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Hawkins, J P, Roberts, C M and Clark, V (2000) The threatened status of restricted-range coral reef fish species. Animal Conservation. pp. 81-88. ISSN 1469-1795

Animal Conservation (2000) **3**, 81–88 Printed in the United Kingdom

The threatened status of restricted-range coral reef fish species

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(Received 16 December 1998; accepted 10 September 1999)

Abstract

Coral reefs are the most diverse ecosystem in the sea. Throughout the world they are being overfished, polluted and destroyed, placing biodiversity at risk. To date, much of the concern over biodiversity loss has centred on local losses and the possibility of global extinction has largely been discounted. However, recent research has shown that 24% of reef fish species have restricted ranges (< 800 000 km^2), with 9% highly restricted (< 50 000 km^2). Restricted-range species are thought to face a greater risk of extinction than more widespread species since local impacts could cause global loss. We searched for information on status in the wild and characteristics of 397 restricted-range reef fish species. Fish body size, habitat requirements and usefulness to people were compared with those of a taxonomically-matched sample of more widespread species. We found that on average species with restricted ranges were significantly smaller (mean total length 19.1 cm versus 24.4 cm), tended to have narrower habitat requirements and were less used by people. Greater habitat specificity will tend to increase extinction risk while, if real, more limited usefulness (equivalent to exploitation) may reduce risk. Fifty-eight percent of restricted-range species were considered common/abundant in the wild and 42% uncommon/rare. Population status and threats to 319 species for which data were available were assessed according to the categories and criteria of the *IUCN red list of threatened animals*. A number of species were found to be rare, were exploited and had highly restricted ranges overlapping areas where reef degradation is particularly severe, placing them at a high risk of extinction. Five species were listed as Critically Endangered, two of them possibly already extinct in the wild, one as Endangered and 172 as Vulnerable. A further 126 species fell into Lower Risk categories and 11 were considered Data Deficient. Given the intensity of impacts to reefs, the broad geographical areas affected and the large numbers of restricted-range species, global extinctions seem likely. Urgent management action is now crucial for the survival of several species of reef fishes.

INTRODUCTION

Coral reefs are the most diverse shallow water ecosystem in the sea and border around one-sixth of the world's coastlines (Birkeland, 1997). Reaka-Kudla (1997) has estimated that while approximately 93 000 species of animal and plant have been described from reefs, they may support up to 10 times that number. However, with almost half a billion people (approximately 8% of the world's population) now living within 100 km of a coral reef (Bryant *et al*., 1998) their over-exploitation and pollution from land-based sources has become a serious problem (Wilkinson, 1992; Ginsburg, 1994; Jameson, McManus & Spalding, 1995; Birkeland, 1997).

The status of the world's reefs has recently been assessed by Bryant *et al*. (1998). They combined the world's most comprehensive database on reef area and distribution, ReefBase (McManus & Ablin, 1997), with a global database of indicators of human pressure on reefs developed at the World Resources Institute (Bryant *et al*., 1998). The principal factors used to determine threat to reef habitat were coastal development, overfishing, and sediment and nutrient pollution from land (Roberts, 1993; Ginsburg, 1994). Using this database they estimated whether threats to reefs were low, medium, high, or very high. Their findings suggest that globally 57% of reefs are threatened by human activities and over a quarter face high or very high levels of threat. The most badly affected areas were south-east Asia and the Caribbean. In south-east Asia, which contains a quarter of the world's reefs, 82% are at high or very high risk, while in the Caribbean 61% fell into these two categories.

