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Paris Conference

Extinctions and threat in the sea

By Nicholas K. Dulvy

THERE HAVE BEEN FEW species extinctions in the sea (18-21) compared to on land (829). Given the relatively high degree of human impact on the oceans this could be interpreted to suggest the effect of human impacts on marine biodiversity has been low. Alternatively, it could be that it is more difficult to detect extinctions of non-air-breathing marine organisms. Current evidence suggests population and species extinctions have occurred in the last 100 years and that a large number are threatened, primarily by exploitation and habitat loss or degradation. Evidence for poor detection of marine extinctions is consistent with the hypothesis that the number of marine extinctions is underestimated. Reducing fishing effort would reduce extinction risk in the sea.

Species extinctions

Human impacts on the oceans are widespread and substantial, and concern has been growing of the possibility that marine species are being driven to extinction (Roberts & Hawkins 1999; Hutchings & Reynolds 2004). Current evidence suggests few marine organisms have become globally extinct in the past 300 years, compared to on land where 829 species have disappeared (Baillie *et al.* 2004). There is unequivocal evidence for the extinction of 12 marine species, comprising three mammals, five seabirds and four gastropods (Carlton *et al.* 1999). An additional three bird and mammal species are listed as extinct by the World Conservation Union (IUCN) Red List (Baillie *et al.* 2004). A recent survey of marine extinctions has uncovered evidence to suggest the global extinction in the wild of a further six species comprising two fishes, two corals and two algae (Dulvy *et al.* 2003). These species – the Galapagos damselfish *(Azurina eupalama)*, the Mauritius green wrasse *(Anampses viridis)*, and two corals *(Millepora boschmai, Siderastrea glynni)*, Turkish towel algae *(Gigartina australis)* and Bennett's seaweed *(Vanvoortsia bennettiana)* – are thought to be extinct throughout their small geographic ranges.

There are a number of problems with determining the number of marine species extinctions; in particular is the uncertainty of taxonomic status and also in defining when the last individual has gone (Carlton *et al.* 1999). A number of taxa could be added to the list of global extinctions. However, it is not clear whether these are full valid species, clinal variants, hybrids or aberrant specimens (Carlton *et al.* 1999). In many cases there is little museum reference material to work with, so it is unlikely that this problem can be resolved. In summary, excluding these uncertain records, there is good evidence that between 18-21 species have become globally extinct in the last three hundred years.

Population extinctions

There are three reasons for considering population-scale extinctions. First, populations hold unique genetic material and are often behaviourally and morphologically distinct (Carlton *et al.* 1999). Second, in metapopulation dynamic theory, source populations may also rescue other sink populations and thus have the capacity to contribute to the resilience of the species as a whole (Smedbol & Stephenson 2001). The corollary to this is that the extinction of populations is the first step toward species extinctions (Pitcher 1998; Hutchings & Reynolds 2004). Finally, conservation interventions and management action typically occur at the population or stock scale in the marine environment. If the definition of extinction is relaxed to consider local and regional disappearances, then the list of population-level extinctions is much longer.

A recent compilation estimated that a total of 133 marine species have undergone a local, regional or global extinction (Dulvy *et al.* 2003). The authors highlighted that this dataset was far from definitive, because of the problems of recognising and defining extinction. However, since this dataset was compiled, no evidence has come to light that suggests that any of the species or populations originally highlighted have recovered or reappeared. Instead, there is evidence for additional population-level extinctions, particularly on coral reefs, including: the disappearance of the rainbow parrotfish *(Scarus guacamaia)* from the coastline of Brazil (Ferreira *et al.* 2005), population extinctions in the world's largest parrotfish, the giant bumphead parrotfish *(Bolbometopon muricatum)* (Bellwood *et al.* 2003; Dulvy & Polunin 2004), and the local and near-global extinction of two coral-dwelling gobies (Gobiidae) (Munday 2004).

