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Working Seascapes

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19 Working Seascapes

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Marine species are being listed under the Endangered Species Act with increasing frequency and this trend can be expected to continue (Armsworth et al. 2006). The taxonomic focus of marine listings is also diversifying (Armsworth et al. 2006). Despite long-held assumptions that life history characteristics of some marine species render them less vulnerable to extinction, anthropogenic impacts to marine ecosystems have imperiled a growing number of species. In this chapter, we review both the threats endangering marine species and some of the strategies being employed to mitigate those threats.

Listing decisions reveal the relative importance of different threats across taxonomic groups and ecosystems (Kappel 2005). Although many threats facing marine organisms are not unique to the seas, their relative importance differs from those faced by terrestrial species. For listed marine, estuarine, and diadromous species the most commonly identified threat is overexploitation (including targeted harvest, bycatch, and indirect effects), which threatens 81 percent of marine, estuarine, and diadromous listed species (Kappel 2005). Habitat degradation ranks second and is listed as a threat to 76 percent of vulnerable marine species, followed by pollution at 61 percent (Kappel 2005). In contrast, Wilcove et al. (2000) found that habitat impacts topped the list of threats to terrestrial and freshwater species, while invasive species and pollution ranked second and third. As for terrestrial species, habitat degradation is the most frequent threat to many estuarine and diadromous species (Kappel 2005).

Two other efforts to list marine species at risk of extinction, the IUCN Red List of Threatened Species (IUCN 2003) and the American Fisheries Society

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list of fish stocks at risk from extinction (Musick et al. 2000), provide interesting comparisons to the set of species listed as endangered, threatened, or as species of concern under the Endangered Species Act (see Armsworth et al. 2006; NMFS 2002d). Where they intersect in their taxonomic and spatial coverage, the three lists generally agree on the species and subspecies that are most vulnerable. However, each list was created for a distinct purpose and each used different criteria to assess extinction risk. Disparities between lists may therefore reflect gaps in coverage of candidate species, differences in assessment criteria, or different assessment outcomes for particular species.

Over 80 percent of the threatened marine species on the red list were included, at least in part, under IUCN (World Conservation Union) criterion A, or in other words because they had undergone large declines in relative abundance in a limited time period (IUCN 2003). Application of this criterion to marine species is controversial (Musick 1999; Powles et al. 2000; Hutchings 2001). The critical question concerns how large a proportional decrease in abundance a marine species can support before it is at risk of extinction. For example, the central/southern population of the rockfish bocaccio (*Sebastes paucispinis*) has undergone a 96 percent decline in spawner abundance off the California coast but at the same time there are estimated to still be 1.6 million fish of age one (NMFS 2002e).

The American Fisheries Society (AFS) recently published its first recognized list of distinct population segments (DPS) of marine fish at risk of extinction in North America (Musick et al. 2000). The list includes marine, estuarine, and diadromous fish but does not cover Pacific salmonids. It includes 151 distinct population segments from seventy-nine species that are vulnerable to local extirpation; twenty-two of these species are vulnerable to global extinction because all of their population segments are listed. The American Fisheries Society also lists species if they undergo sufficiently large declines in abundance. But unlike the IUCN criterion, which is applied consistently across all species, the society first estimates intrinsic rates of increase of each species and then applies different thresholds for assigning threatened status to species that fall into different resilience classes (Musick 1999).

The IUCN and AFS lists are based on simple quantitative criteria that are applied consistently across species; they do not rely upon the detailed, case-by-case assessments required for federal listings. These lists, then, are perhaps most useful for flagging particular species that may warrant further scrutiny and for identifying common characteristics of those species that are most vulnerable. A petition is required before a species is considered for listing under the Endangered Species Act and, therefore, only a subset of the species considered by the IUCN and AFS have been examined by the National Marine Fisheries Service.

The ESA assessment process, however, is more rigorous for those species that are evaluated.

Threats to Marine Biodiversity

The threats to marine species have recently been reviewed at length by the Pew Oceans Commission (2003) and the U.S. Commission on Ocean Policy (2004). In this section, we specifically examine the implication of different threats both for endangered species and for the likelihood of additional listings in the future.