Among organisms occurring on coral reefs, fish are

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undoubtedly the best studied group. Around 30% of the world's marine fish species can be found on coral reefs (McAllister, 1991; Nelson, 1994). In view of the threats faced by reefs the World Conservation Union's (IUCN) Species Survival Commission, Coral Reef Fish Specialist Group set out to document distribution, diversity and endemism among reef fishes on a global scale. Of 1677 coral reef fish species they examined, a remarkable 9.2% had ranges of less than 50 000 km^2 (Roberts *et al.*, in press *b*). On land these species would be considered to have a restricted range (ICBP, 1992). Applying a less stringent criterion of restricted range, of 800 000 km^2 or less (roughly equivalent to the area of the Australian Great Barrier Reef, or two-thirds the length of the Red Sea), 24% of reef fishes would qualify as having a restricted range. Although such an area seems large, only 0.34% of the typical range consisted of coral reef (Roberts *et al.*, in press *b*).

To refine their analysis of threat, Roberts *et al.* (in press *b*) examined overlap of individual species ranges with areas of reef classified as critically endangered and threatened by Wilkinson (1992). One species in 13 (7.7%) had ranges totally overlapping critically endangered reefs, while nearly a quarter (23%) completely overlapped critically endangered and threatened reefs combined. A third of all species (34%) had less than one-fifth of their range overlapping regions where reef condition was considered stable. Of those species whose ranges entirely overlapped endangered and threatened reefs, 53.1% had restricted ranges.

This study by Roberts *et al.* (in press *b*) suggests that many species of coral reef fishes, especially those with restricted ranges, could be at risk of extinction from human impacts. However, virtually nothing is known about the status of these fishes. The present study aims to: (1) compile information on the status of restricted-range species in the wild; (2) determine whether these species possess characteristics other than small range that may render them vulnerable to extinction; and (3) assess restricted-range species against the *IUCN red list* criteria.

METHODS

Status in the wild

The database of coral reef fish species distributions compiled by Roberts *et al.* (in press *b*) provided the starting point for this study. From it we generated a list of 397 species whose ranges covered less than 800 000 km^2 of ocean surface. The figure of 800 000km^2 was used as an arbitrary cut-off point to separate restricted-range from more widespread species and corresponds to a region comprising 16 of the grid cells used in mapping. Ranges were defined by drawing polygons around the outermost records for a species, corresponding to a species' 'extent of occurrence'. The 'area of occupancy' is much smaller. As noted earlier, Roberts *et al.* (in press *b*) calculated that, on average, only 0.34% of the extent of occurrence was comprised of coral reefs (which would correspond to 2720 km^2 for a species with the maximum of an 800 000 km^2 extent of occurrence). Figure 1 shows the distribution of geographical range sizes for these species.

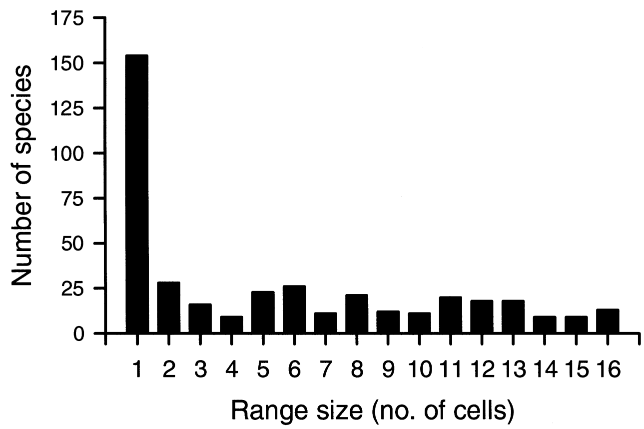

Fig. 1. The distribution of geographical range sizes for the 397 species examined in this study. Ranges were mapped as point maps of known occurrences onto a global grid of equal-area cells that covered all tropical seas in a total of around 4500 cells. Each cell covered 50 000 km^2, including both reefs and open sea. Range size was estimated by assuming that a species occurred in all cells bounded by a polygon drawn around the outermost records.

We then searched for information on the biology and natural history of restricted-range species. A wide variety of sources were used including original species descriptions, taxonomic monographs, ecological studies, field guides, personal observations from reefs around the world and *FishBase 1997* (Froese & Pauly, 1997). In general very little has been written about restricted-range species because their narrow distribution means few people have studied them. Consequently, we generated lists of species from different geographical regions of the world and wrote to numerous experts with experience in these regions asking for details of their unpublished observations.

