).[11]
	Address threats with monitoring and implementation tasks.[g,i]	Briefly mentioned in implementation monitoring section*[11,29]

	Include information on magnitude, timing, frequency, and severity of threats.[l]	Calls for information gathering and inclusion of a threats tracking table and threats assessment[4,22,27,28]
Taxonomic Bias	Develop and implement plans equally across taxa.[b,c,g,f,h,m]	Only a brief recognition of need to eliminate taxonomic bias**[1]

*Indicates recommendation that was partially incorporated
**Indicates recommendation that was not addressed
[a]Clark et al. 2002; [b]Harvey et al. 2002; [c]Lundquist et al. 2002; [d]Boersma et al. 2001; [e]Hatch et al. 2002; [f]Gerber & Schultz 2001; [g]Campbell et al. 2002; [h]Schultz & Gerber 2002; [i]Brigham et al. 2002; [j]Gerber & Hatch 2002; [k]Morris et al. 2002; [l]Lawler et al. 2002; [m]Hoekstra et al. 2002b
[1]Box 1.0 – "2002 Society for Conservation Biology study of FWS recovery plans and its application to the NMFS recovery program" in NMFS (2010); [2]Appendix K – "Sample recovery outline;" 5.1 – "Contents of a recovery plan;" Box 5.1.9.2 – "Recovery action outline: Atlantic Coast population of the Piping Plover (Charadrius melodus)" in NMFS (2010); [3]Box 3.2.2-1 – "Prompt sheet for biological assessment" in NMFS (2010); [4]Box 3.2.2-2 - "Prompt sheet for threats assessment" in NMFS (2010); [5]Box 3.2.2-3; Box 3.2.3-1; Box 3.2.3-2 in NMFS (2010) [6]3.3.5 – "Using/ updating the recovery outline" and 6.2 – "Modifying the recovery plan" in NMFS (2010); [7]1.1 – "Why develop recovery plans?" in NMFS (2010); [8]1.2 – "Legal and policy guidance for recovery planning" in NMFS (2010); [9]1.4 – "Opportunities for streamlining and flexibility" in NMFS (2010); [10]1.0 – "Purpose and overview" in NMFS (2010); [11]5.1.9.3 – "Recovery action narrative" in NMFS (2010); [12]5.2.3 – "Incorporation of comments" in NMFS (2010); [13]5.1.7 – "Recovery strategy" and 5.1.8.1 – "Recovery goals" in NMFS (2010); [14]5.1.9 – "Recovery program" in NMFS (2010); [15]2.3.2.2 – "Use of NMFS biologists to write recovery plans" in NMFS (2010); [16]2.3.3.2 – "Recovery team composition" in NMFS (2010); [17]5.1.10 – "Implementation schedule and cost estimates" in NMFS (2010); [18]2.3.1 – "Coordination" in NMFS (2010); [19]Appendix I – "Terms of reference for the Hawaiian Monk Seal" in NMFS (2010); [20]Appendix Q – "Example implementation schedule" in NMFS (2010); [21]5.1.8.3 – "Recovery criteria" in NMFS (2010); [22]5.2.1.2 – "Analysis" in NMFS (2010); [23]Box 5.1.8.3-1 – "When drafting recovery criteria, remember that they should be 'SMART'" in NMFS (2010); [24]5.1.6.9 – "Biological constraint and needs" in NMFS (2010); [25]4.5 – "Monitoring considerations" in NMFS (2010); [26]1.3.2 – "The significance of threats in recovery planning"; see also Box 5.1.6.7 in NMFS (2010); [27]5.1.6.7 – "Reasons for listing / threats assessment" in NMFS (2010); [28]Appendix C – "Threats assessment" in NMFS (2010); [29]6.1 – "Implementation, monitoring, and information management" in NMFS (2010).