Fishing

Impacts of overfishing predate all other anthropogenic stressors of coastal ecosystems (Jackson et al. 2001). The importance of fishing as a risk factor contrasts with the relatively low ranking of excessive harvest as a threat to terrestrial species in the United States (Wilcove et al. 2000). In part, this reflects the fact that ocean fisheries are the last permitted market harvest of wild animals (Goble, this volume).

Fishing has both direct and indirect impacts on marine species. Target species experience direct fishing mortality, which can cause shifts in the age, size, sex, social, and genetic structure of populations (National Research Council 1999b). Top predators are the preferred targets of many fisheries and thus suffer the most pronounced losses (Pauly et al. 1998; Myers and Worm 2003). Populations of large-bodied species can be less resilient to overexploitation because they often are slow to mature and exhibit low fecundity. Of the seventy-nine species identified by the American Fisheries Society as containing at least one vulnerable distinct population segment, forty-eight are estimated to have low intrinsic rates of increase; these include a number of sharks, sturgeons, rockfish, and larger groupers (Musick et al. 2000). Mixed-species fisheries present a particular threat to low-productivity species because catches of more productive stocks continue to support fishing while less resilient populations collapse (Huntsman 1994; Musick et al. 2000).

Bycatch is listed as a threat to 42 percent of marine and estuarine endangered, threatened, and species of concern (Kappel 2005). Bycatch mortality was identified as the primary factor behind declines leading to listing of smalltooth sawfish (*Pristis pectinata*) (NMFS 2003b) and remains a critical threat to listed populations of leatherback (*Dermochelys coriacea*), Kemp's ridley (*Lepidochelys kempii*), and olive ridley (*L. olivacea*) sea turtles (NMFS 2002d). Based on catch data and observer programs from around the world, a recent assessment estimated that over two hundred thousand loggerhead turtles (*Caretta caretta*) and fifty thousand leatherbacks may have been taken in pelagic longline fisheries in 2000 (Lewison et al. 2004).

Aquaculture

Aquaculture operations have multiple impacts on marine ecosystems (Goldburg et al. 2001). Individuals that escape from aquaculture facilities can damage wild stocks through competition, by introducing novel diseases and parasites, and by diluting the gene pool if interbreeding occurs. Atlantic salmon (*Salmo salar*) are extinct throughout the United States in all but eight rivers in Maine (Musick et al. 2000), where they are listed as endangered (USFWS and NMFS 2000d). Escaped aquaculture fish of the same species, but of distinct, and often European genetic origin, can comprise over 80 percent of the individuals in rivers in Maine (USFWS and NMFS 2000d). Furthermore, a novel and lethal virus, *infectious salmon anemia*, which was first detected in aquaculture sea pens in New Brunswick, has now been detected in escapees and wild fish in nearby rivers (USFWS and NMFS 2000d). Atlantic salmon are also farmed on the West Coast; here, too, individuals have escaped and are now breeding in British Columbia reaches (Volpe et al. 2000) where they might present a new threat to Pacific salmon and steelhead.

Habitat Destruction

Roughly 45 percent of endangered and threatened species depend on coastal habitats (Glomb 1995). These habitats are being lost to coastal development. Species like the tidewater goby (*Eucyclogobius newberryi*), which was listed as endangered in 1994, depend on shallow coastal lagoons and estuaries and are threatened by filling of wetlands, dredging, breaching of coastal lagoons and diversion of freshwater flow (Lafferty et al. 1996). The key silverside (*Menidia conchorum*) and mangrove rivulus (*Rivulus marmoratus*), both listed as species of concern, are threatened by the loss of mangrove habitats (Gilbert 1992). Of the marine, estuarine, or diadromous ESA species affected by habitat degradation, 85 percent use fresh or brackish water or land for some part of their life cycle, bringing them in contact with coastal development and altered landscapes; all forty listed diadromous species are affected by habitat degradation (Kappel 2005). Fully marine species are also directly and indirectly impacted by habitat degradation (Kappel 2005). Offshore, the action of some fishing gears, such as scallop dredges and otter trawls, radically increases the frequency and magnitude of disturbances to sensitive benthic habitat structures (Watling and Norse 1998; Koslow et al. 2000).