Characteristics of restricted-range species

A further objective of this study is to determine whether fish with restricted ranges possess characteristics that set them apart from other more widely distributed species. In particular, are there any characteristics that might increase their vulnerability to human threats? Studies of other groups such as reef-dwelling mantis shrimps (Reaka, 1980), terrestrial birds (Schoener, 1968), lizards (Turner, Jennrich & Weintraub, 1969) and mammals (Harestad & Bunnell, 1979) have noted positive correlations between body size and range size. It is also widely acknowledged that in macroscopic marine animals there is a strong correlation between small body size, short planktonic stage and short dispersal periods resulting in restricted geographical distributions (Hansen, 1978; Reaka, 1980; Reaka & Manning, 1981; Strathmann & Strathmann, 1982; Jablonski & Lutz, 1983; Jablonski, 1986). As might be expected the converse is often observed with larger species, whose larvae disperse for extended periods, having broader geographical ranges (Reaka-Kudla, 1995).

The first question we examined is whether there is a significant difference in body size between fish species with restricted ranges and those more broadly distributed? Body size data were obtained from *FishBase 1997* (Froese & Pauly, 1997), from taxonomic papers and field guides. Where only standard lengths were given, they were converted to an estimate of total length by multiplying them by 1.3. This multiplication factor was calculated by measuring the ratio of total length to standard length for a sample of 50 species from a broad variety of fish families illustrated in Lieske & Myers (1996). Standard length represents the length from nose tip to the last vertebra, while total length is measured from the tip of the nose to the tip of the tail.

Comparisons among different groups of organisms may be compounded by taxonomic problems (Harvey & Pagel, 1991). For example, if all restricted-range species in a sample were gobies, and all the more widespread species were sharks, then a strong correlation between range size and body size would be found. However, this may not relate to body size but to some other way in which being a shark differs from being a goby. To eliminate such confounding phylogenetic effects we randomly selected a comparative group containing an equal number of more widespread species from each of the families represented in the restricted-range species data set. By doing this we can place much greater confidence in differences being related to whether a species has a restricted range or not, rather than what family it comes from. Table 1 shows the composition of the restricted-range and taxonomically matched data sets.

A second way in which restricted-range species may differ from more widespread ones is in their habitat requirements. If a species has narrow habitat requirements it may have difficulty in colonizing new areas, so limiting its range (Gaston, 1994). Using *FishBase 1997* we measured a species' habitat specificity based on its vertical depth range and use of different habitats. Species were classed as having broad habitat specificity if they occupied more than one habitat or a single habitat over a wide depth range. They were classed as having narrow habitat specificity if they occupied only a single habitat, or had a very narrow depth range. We then compared measures of habitat specificity among species in the restricted and non-restricted-range data sets.

Finally, *FishBase 1997* lists whether or not species are used by people. Generally this refers to exploitation for food, the aquarium trade, or medicine. Exploitation by people might further increase vulnerability to extinction. Again, we compared measures of human use between our two data sets.

For each of the above measures, data could only be obtained for subsets of the restricted-range and matched data sets of more widespread species. Sample sizes for each of the comparisons are given in the results.

Table 1. Number of species from each family included in the restricted-range and taxonomically matched non-restricted-range data sets

Family	Restricted-range	Non-restricted-range
Acanthuridae	5	5
Balistidae	6	6
Batrachoididae	2	2
Blenniidae	3	3
Clinidae	7	7
Chaetodontidae	28	28
Diodontidae	3	3
Gobiidae	12	12
Labridae	92	92
Labrisomidae	6	6
Lethrinidae	1	1
Lutjanidae	7	7
Pomacanthidae	22	22
Pomacentridae	85	85
Serranidae	89	89
Siganidae	6	6
Syngnathidae	1	0
Tetraodontidae	23	23