Table 2: Potential Biases for Threats in Recovery Plans

Findings	SCB study	Current study
# threats/species	animals > plants[a]	animals > plants[a]
# direct threats/species		animals > plants[a]
# threats with recognition of uncertainty		animals = plants[b]
# threats with complete documentation		major > minor[c] direct > indirect[c]
# recovery tasks/threat	animals > plants[a]	animals = plants
% threats addressed by recovery task	major > minor[c] direct > indirect[c]	major = minor direct = indirect
# threat recovery tasks/plan		major > minor[c] direct > indirect[c]
Prioritization of threat recovery tasks	major > minor[c]	major = minor
% threats monitored		animals = plants major > minor[c] direct > indirect[c]
% major threats monitored		animals = plants
% monitoring tasks for focal species		animals > plants[a]
% threats with monitoring protocol clearly linked with species biology		animals < plants[a]
% threats addressed by a recovery criteria		animals < plants[a]

Note: Blank cells indicate that there was no related SCB finding.
[a]Independent samples t-test, $p < 0.05$
[b]Independent samples t-test, $p = 0.057$
[c]Wilcoxon signed ranks test, $p < 0.05$

Figure 1: Percentage of Total Threats by Category Found in Each Study

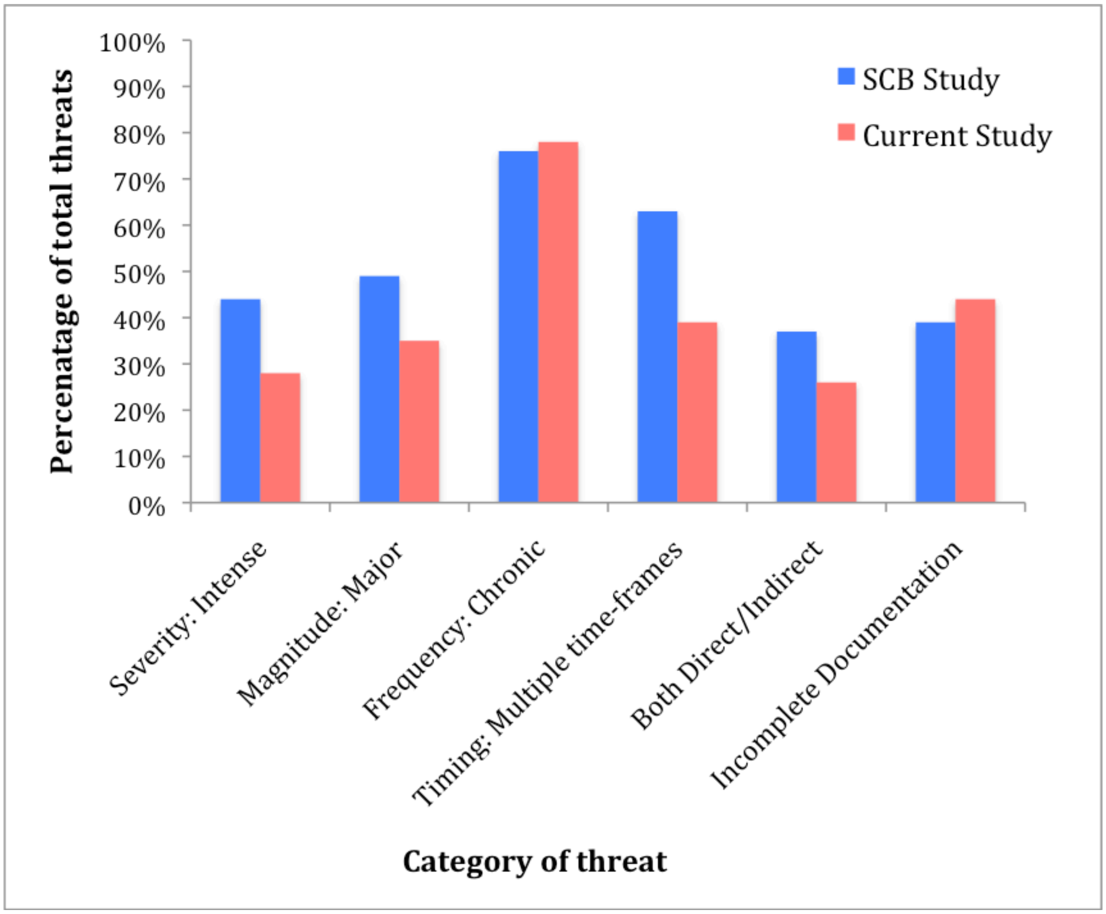


Figure 2: Threats by Category Addressed by Recovery Tasks

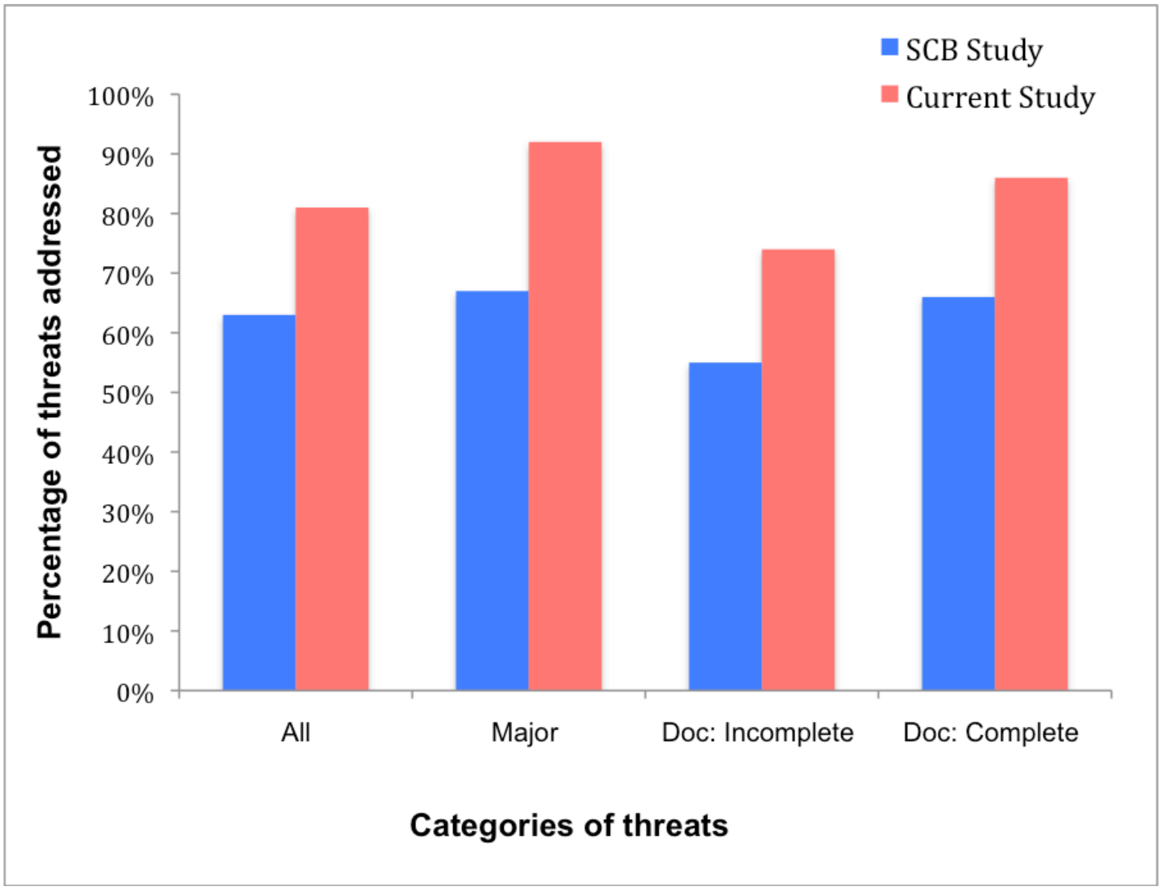
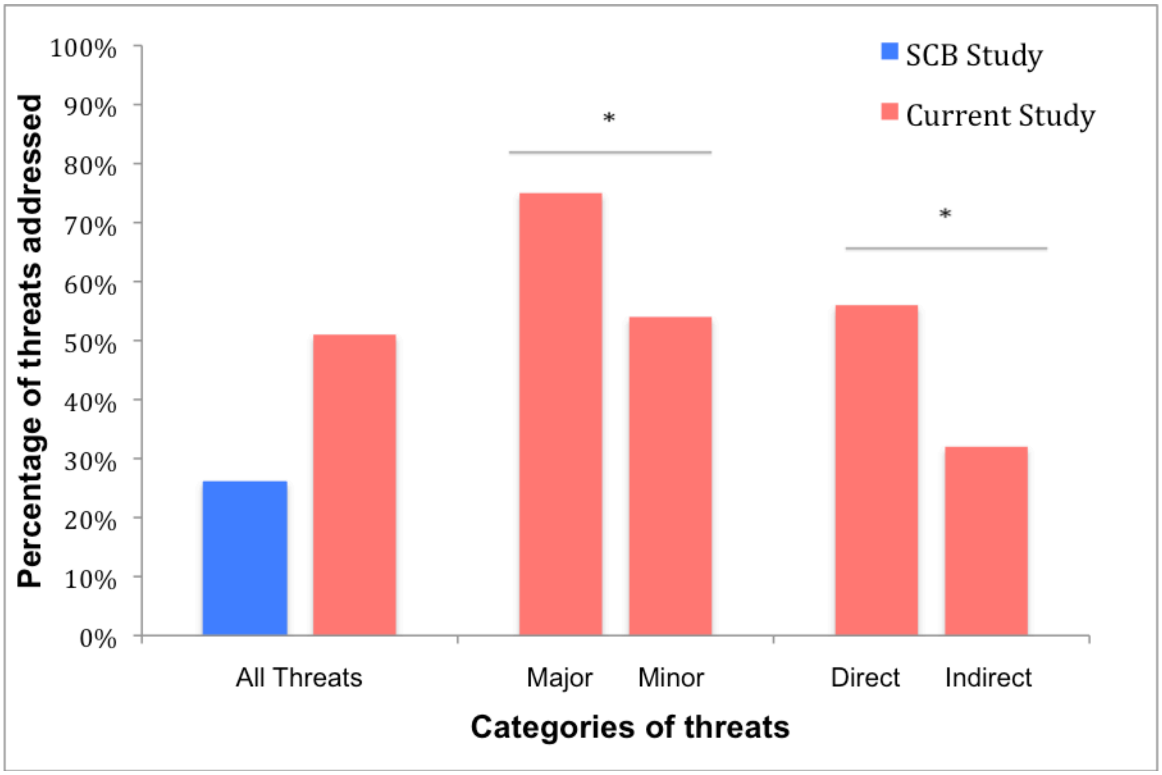