Water Diversion and Flow Modification

Alterations of fresh water and tidal flows are significant threats to diadromous and estuarine species. Diadromous stocks depend on water quality, sufficient in-stream flows, and particular substrate characteristics within the streams and rivers they utilize, all of which may be impacted by terrestrial human activities. Construction of upstream dams can impede spawning by inhibiting access to spawning sites or reducing in-stream flows to the point at which rivers or estuaries become uninhabitable. Impacts other than hydropower development are also important. For example, the totoaba (*Cynoscion macdonaldi*), a federally listed endangered fish that inhabits Mexican Gulf of California waters depends on the Colorado River delta for spawning. However, outflows in the delta have effectively ceased because of diversions for crop irrigation and municipal water needs (Dalton 2003). Channelization and dredging reduce complexity of streambeds, tidal creeks, and estuaries and can destroy spawning, foraging, and refuge habitats. For example, sandbars that restrict tidal flow into coastal lagoons and estuaries are often breached to create boat access and harbor facilities. The resultant increase in flow, scouring and erosion, and salinity can have major impacts on lagoon and estuarine communities, as has been the case in Elkhorn Slough, California, since creation of a direct opening to the ocean in 1947 (Caffrey et al. 2002).

Pollution, Sedimentation, and Run-off

Marine pollution comes from both catastrophic and chronic sources. There were 8,700 oil spills of over 1,000 gallons in U.S. waters between 1973 and 2000 (one every twenty-eight hours) and 30 of these were of more than 1 million gallons (U.S. Coast Guard 2001). Spills associated with the extraction and transportation of petroleum, however, constitute only a small fraction of the petroleum entering the sea as a result of human activities. Fully 85 percent of these inputs come from diffuse sources associated with petroleum consumption in cars and private boats, and from run-off from paved areas (National Research Council 2003b). Chemical pollutants, such as PCBs, DDT, and other organic contaminants, accumulate in the tissues of top predators, sea turtles, and seabirds, and may interfere with health and reproduction (NMFS 2002d). Plastic debris and other garbage is a major threat to sea turtles that ingest it or become entangled (NMFS 2002d). Estuaries and shallow coastal waters are becoming increasingly eutrophic due to run-off of agricultural fertilizers and waste products. The resulting increase in nitrogen can lead to explosive growths of algae, some of which are toxic (Burkholder at al. 1992). The hypoxia that accompanies these algal blooms causes radical shifts in community structure; pelagic organisms are displaced and there is a selective loss of benthic organisms

(Rabalais and Turner 2001). Threatened Johnson's seagrass, (*Halophila johnsonii*), the only listed marine plant, is restricted to a small area on the east coast of Florida, where its survival is jeopardized by siltation, eutrophication, and altered water quality (NMFS 2002d). Approximately 40 percent of U.S. estuaries exhibit high eutrophication conditions, with the Gulf of Mexico and mid-Atlantic coast most severely affected (Bricker et al. 1999).

Invasives

Nonindigenous species are arriving on our coasts at an accelerating rate. Commercial shipping is the primary vector for marine invasives. Planktonic organisms, including larvae of many species, are transported inside ships' ballast water tanks (National Research Council 1996b). These species can radically alter ecosystem interactions and outcompete or prey upon native species. The San Francisco Bay is currently home to at least 234 exotic species (the origins of 125 more are uncertain); a new species is introduced to the bay every fourteen weeks (Cohen and Carlton 1998). In some of the bay communities, nonindigenous species comprise 40–100 percent of common species, 97 percent of the total abundance of organisms, and 99 percent of the biomass (Cohen and Carlton 1998). Some are spreading to other estuaries and sites along the coastline.

