2006

Marine Species

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Published in *The Endangered Species Act at Thirty, Volume 1: Renewing The Conservation Promise,* edited by Dale D. Goble, J. Michael Scott, & Frank W. Davis (Washington: Island Press, 2006), pp. 36-44.

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The 4.1 million square miles of ocean inside the 200-mile *exclusive economic zone* around the United States surpasses the 3.6 million square miles total land area within federal jurisdiction (Lindholm and Barr 2001). The coastal oceans contain a great diversity of habitat types and ecosystems. These habitats are associated with particular substrate features such as coral reefs, sea grass beds, rocky shores and soft-bottom habitats, and also with persistent oceanographic features such as frontal convergence zones and upwelling regions.

Our marine ecosystems contain unique and rich biotas. At higher taxonomic levels, biodiversity is much richer in the marine environment than it is on land or in freshwater. For example, thirty-six out of thirty-seven animal phyla are represented in the sea (Groombridge and Jenkins 2002), and 64 percent of animal phyla are found exclusively there, whereas only 3 percent are confined to land and none are exclusive to freshwater (May 1994; Reaka-Kudla 1997). Marine ecosystems appear relatively less diverse at the species level—roughly 15 percent of all described species are marine (Reaka-Kudla 1997).

Consistent national accounting of marine ecosystems is constrained by a lack of data, but the available indicators are worrying. As of 2002, of 237 domestic stocks managed by the National Marine Fisheries Service (NMFS) whose current status are known, 86 are overfished and overfishing continues for 66 stocks (NMFS 2003). The overfished status of the remaining 695 managed stocks, which are mostly of lesser commercial importance, is unknown (NMFS 2003). Two comprehensive national reviews of the state of marine ecosystems, the first in over thirty years, report that marine ecosystems are "in crisis" (Pew Oceans Commission 2003) and "in trouble" (U.S. Commission on Ocean Policy 2002).

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In this chapter, we review the role of the Endangered Species Act in protecting endangered marine species. Although our main focus is on those populations whose ranges fall primarily within the exclusive economic zone, we include both U.S. and foreign listed species in our analyses. Elsewhere (Armsworth et al., forthcoming), we review threats and conservation strategies for endangered marine species.

Extinct Marine Species

Relatively few species extinctions have been documented in marine ecosystems (Roberts and Hawkins 1999; Dulvy et al. 2003), but local extirpations of populations are more common (Dulvy et al. 2003; Musick et al. 2000; Powles et al. 2000). "Ecological" or "functional" extinctions are more common still and occur when species, such as top predators, that determine key ecosystem properties are diminished to a size at which fundamental ecosystem characteristics are altered (Jackson et al. 2001). Local extirpations and severe population reductions may be "the first steps on the road to global extinctions" (Dulvy et al. 2003).

That more marine extinctions have not been reported might be interpreted as support for a commonly stated view that marine species are less vulnerable to extinction than are terrestrial or freshwater species (Malakoff 1997; Roberts and Hawkins 1999; Hutchings 2001). This view is premised on the fact that some well-known marine species have large range sizes, high fecundities, and significant dispersal potential. The small number of documented extinctions may, however, reflect a paucity of data for marine ecosystems (Malakoff 1997; McKinney 1999). We have hardly begun to catalogue marine biodiversity, and the number of cryptic species is unknown. Without better stocktaking of marine biodiversity, it is not possible to evaluate with confidence the risk or frequency of human-induced extinctions. For example, Carlton et al. observe that the extinction of the eelgrass limpet (*Lottia alveus*), which was once abundant on New England shores, went unnoticed by the scientific community for over fifty years (Carlton et al. 1991). A recent review of 130 local to global extinctions of marine populations found that the median delay in reporting was fifty-three years (Dulvy et al. 2003).

Contrary to the perception that "typical" marine life histories render species less vulnerable to extinction, many marine species show a high degree of endemism and habitat specialization, and many others are long lived, have low fecundities, and mature slowly (Musick et al. 2000). Among vulnerable species on the World Conservation Union's red list, the proportions of species whose ranges are restricted that are (1) terrestrial and freshwater, (2) strictly marine, or (3) use marine habitats at some point in their life cycles are comparable (2.4

percent, 3.2 percent, and 2.2 percent respectively). Even species with large range sizes and high dispersal ability may not realize their full dispersal potential and can display significant local differentiation (Taylor and Hellberg 2003). There is also little evidence that highly fecund species enjoy greater reproductive success than species that invest more heavily in a small number of offspring (Hutchings 2001). Myers et al. found similar maximum reproductive rates across a variety of marine fish with a broad range of fecundities, and these maximum reproductive rates were comparable to those of terrestrial vertebrates (Myers et al. 1999).