Figure 3: Threats by Category Addressed by Monitoring Tasks



* $p < 0.05$

REFERENCES

Boersma, P. D., P. Kareiva, W. F. Fagan, J. A. Clark, and J. M. Hoekstra. 2001. How good are endangered species recovery plans? BioScience **51:**643-649.

Brigham, C. A., A. G. Power, and A. Hunter. 2002. Evaluating the internal consistency of recovery plans for federally endangered species. Ecological Applications **12:**648–654.

Campbell, S. P., J. A. Clark, L. H. Crampton, A. D. Guerry, L. T. Hatch, P. R. Hosseini, J. J. Lawler, and R. J. O'Connor. 2002. An assessment of monitoring efforts in endangered species recovery plans. Ecological Applications **12:**674–681.

Carwardine, J., T. O'Connor, S. Legge, B. Mackey, H. P. Possingham, and T. G. Martin. 2012. Prioritizing threat management for biodiversity conservation. Conservation Letters **5:**196-204.

CBS DC. 2014. Republicans in Congress want to change the Endangered Species Act. CBS Local, Washington D.C. Available from http://washington.cbslocal.com/2014/02/04/republicans-in-congress-want-to-change-the-endangered-species-act/ (accessed March 2014).

Clark, J. A., and E. Harvey. 2002. Assessing multi-species recovery plans under the Endangered Species Act. Ecological Applications **12:**655–662.

Clark, J. A., J. M. Hoekstra, P. D. Boersma, and P. Kareiva. 2002. Improving U.S. Endangered Species Act recovery plans: key findings and recommendations of the SCB recovery plan project. Conservation Biology **16:**1510-1519.

Crain, C. M., B. S. Halpern, M. W. Beck, and C. V. Kappel. 2009. Understanding and managing human threats to the coastal marine environment. Annals of the New York Academy of Sciences **1162:**39–62.