To date there has been little evidence that interactions with marine invasive species lead to native species extinctions (Carlton 1993). A few examples, however, suggest that such impacts may be more common than previously thought. For example, *Spartina alterniflora*, an East Coast native cordgrass, was introduced to the Pacific coast where it spreads and hybridizes with *S. foliosa*, a West Coast native. Genetic evidence shows that *S. alterniflora* and the hybrid dominate invaded marshes while *S. foliosa*'s abundance plummets (Ayres et al. 1999). In another case, the decline of a native mussel species (*Mytilus trossulus*) was masked by the invasion of a visually indistinguishable nonnative (*M. galloprovincialis*); the decline may have been linked to competition with the invader (Geller 1999). Within its coastal lagoon habitat, the tidewater goby is threatened by competition with and/or predation by introduced fish, crayfish, and clawed frogs. The U.S. Fish and Wildlife Service critical habitat designation for this fish prescribes removal of all exotics from its critical habitat and the prevention of new introductions (USFWS 2000).

Disease

The spread of disease, which may also be facilitated by global shipping and navigation, threatens many native species (Harvell et al. 1999). For example, withering syndrome has led to a die-off of black abalone (*Haliotis cracherodii*), now a species of concern (NMFS 2004b), and may also restrict recovery prospects for endangered white abalone (*H. sorenseni*) and pink (*H. corrugata*) and green (*H. fulgens*) abalone, which were recently added to the species of concern list (Hobday and Tegner 2000; NMFS 2004c, 2004d). The elkhorn coral (*Acropora palmata*) and the staghorn coral (*Acropora cervicornis*) are now on the species of concern list following declines of 80–98 percent from 1970s abundance associated with the outbreak of white band disease among Caribbean populations in the late 1970s and early 1980s (Gladfelter 1982; McClanahan and Muthiga 1998). In another example, fibropapillomatosis, a sometimes-fatal disease that causes tumors on the skin and eyes, is a major threat to green (*Chelonia mydas*), loggerhead, Kemp's ridley, and olive ridley sea turtles, and is thought to be the main roadblock to recovery of Hawaiian populations of green sea turtles (NMFS 2002d).

Stressors of marine species also act indirectly, as in the case of the eelgrass limpet (*Lottia alveus alveus*), which was lost from the Atlantic Ocean basin in the 1930s after beds of the seagrass (*Zostera marina*), upon which it lived, succumbed to a disease (Carlton 1993). The seagrass retreated to brackish water refugia, but the limpet, whose physiology could not tolerate reduced salinity, could not follow and was extirpated.

Climate Change

The effect of climate change on ocean conditions remains uncertain. Many species, however, are finely adapted to ocean conditions for migration and dispersal. Changes in these conditions could destroy critical dispersal pathways and interrupt the timing of consumer-resource dynamics (Fields et al. 1993). Warmer ocean temperatures from the late 1970s through the mid-1990s associated with a quasi-cyclic shift in oceanic regime are thought to have contributed to poor recruitment of bocaccio and other rockfish along the California coast (MacCall and He 2002; Armsworth et al. 2006). Rising ocean temperatures can also interact with diseases to increase their impacts on populations (Harvell et al. 1999). For example, withering syndrome, which affects black and perhaps other species of abalone, is present at low levels in the population at all times but seems to increase mortality during El Niño events, which bring warm water (Friedman et al. 1997). Coral reef ecosystems are thought to be particularly vulnerable to the effects of climate change. Increased water temperatures, ocean acidification, and storm frequency and severity due to global climate change could adversely impact coral populations through increased bleaching, reduced calcification rates, more frequent physical disturbance, and pathogen outbreaks (Fields et al. 1993; Pittock 1999; Knowlton 2001).

Conservation Strategies

Given the variety of stressors of marine ecosystems, a suite of conservation strategies is required. For our purposes, it is useful to distinguish between those conservation measures intended to protect or restore particular endangered species from more general conservation strategies. The former management approaches clearly fall within the mandate of the Endangered Species Act, but the latter may not.

Endangered Species Protection

For some direct threats to endangered marine species, where takings are easily delineated and causal relationships are apparent, the necessary remedial measures are obvious; they would include, for example, the prohibition of directed fishing and development projects or polluting activities that threaten critical habitats. For many threats, however, causal linkages are uncertain and the involvement of many stakeholders dilutes personal responsibility. These more diffuse threats will be best managed by improving marine resource management and conservation in general.