Assessment against IUCN criteria

Assessments were made of the status of all species for which sufficient information could be found with a view to including them in the next *IUCN red list of threatened animals*. The *IUCN red list* categories and criteria have been described in detail elsewhere (Baillie & Groombridge, 1996). In brief there are five categories under which species still extant in the wild can be listed: Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Lower Risk (LR) and Data Deficient (DD). For the first three categories there are a number of criteria relating to population size, extent of occurrence or area of occupancy, any one of which a species must meet in order to be listed under that category. Criteria for listing under the Critically Endangered category are the most stringent and diminish with each subsequent category. For example a population reduction of 80% over the last 10 years or three generations, whichever is longest, is necessary for listing as Critically Endangered, a 50% reduction for Endangered or a 20% decline for Vulnerable. Species may be listed according to extrapolation of present population trends or impacts as well as past decline.

If a species fails to meet criteria for these categories it can be considered under the Lower Risk category, which is further divided into three sub-categories of respectively diminishing threat: Conservation Dependent (cd), Near Threatened (nt) and Least Concern (lc). Data Deficient applies when there is insufficient information to assess a species on the basis of its distribution or population status.

When making assessments of restricted-range reef fishes the following key risk factors were taken into consideration:

1. Small range size. Reported ranges for restricted-range species varied from 50 000 km^2 to 800 000 km^2, and the smaller the range the greater the risk.
2. Geographical location in relation to threats to reefs. Species whose ranges completely overlapped regions

identified by Bryant *et al.* (1998) as being under a high level of threat from human activities were considered to be at a greater degree of risk than those in areas where reef condition is stable.

3. Rarity. Information on commonness or rarity was obtained primarily from scientists familiar with the species in the field. They were asked to place species into one of the following categories: rare, uncommon, common, or abundant. Rare species are more likely to be threatened by human activities such as exploitation than common or abundant species.
4. Shallow, near-shore distribution. Species living close to the shore or in shallow water are more likely to be threatened than those living further offshore in deep water. For example, fish stocks are usually more over-exploited near to the shore and population centres compared to those further offshore (Lock, 1986), and reef degradation by pollution or fishing is likely to be greatest in shallow waters near the shoreline (Bryant *et al.*, 1998).
5. Exploitation. Species that are directly exploited generally face a higher level of risk from human activities than those that are not.

Direct data or observations of population declines were only available for a handful of species. The above factors were used to infer the likelihood of declines having taken place, or the probability of their taking place in the future, of the magnitudes specified under the *Red list* criteria. Assessments are thus preliminary and need to be ground-truthed against field data.

The locations of the centres of the geographical ranges of all species assessed as Critically Endangered, Endangered or Vulnerable were plotted on a map (Fig. 2). Range centres were based on polygons drawn around the outermost records for each species. Some species occurred in two or more sites separated by open sea, for example St. Helena and Ascension Island in the Atlantic. The points marking the centres of their ranges therefore lie over open sea.

RESULTS

Status in the wild and characteristics of restricted-range species

Among the 257 restricted-range species for which we could obtain information on abundance in the field, 42% were classed as rare/uncommon, while the remaining 58% were common/abundant. Restricted-range species may be among the most abundant species in a particular locale, and small range does not necessarily predispose a species to being rare.

Table 2 shows that restricted-range fishes were significantly smaller on average than those in a taxonomically matched set of non-restricted-range species (Mann-Whitney *U*-test, $P < 0.003$, $n = 281$ species in each data set). Table 3 shows there was no significant difference in vertical depth range between these groups (Mann-Whitney *U*-test, $P = 0.13$, $n = 195$ species in each data set), although there was a trend for restricted-range

Table 2. Comparison of body size (total length in cm) between restricted-range species (RR) and a taxonomically matched set of non-restricted-range species (Non-RR)

Maximum body size (total length in cm)	Mean	Median	Standard deviation
RR	19.1	13	19.4
Non-RR	24.4	15	22.9

$n = 281$ species in each data set; Mann-Whitney *U*-test, $P < 0.003$.