Causes of extinctions

In Dulvy *et al.* (2003), local, regional and global extinctions were categorised according to causal factor. There are difficulties in categorising causal factors, particularly as it is often difficult to rule out possible causes retrospectively. Despite these problems the authors tried to be conservative in their categorisations. Most of the extinctions (over all spatial scales) could be attributed to a single primary causal factor (80%). Exploitation, either through hunting or fishing, was the primary factor for 55% of reported cases, and habitat loss/degradation resulted in 37% of reported extinctions (Dulvy *et al.* 2003). Other threats were relatively minor; 2% of extinctions could be attributed to the effects of invasive species, and 6% were attributed to other factors such as climate change, pollution and disease (Dulvy *et al.* 2003).

A recent survey of the degree of threat in North American marine fishes found that 82 marine fish species and subspecies were threatened with extinction, according to the American Fisheries Society threat criteria (Musick 1999; Musick *et al.* 2000). At least 22 of these species are endemic to North America and could also be considered vulnerable to global extinction. The main causes of threat in North American marine fishes were exploitation 55% (45 species and subspecies) and habitat degradation 39% (25 species or subspecies) (Musick *et al.* 2000). An additional seven species and subspecies were threatened by a combination of exploitation and habitat degradation. The remaining species were threatened by invasive species and pollution (Musick *et al.* 2000).

What is the rate of marine extinctions

There are three problems with assessing the rate of marine extinctions. First, the number of marine species is difficult to know; current estimates suggest approximately 15% of recorded species are found in the sea (May 1994). The estimated total number of species on Earth varies widely, but the consensus is that there are somewhere between 1.75-13.6 million species (May 1988, 1994; Hawksworth & Kalin-Arroyo 1995). Many species are unknown, inaccurately described and our knowledge is biased toward certain taxa and habitats (Hammond 1992). Second, a comprehensive assessment of threat and extinction risk has yet to be undertaken for marine species. The World Conservation Union has conducted threat assessments of only 814 marine species to date (Baillie *et al.* 2004). The threat status of one-third (373 species) of chondrichthyan fishes (sharks, rays and chimaeras) has been assessed to date. Seventeen per cent of chondrichthyans were listed as Threatened, 19% as Near-threatened, 26% as Least Concern and 38% were Data Deficient (Cavanagh & Dulvy 2004). This rate of threat is likely to decrease as the remaining species are included; often the first species assessed are the best known or most threatened (Darwall 2004). Third, detecting the extinction of non-air-breathing marine animals is extremely challenging (Roberts & Hawkins 1999). Below, I outline two lines of evidence why this might be so.

(1). Eighty per cent of the local, regional and global extinctions were detected using retrospective, indirect survey methods, such as questionnaire of fishers' traditional knowledge and species catch lists (e.g., Sadovy & Cheung 2003; Dulvy & Polunin 2004), or comparisons of present-day faunal lists with previous inventories (Smith-Vaniz *et al.* 1999; Wolff 2000a; Wolff 2000b). Relatively few extinctions (20%) were described using direct methods such as regular field surveys, e.g. barndoor skate (Dulvy *et al.* 2003; Dulvy *et al.* 2004).

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Manta birostris.

(2). Poor detection is indicated by the 53-year lag between the last sighting of an individual and the reported extinction. By comparison, the lag between last sighting and reported extinction is no more than four years in birds (Baillie *et al.* 2004). If our detection of marine extinctions were perfect then no lag is expected between the death of the last individual and first reports of the demise of the species (Dulvy *et al.* 2003).

Species and population extinctions have occurred in the sea but it is difficult to estimate their number and rate, though we can be reasonably certain that marine extinctions are underestimated. The lack of detailed knowledge on marine extinctions should not hinder mitigating action. Scientific advice has consistently highlighted the overcapacity of fishing fleets. Reducing fishing effort in line with the ecosystem approach to fisheries management will not only improve fishery stability and profitability (Sinclair & Valdimarsson 2003), but will also have the benefit of lowering extinction risk, particularly for large-bodied species.

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