Endangered Marine Species

Responsibility for ESA listing decisions and for the conservation and management of endangered and threatened marine, estuarine, and diadromous species resides primarily with the NMFS's Office of Protected Resources. For seabirds, this responsibility lies with the U.S. Fish and Wildlife Service (USFWS), as it does for a number of coastal, brackish-water fish.

The first step in determining whether a species will be listed as endangered or threatened under the Endangered Species Act (ESA) is to determine whether it meets the definition of a "species" under the statute. The act is not restricted to full biological species but can be used to protect any species or subspecies of fish, wildlife, or plant, and, for vertebrates only, the act can protect distinct population segments (DPSs) of a species (see Waples [forthcoming] for a review of the DPS and ESU [Evolutionarily Significant Unit] concepts and their application to Pacific salmon). The inclusion of DPSs allows vertebrate species to receive differing levels of protection in different parts of their range and can serve to guard against local extirpations.

To date, marine species have been listed as DPSs more frequently than their terrestrial counterparts (Scott, Goble, et al., this volume). The 39 marine, estuarine, or diadromous species listed as endangered or threatened are represented by 70 species, subspecies, and DPSs. The five salmon and steelhead species alone account for 26 listings. Only 25 marine species are listed across their entire range. By contrast, of the 1,855 listed species, subspecies, or DPSs reported by the USFWS, 98 percent represent full biological species. This disparity could reflect a real difference in population structure of marine and terrestrial species, or it could simply be an historical artifact of different listing processes used by the agencies.

The vulnerability of a species (including subspecies and DPS) that is being considered for listing under the ESA is assessed by NMFS or USFWS in a twelve-month scientific review process. The species appears on a candidate

species list during this year. At the end of the formal assessment period, the species can be listed in the *Federal Register* as being endangered or threatened, or it can be removed from the candidate list if it is not foreseeably imperiled. In some circumstances, a species may not be listed as threatened or endangered but may be retained as a species of concern for future reappraisal. This designation was created by NMFS in 2004 to identify species for which "significant concerns or uncertainties remain regarding their biological status and/or threats," though they may not be currently considered for listing under the ESA.

Marine species are being listed under the ESA with increasing frequency (NMFS 2002), although they still make up only a tiny fraction of total listings (70 of 1,855 U.S. and foreign endangered and threatened listings). Early marine applications of the act focused on marine mammals and turtles (Wilcove and McMillan, this volume). Gradually, the emphasis in listings has shifted toward fish, but it has also diversified to include other taxonomic groups, including gastropods, corals, and marine plants. The current list of species of concern reflects this increased focus on other taxonomic groups. The majority of recent listings have been for Pacific salmon (*Oncorhynchus* spp.) and steelhead (*Oncorhynchus mykiss*) ESUs. Diadromous species feature prominently, both because obligate habitat specializations render them vulnerable to degradation of freshwater and estuarine environments and because diadromy lends itself to differentiation of local population units, which can sometimes be listed individually. Also noteworthy are the growing numbers of fully marine species listed as endangered, threatened, candidate species, or species of concern (see boxes 3.1 and 3.2).

Of the seventy marine species examined here that were once assessed as being endangered or threatened, only one, the eastern North Pacific population of the gray whale (*Eschrichtius robustus*), has recovered to the point at which its removal from the list was warranted (USFWS and NOAA 1994a). A second species, the Caribbean monk seal (*Monachus tropicalis*), has most likely gone extinct since it was listed. Nevertheless, NMFS reports that the status of marine species under ESA is "encouraging" (NMFS 2002). In its September 2002 report to Congress, the agency stated that of the endangered and threatened species with recovery plans in place, 36 percent "had been stabilized or were improving," 31 percent were declining, and 33 percent were "unknown or mixed in their status" (NMFS 2002). These trends are comparable to those for listed terrestrial and freshwater species, of which 39 percent were stable or improving, 34 percent were declining, 24 percent were uncertain, and 3 percent were extinct or found only in captivity in 2000 (USFWS 2003c).

Ocean Governance and the Role of the Endangered Species Act

Governance of our oceans is extremely fragmented, and the ESA must mesh with many other statutes, the implementation of which involve multiple agencies. Waters up to 3 miles offshore are managed by states, while those from 3 to 200 miles offshore are the responsibility of the federal government. Over 140 statutes govern exploitation of marine environments of which 43 are considered to be major. Regulation of our oceans spans sixty congressional committees overseeing nearly twenty agencies and permanent commissions. "Individuals who work and live on the water . . . face a Byzantine patchwork of federal and state authorities and regulations" (U.S. Commission on Ocean Policy 2002, 4). There are increasingly vocal calls for a reorganization of national ocean policy, one that would consolidate and integrate across these disparate management schemes (Cicin-Sain and Knecht 2000; Pew Oceans Commission 2003; U.S. Commission on Ocean Policy 2002).