Table 3. Comparison of vertical depth range (in m) between restricted-range species (RR) and a taxonomically matched set of non-restricted-range species (Non-RR)

Vertical depth range (m)	Mean	Median	Standard deviation
RR	45.6	25	79.5
Non-RR	58.6	29.0	93.7

$n = 195$ species in each dataset; Mann-Whitney *U*-test, $P = 0.13$, NS.

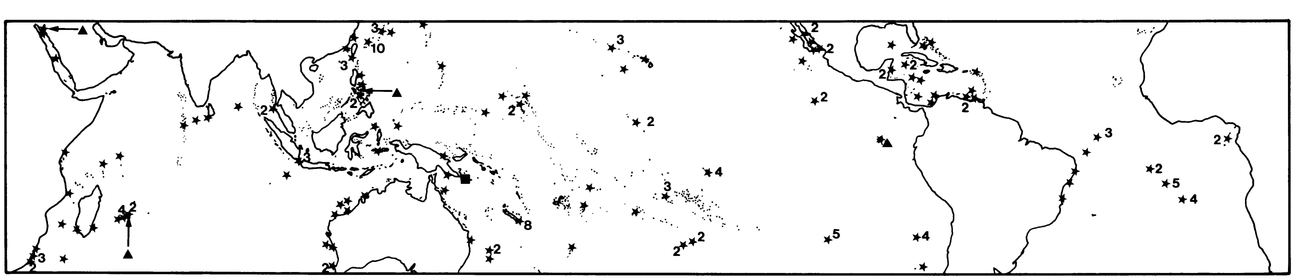

Fig. 2. Global distribution of species considered as Vulnerable (★), Endangered (■) and Critically Endangered (▲). Symbols mark the centre of the geographical range for each species (which is why some symbols are located over open sea). Where more than one species shares the same point, a number indicates how many there are.

species to have narrower depth ranges. A qualitative comparison of habitat requirements (broad versus narrow) revealed these to be narrow for 57% of restricted-range species (n = 65 species) but broad for 73% of widely distributed species (n = 90 species). When it came to commercial or subsistence use by people, only 28% of restricted-range species were considered to be used (n = 79 species), compared to 56% of species with wide distributions (n = 100 species).

Assessment against IUCN criteria

A total of 319 species for which adequate information could be obtained were evaluated against the *IUCN red list* criteria. Four were classified as Critically Endangered; one as Endangered; 172 as Vulnerable; 60 as Lower Risk:Near Threatened; 66 as Lower Risk: Least Concern; and one as Lower Risk:Conservation Dependent; 11 were classified as Data Deficient. Full details of the species and their listings are provided in Roberts *et al*. (in press *a*). Fourteen of the species assessed were already included in the 1996 *Red list* (Baillie & Groombridge, 1996). Our analysis confirmed previous assessments for 10 of those species, downgraded concern for two others (from Vulnerable to Lower Risk categories) and assessed as Vulnerable two listed as Data Deficient in 1996. Figure 2 shows that species considered to be at some risk of extinction can be found throughout the tropics. In a few areas, hotspots of endemism overlap regions where reefs are highly threatened. They include the Philippines, Taiwan and Japan, and within these areas species appear to be particularly at risk.

The following examples show how assessments within each category were arrived at.

Data deficient

In one sense, all of the 80 species present in our sample but not evaluated can be considered Data Deficient. However, a few of those for which we could find some information remain Data Deficient and are listed as such here. For example *Cirrhilabrus rubrisquamis* was known to have a range larger than that which would qualify it under the Vulnerable category (VU D2), but the only other information we had was that it was found in deep water. The species could be rare, or subject to exploitation or some other threat that might qualify it for inclusion in one of the other five categories we used, but we cannot tell and so prefer to list it as Data Deficient.