Crouse, D. T., L. A. Mehrhoff, M. J. Parkin, D. R. Elam, and L. Y. Chen. 2002. Endangered species recovery and the SCB study: a U.S. Fish and Wildlife Service perspective. Ecological Applications **12:**719–723.

Croxall, J. P., S. H. M. Butchart, B. Lascelles, A. J. Stattersfield, B. Sullivan, A. Symes, and P. Taylor. 2012. Seabird conservation status, threats and priority actions: a global assessment. Bird Conservation International **22:**1-34.

Darst, C. R., P. J. Murphy, N. W. Strout, S. P. Campbell, K. J. Field, L. Allison, and R. C. Averill-Murray. 2013. A strategy for prioritizing threats and recovery actions for at-risk species. Environmental Management **51:**786-800.

Doremus, H. 2010. The Endangered Species Act: static law meets dynamic world. Washington University Journal of Law and Policy **32:**175-235.

Doremus, H., and J. E. Pagel. 2001. Why listing may be forever: perspectives on delisting under the U.S. Endangered Species Act. Conservation Biology **15:**1258-1268.

Gerber, L. 2003. Delisting of species under the ESA. Conservation Biology **17:**651-652.

Gerber, L. R., and L. T. Hatch. 2002. Are we recovering? An evaluation of recovery criteria under the U.S. Endangered Species Act. Ecological Applications **12:**668–673.

Gerber, L. R., and C. B. Schultz. 2001. Authorship and the use of biological information in endangered species recovery plans. Conservation Biology **15:**1308-1314.

Goble, D. D. 2009. Endangered Species Act. Pages 300-305 in J. B. Callicott and R. Frodemanin, editors. Encyclopedia of environmental ethics and philosophy vol. 1. Macmillan Reference USA, Detroit, Michigan.

Gregory, R., J. Arvai, and L. R. Gerber. 2013. Structuring decisions for managing threatened and endangered species in a changing climate. Conservation Biology **27**:1212-1221.

Halpern, B. S., et al. 2008. A global map of human impact on marine ecosystems. Science **319:**948-952.

Halpern, B. S. et al. 2009. Mapping cumulative human impacts to California Current marine ecosystems. Conservation Letters **2:**138-148.

Harding, E. K., et al. 2001. The scientific foundations of habitat conservation plans: a quantitative assessment. Conservation Biology **15:**488-500.

Hartl, B. 2014. House Republicans introduce legislation to weaken Endangered Species Act. Center for Biological Diversity, Tucson, AZ. Available from http://www.biologicaldiversity.org/news/press_releases/2014/endangered-species-act-03-28-2014.html (accessed March 2014).

Harvey, E., J. M. Hoekstra, R. J. O'Connor, and W. F. Fagan. 2002. Recovery plans revisions: progress or due process? Ecological Applications **12:**682–689.

Hatch, L., M. Uriarte, D. Fink, L. Aldrich-Wolfe, R. G. Allen, C. Webb, K. Zamudio, and A. Power. 2002. Jurisdiction over endangered species' habitat: the impacts of people and property on recovery planning. Ecological Applications **12:**690–700.

Hoekstra, J. M., J. A. Clark, W. F. Fagan, and P. D. Boersma. 2002a. A comprehensive review of Endangered Species Act recovery plans. Ecological Applications **12:**630–640.

Hoekstra, J. M., W. F. Fagan, and J. E. Bradley. 2002b. A critical role for critical habitat in the recovery planning process? Not yet. Ecological Applications **12:**701–707.

Horowitz, C., and M. Jasny. 2007. Precautionary management of noise: lessons from the U.S. Marine Mammal Protection Act. Journal of International Wildlife Law and Policy **10:**225–232.

James, F. C., and J. S. Glitzenstein. 2011. Inadequate enforcement of the Endangered Species Act. Frontiers in Ecology and the Environment **9:**263.

Kareiva, P., et al. 1998. Using science in habitat conservation plans. Report. American Institute of Biological Sciences, Washington, D.C., and the NCEAS, Santa Barbara, CA. Available from http://www.nceas.ucsb.edu/files/Kareiva%20Using%20science%20in%20habitat%20conservation%20plans.pdf (accessed March 2014).