When localized threats are involved, a useful strategy for protecting species is to designate sensitive habitat areas as reserves. At present, however, U.S. marine reserves are both few in number (there are around thirty fully protected areas in U.S. waters [Palumbi 2002]) and small (many are less than 2 square kilometers in area [Halpern 2003]). Generally, these reserves have been established opportunistically and have not been designed to meet specific biological goals such as the protection of federally endangered species.

The presence of critical habitat would provide compelling reasons for instituting local closures of exploitative activities. To date, multiple areas containing endangered species have been identified and targeted for restriction of some human activities (e.g., seasonal trawling closure in Steller Sea Lion Protection Areas, Gulf of Alaska). A comparison, however, of maps of critical habitat and species protected area sites for listed species (available from http://www.mpa.gov/) with maps of fully protected marine reserves (Palumbi 2002) indicates that none of the protected areas established for listed species is a fully protected reserve.

A growing body of evidence indicates that endangered marine species would benefit if their habitats were designated as reserves. Reserves studied in East Africa contain greater numbers of rare species than nearby fished areas (McClanahan and Arthur 2001). Halpern (2003) documented that biomass of fish and invertebrates was on average 192 percent greater within reserves than in fished areas, while densities, average size, and diversity were 91, 31, and 23 percent greater respectively. Long-term studies of control and reserve sites on two Philippine islands provide some of the best evidence that protection can rebuild depleted populations within reserve boundaries (Russ et al. 2003, 2004). This work also supports the hypothesis that reserves can increase abundance in immediately adjacent habitat areas through the spill-over of biomass across reserve boundaries. Although estimates of increased egg production within reserves suggest that larval spill-over may also occur, there is little empirical evidence yet that reserves enhance recruitment over large spatial scales (Palumbi 2002). For threatened, highly migratory species, reserves can offer benefits if they are designed to protect critical life stages and habitats, including spawning aggregations, and nesting and foraging areas. Finally, reserves can serve as a form of insurance for vulnerable species should regulations being implemented in the broader seascape fail. For example, it is hoped that the newly created Channel Islands reserves provide such insurance for the conservation measures intended to help rebuild bocaccio elsewhere (NMFS 2002e; Armsworth et al. 2006). Unfortunately, many threats to marine ecosystems, such as pollution, invasive species, and climate warming, cannot be excluded and a reserve will offer little protection against them.

In many instances, threats to endangered species occur throughout working seascapes. Localized management measures, such as marine reserves, therefore cannot provide sufficient protection on their own. Instead, regional-scale management approaches that make endangered species protection compatible with the continued operation of exploitative activities must be implemented. The search for such approaches forms part of an ongoing culture change in fisheries management (Fluharty 2000). Traditional, single-species management techniques are complemented by considerations of the ecosystem-level impacts of fishing. For threatened and endangered species to benefit from this change, fishery managers must move beyond considering only the most commercially valuable stocks. Many endangered marine species either were never economically important or are no longer so because of their scarcity (Huntsman 1994).

A concrete example of managing exploitation while protecting endangered species in a working seascape is provided by fishery management plans for Alaskan ground fish stocks. These plans are tailored to minimize the risk of further jeopardizing the endangered western distinct population segment of Steller sea-lions (*Eumetopias jubatus*). A thirty-year decline of 64 percent led to listing the entire U.S. Steller sea-lion population as threatened in 1990. The western population segment, however, continued to decline steadily and was listed as endangered in 1997 (NMFS 1997). Competition with the groundfish fisheries for important prey sources has been suggested as a possible threat to this top predator because population declines partially correlate with growth of those fisheries (Pascual and Adkison 1994; NMFS 1997). The fishery management plans for groundfish seek to protect sea lions through regional-scale conservation measures that include seasonal restrictions to disperse fishing effort in space and time and a requirement that fish stocks be maintained at or above minimum abundance levels. The plans also employ more localized measures, which include many small-scale fishing closures around important sea-lion rookeries and haul-outs (NMFS 2003c).

Recent technological advances in marine management make enforcement of seascape-scale fishery regulations more straightforward. For example, vessel monitoring systems are now mandatory in many fisheries. The U.S. Ocean Commission recently called for the installation of these systems to be a prerequisite for any commercial vessel to receive a fishing permit under a federal fishery plan (U.S. Commission on Ocean Policy 2004). These systems allow managers to determine when and where fishing is occurring, and they support the enforcement of marine reserves, time-area closures, and other spatially structured management strategies. In 2001, a prosecution based exclusively on data from such a monitoring system succeeded for the first time, when a New England scallop fisherman was fined for repeatedly entering areas closed to protect spawning groundfish (NOAA 2001).