We feel it is time for discussion on how the ESA might most effectively support sustainable management and conservation of marine species. Discussions on the future of the ESA, as reviewed elsewhere in this book, are occurring in parallel with the first comprehensive reviews of ocean policy in over thirty years (Pew Oceans Commission 2003; U.S. Commission on Ocean Policy 2004). Therefore, we find it disappointing that the role of the ESA, of extinction processes in the marine environment, and of the need for a fuller stocktaking of marine biodiversity have not appeared more prominently in these discussions on ocean policy. For example, while the Pew report repeatedly calls for crosscutting and integrative regulations and provides a comprehensive suite of recommendations for improving marine conservation and management in general, it only discusses the ESA in passing and as a minor theme.

The remit of the ESA overlaps in marine systems with other key regulations. For example, rebuilding depleted populations is also a central goal of the Sustainable Fisheries Act (SFA) (Act of October 11, 1996) and of the Marine Mammal Protection Act (MMPA) (Act of October 21, 1972), a goal that has resulted in regulation of and moratoria on take of depleted species under these statutes. For both of these acts, however, the goal of rebuilding is not merely to prevent full extinction, as it is under the ESA, but rather to restore a species to some "optimal" abundance level. For the SFA, the goal under national standard 1 is to rebuild species to abundance levels that will provide "on a continuing basis . . . optimal yield for the US fishing industry." The major objective of the

BOX 3.1. White Abalone

The white abalone (*Haliotis sorenseni*), a gastropod, was listed as endangered under the ESA on May 29, 2001; it is the first marine invertebrate to be listed (NOAA 2001). The species is a broadcast spawner and adults are highly fecund and produce millions of eggs or sperm during spawning. However, fertilization success depends on the density of adults and may fall off sharply when adults are sparsely distributed (Leighton 1972; Babcock and Keesing 1999; Hobday and Tegner 2000). White abalone undergo a free-swimming larval stage of nine to ten days during which they are thought to have relatively limited dispersal potential (Hobday and Tegner 2000). Abalone grow slowly, do not mature until four to six years of age, and have a lifespan of thirty-five to forty years.

Over the last thirty years, abalone abundance is thought to have declined by 99.9 percent from approximately 2.22–4.24 million individuals to 1,613–2,540 animals (NOAA 2001). The decline was driven by overfishing. Commercial fishing of white abalone began in 1967 and landings peaked at 86,000 individuals in 1972 (NOAA 2001). The commercial fishery collapsed within ten years of first opening.

In California, white abalone are now restricted to a few localized populations, mostly within the Channel Islands. The sedentary nature of adults (movements on the order of meters or less) means that it is possible to delineate these localized populations. However, the National Marine Fisheries Service declined to specify critical habitat for abalone because of concerns that publicly identifying remaining habitats could encourage poaching. Hobday and Tegner estimated that 3.7 square miles of suitable habitat for white abalone exist within its historic range, but much of this area remains unoccupied (Hobday and Tegner 2000).

The white abalone population is not expected to recover without human intervention. Recruitment failure is believed to be recurrent and the remaining population may constitute aging adults, surviving offspring from the last known successful recruitment in 1966 before the population collapsed (Hobday and Tegner 2000). Current densities, estimated at 0.0002 per meter, are well below the threshold of 0.15 per meter at which fertilization success for abalone in the field drops by 50 percent (Babcock and Keesing 1999; Hobday and Tegner 2000). Restoration efforts based on captive breeding are under way (Western Ecological Research Center 2002), but the science of marine restoration ecology is very much in its infancy.

BOX 3.2. Bocaccio

On January 30, 2001, the National Marine Fisheries Service (NMFS) received a petition to list the central/southern population of bocaccio (*Sebastes paucispinis*), a species of rockfish, as a threatened species (Natural Resources Defense Council et al. 2001). Bocaccio ranges from Baja California to Stepovak Bay, Alaska. The species is separated into northern and southern segments by an area of low abundance off northern California and southern Oregon. NMFS ruled that the two subpopulations constitute distinct population segments (MacCall and He 2002) and that therefore the central/southern subpopulation could be considered for listing. However, at the end of the review process, NMFS announced that a listing was not warranted.