Knickerbocker, B. 2005. Endangered Species Act under fire from two directions. The Christian Science Monitor, Ashland, OR. Available from http://www.csmonitor.com/2005/0628/p03s02-uspo.html (accessed March 2014).

Kostyack, J., and D. Rohlf. 2008. Conserving endangered species in an era of global warming. The Environmental Law Reporter **38**:10203-10213.

Lawler, J. J., S. P. Campbell, A. D. Guerry, M. B. Kolozsvary, R. J. O'Connor, and L. C. N. Seward. 2002. The scope and treatment of threats in endangered species recovery plans. Ecological Applications **12:**663–667.

Lundquist, C. J., J. M. Diehl, E. Harvey, and L. W. Botsford. 2002. Factors affecting implementation of recovery plans. Ecological Applications **12:**713–718.

McClenachan, L., A. B. Cooper, K. E. Carpenter, and N. K. Dulvy. 2012. Extinction risk and bottlenecks in the conservation of charismatic marine species. Conservation Letters **5:**73-80.

Morris, W. F., P. L. Bloch, B. R. Hudgens, L. C. Moyle, and J. R. Stinchcombe. 2002. Population viability analysis in endangered species recovery plans: past use and future improvements. Ecological Applications **12:**708–712.

NCEAS (National Center for Ecological Analysis and Synthesis). 2002a. Recovery planning. NCEAS, Santa Barbara, CA. Available from https://www.nceas.ucsb.edu/recovery/index.html (accessed March 2014).

NCEAS (National Center for Ecological Analysis and Synthesis). 2002b. Data Collection. NCEAS, Santa Barbara, CA. Available from https://www.nceas.ucsb.edu/recovery/datacollection.html (accessed March 2014).

NCEAS (National Center for Ecological Analysis and Synthesis). 2002c. Recovery planning: publications. NCEAS, Santa Barbara, CA. Available from http://www.nceas.ucsb.edu/recovery/publications.html (accessed March 2014).

NMFS (National Marine Fisheries Service). 2010. Interim endangered and threatened species recovery planning guidance version 1.3. NMFS, Silver Spring, MD. Available from http://www.nmfs.noaa.gov/pr/pdfs/recovery/guidance.pdf (accessed March 2014).

Ruhl, J. B. 2003. Taking adaptive management seriously: a case study of the Endangered Species Act. University of Kansas Law Review **52**:1249-1284.

Salafsky, N., et al. 2008. A standard lexicon for biodiversity conservation: unified classifications of threats and actions. Conservation Biology **22:**897-911.

Schultz, C. B., and L. R. Gerber. 2002. Are recovery plans improving with practice? Ecological Applications **12:**641–647.

Schultz, C. B., and P. C. Hammond. 2003. Using Population Viability Analysis to develop recovery criteria for endangered insects: case study of the Fender's Blue Butterfly. Conservation Biology **17**:1372-1385.

Suckling, K., N. Greenwald, and T. Curry. 2012. On time, on target: how the Endangered Species Act is saving America's wildlife. Report. Center for Biological Diversity, Tucson, AZ. Available from http://www.esasuccess.org/report_2012.html (accessed March 2014).

Taylor, M. F. J., K. F. Suckling, and J. J. Rachlinski. 2005. The effectiveness of the Endangered Species Act: a quantitative analysis. BioScience **55:**360-367.

USDI (United States Department of the Interior). 2010. Adoption of interim recovery planning guidelines and request for feedback. USDI, Washington, D.C. Available from http://www.fws.gov/ENDANGERED/esalibrary/pdf/AD_memo_adopting_NMFS_guidance_Interim_signed_August_26_2010.pdf (accessed March 2014).

USFWS (U.S. Fish and Wildlife Service). 2011. Service announces work plan to restore biological priorities and certainty to endangered species listing process. USFWS, Washington, D.C. Available from http://www.fws.gov/cno/press/release.cfm?rid=216 (accessed April 2014).

BIOGRAPHICAL SKETCH

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