For some endangered marine species, such as white abalone (*Haliotis sorenseni*), prohibitive management measures alone are unlikely to prevent extinction, and restoration efforts are urgently needed (Armsworth et al. 2006). Unfortunately, the science of restoration ecology in marine environments is in its infancy. There have been, however, some encouraging early success stories, such as the successful reestablishment of populations of the endangered tidewater goby in California (Lafferty et al. 1996).

Marine Biodiversity Conservation

Although the Endangered Species Act has typically been aimed at single-species conservation, the act states that its purposes "are to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, [and] to provide a program for the conservation of such endangered species and threatened species" (sec. 2(b)). Since 1994, NMFS and USFWS policies have required consideration of impacts to ecosystems when making decisions regarding listed species. As noted in the cooperative policy agreement, "species will be conserved best not by a species-by-species approach but by an ecosystem conservation strategy that transcends individual species" (USFWS and NMFS 1994b, 34274). Thus, the wording of the act and the implementing policies can benefit overall marine biodiversity by requiring the protection of ecosystems and their natural processes in the course of species protection.

Ancillary benefits will be conferred on other species that share habitats protected for listed species. For example, programs to remove invasive species from critical habitat of listed species, as called for in the critical habitat designation for the tidewater goby (USFWS 2000), could benefit whole ecological communities by reducing local impacts of invaders. Similarly, regulations and technologies that reduce bycatch of listed species may also reduce bycatch of other, unlisted species. Interdependencies among listed species also suggest that improvements in the status of one species can enhance recovery prospects for others. Salmon runs, for example, provide an important conduit of marine nutrients into diffuse stream networks and lake systems throughout the Pacific Northwest (Gende et al. 2002). The recovery of salmon populations thus could provide cascading benefits and also improve the prospects of threatened bull trout (*Salvelinus confluentus*) (Peery et al. 2003). The Endangered Species Act has the potential to support broader marine biodiversity conservation either directly, through ecosystem-based management approaches to endangered species conservation, or indirectly, through side-benefits of species-based management.

Conclusion

Endangered species protection and biodiversity conservation take place within different cultural and institutional contexts for marine and terrestrial systems. Unlike the terrestrial realm, there is no large, established system of reserves in the marine environment. Development of an ecologically effective network of such reserves should be pursued as one critically important component of integrated seascape management. On their own, however, marine reserves do not offer a panacea (Norse et al. 2003). Policy makers must also look beyond reserves to protect endangered marine species and to manage marine ecosystems sustainably because many species need protection throughout the broader seascape and some threats are most effectively tackled at their point of origin rather than their point of impact.

In looking beyond reserves, we again note that the marine environment differs from the terrestrial. Lands outside reserves have been privatized and the conflict is with private landowners. The marine environment, on the other hand, to some degree remains a commons and the conflict is with the perceived right of individuals to exploit the seas free from regulation. Common-property issues are most difficult for highly migratory species that leave the Exclusive Economic Zone. The recent petition to list Atlantic white marlin (*Tetrapturus albidus*) illustrates this problem: the United States is responsible for only 5 percent of the total mortality of this species, most of which is due to bycatch by international longline fleets.

Marine conservation is also inhibited by widely held beliefs that stocks cannot be overfished and that the oceans' ability to absorb pollution is unlimited. In part, this syndrome may reflect the myopia of each new generation of resource users, which sets up a shifting baseline, or more accurately a declining one, against which the status of marine ecosystems is judged (Pauly 1995; Jackson et al. 2001). The growing number and diversity of marine species facing an immediate risk of extinction belies these assumptions. Marine species are being imperiled as a direct result of anthropogenic impacts to marine ecosystems. Conservation action is urgently needed to protect these species. When integrated with other statutes (Armsworth et al. 2006), the Endangered Species Act provides an important policy framework both to support and to mandate these actions.