Bocaccio are ovoviviparous and females give birth to 20,000 to 2,298,000 larvae (Love et al. 2002). Recruitment is highly variable in bocaccio. Individuals mature after about five years and can live up to forty years (MacCall and He 2002; Love et al. 2002). Adults are widely distributed and are often found over rocky reefs or boulder fields.

Bocaccio abundance has decreased steadily since 1969. Current abundance is estimated to be 1.6 million fish of age one or older, or 3.6 percent of estimated unfished spawner abundance (NOAA 2002). Stock assessments since 1996 indicate that the population is in severe decline and it was formally declared overfished in 1999. The decline of bocaccio has been driven by directed fishing and bycatch and has been exacerbated by a string of poor recruitment years. The published ruling by NMFS catalogues a sequence of problems with the scientific advice provided to the Pacific Fishery Management Council and repeated management failures on the part of the council to take action (NOAA 2002).

The decision not to list the population was based on recent conservation measures that have been adopted by the council and the State of California. These measures include the prohibition of directed fishing or retention of the species, measures to reduce bycatch of bocaccio, large catch reductions, with allowable catch rates less than 5 percent of their average over the previous fifty years, marine reserve creation, and time-area closures. Bocaccio remain on the agency's list of species of concern.

MMPA is to ensure that marine mammal species remain a "significant functioning element in the ecosystems of which they are a part," in other words, to prevent functional extinctions. Therefore, each of these statutes sets more conservative rebuilding targets than are required under the ESA for the suite of species that they protect.

If interpreted and applied judiciously, the ESA can play important roles in marine management. These roles will vary somewhat across taxonomic groups, however, because of the interaction of the act with other statutes. For species that receive protection under complementary regulations, such as the SFA and MMPA, the ESA provides an extra layer of protection and can serve as a strong safety net should other, perhaps more flexible, regulatory instruments fail to prevent a species from becoming imperiled. However, not all species receive protection under other statutes, many of which like the MMPA have a narrow taxonomic or other focus. Therefore, the ESA also has a crucial role to play in ensuring that species, like Johnson's seagrass (*Halophila johnsonii*) or the tidewater goby (*Eucyclogobius newberryi*), receive at least some measure of protection and do not fall between the regulatory cracks.

The laws that protect marine species differ not only in the species they cover but also in the burdens they place on regulators and when they are binding. The ESA is only binding when there is a credible threat of extinction to a species, subspecies, or vertebrate DPS. In contrast, the SFA and other laws confer protection to species regardless of their current plight. When the ESA is applicable, it can provide substantial security to a species and place a heavy burden of responsibility on managers. To illustrate, suppose some species of conservation concern is caught as unwanted bycatch in a fishery. If the vulnerable species is listed, then NMFS must ensure that any continued operation of the fishery is "not likely to jeopardize the continued existence" of the listed species under section 7 of the ESA. In contrast, if the species is not listed, then the agency must implement management measures under national standard 9 of the SFA that "to the extent practicable, (A) minimize bycatch and (B) to the extent that bycatch cannot be avoided, minimize the mortality of such bycatch."

We anticipate that listings and listing petitions for marine species will continue to increase in frequency and that therefore the profile of the ESA in marine management discussions will grow. An increase in listing attempts could reflect the continuing decline of species that are already intensely impacted by human activities as well as more accurate reporting of these declines as additional data become available. An increase in listings could also reflect a broadening of the suite of marine species confronting anthro-

pogenic impacts as human influences propagate further within and across marine ecosystems. Marine taxonomy is relatively underdeveloped and an increase in listings will result from improvements in taxonomic resolution, which are certain to reveal more cryptic species and subspecies. Frustrated stakeholder groups may turn to listing attempts in light of the growing scarcity of marine resources and increasing conflicts over marine ecosystems. This outcome seems particularly likely given the growth in the marine conservation lobby.

It is important that managers and stakeholders strive to find the statute that provides the best available tool for the issue at hand. When trying to prevent the final extinction of an already critically depleted species like white abalone (*Haliotis sorenseni*), the ESA is the appropriate regulatory instrument. Implementation of the act will likely be most effective when the species in question has a spatially restricted and easily demarcated range; when the listing only impacts a small and concentrated number of resource users; and when a taking can be clearly defined and a "no takings" policy can be efficiently enforced. When trying to alter exploitation practices to stem the flux of additional species into endangerment, however, other regulations like the SFA provide more suitable tools.

If more general resource conflicts can be managed successfully under the suite of other marine statutes, then the ESA could be freed to fulfill its role as a species safety net; it could then serve as a powerful tool for preventing further marine extinctions. Provided it is not expected to carry the weight of broader marine biodiversity conservation, we perceive much potential for applying the ESA to improve the status of threatened marine species.