Lower risk:least concern

This category was applied to species that typically had ranges larger than 4 grid cells (each grid cell covered 50 000 km^2 of sea), and where the species occurred in an area where reefs were not particularly threatened. Additionally, this category could be used where there were no obvious other risks such as exploitation, or the species was abundant or common. For example, *Chaetodon austriacus* is limited to the central and northern Red Sea, but is one of the most common butterflyfishes present.

Lower risk:near threatened

This classification was used for species whose range size was not small enough to qualify them as Vulnerable, but where there were other indications that the species might be at risk. For example, if the range overlapped an area where reefs are being seriously degraded, or the species was rare and exploited for the aquarium trade, then it would be listed as Lower Risk:Near Threatened. For example *Centropyge shepardi* is limited to the Mariana Islands, Palau and Japan. Over half of this range consists of threatened habitat and the species is exploited for the aquarium trade.

Vulnerable

The majority of species listed as Vulnerable were listed under criterion D2 (see Baillie & Groombridge, 1996, for a full definition of criteria), which indicates a highly restricted area of occupancy (< 100 km^2). For example *Chromis sanctaehelenae* is restricted entirely to the small island of St. Helena. Although the classification of restricted range was based on a range size of 50 000 km^2 to 800 000 km^2 taken from the Coral Reef Fish Specialist Group database, it should be recalled that very little of this is actually coral reef, and even less of the area that is reef will constitute suitable habitat. Roberts *et al*. (in press *b*) calculated that coral reef area available to the median restricted-range species was just 500 km^2 (equivalent to a circular reef of 25 km diameter). We used the D2 classification mainly for species with a range size of 4 grid cells or less. However, where there was an indication that the species had a patchy distribution within their range, and were rare or threatened within the range, we would list a species with a larger distribution (up to 6 or 7 grid cells) as VU D2.

Endangered

The only species listed as Endangered was *Chrysiptera niger*, a damselfish whose case is described later.

Critically endangered

This category was applied to species that have undergone extreme population declines and/or habitat loss throughout their range. In several cases, such as that of the Galapagos damselfish, *Azurina eupalama*, the species is possibly already extinct and so warrants the highest level of concern offered by the *Red list*. However, to be listed as extinct, it is necessary to demonstrate that there have been no confirmed sightings in the wild for 50 years, and this species only disappeared in the early 1980s.

DISCUSSION

Roberts *et al.* (in press *b*) found a surprisingly large proportion, 24%, of coral reef fish species had restricted ranges. They also found that many species' ranges showed a high degree of overlap with areas of reef under serious threat from human activities. This suggests that some species may be at considerable risk of local and possibly even global extinction. Our findings confirm this concern, indicating that 55% of 319 species qualify as being Vulnerable to threats, mainly from human activities, less than 1% are Endangered, and just over 1% are Critically Endangered. Two of the five species listed as Critically Endangered, the wrasse *Anampses viridis* and the damselfish *Azurina eupalama*, may have already become extinct.

The data we have used have a number of limitations which mean that our assessments are preliminary and will need to be re-examined as new information is gathered. For example, the polygon method of calculating species' range sizes measures the extent of occurrence. We have assumed that species are present on reefs throughout their ranges, but many will have patchy distributions that mean they have even smaller areas of occupancy than inferred by us. On the other hand, some of the ranges will undoubtedly be expanded as new records are reported. Bryant *et al.*'s (1998) analysis was conservative in estimating threats to reefs and was based on proximity to various kinds of threat, rather than absolute magnitude. Data obtained from *FishBase 1997* only identified whether or not species were exploited rather than the intensity of exploitation. Consequently, apart from possible underestimation of the true extent of occurrence of species, our assessments are conservative.

Restricted-range species were significantly smaller than comparable more widespread species, and tended to be more specialized in terms of habitat use. In part the latter may be an effect of body size since smaller species tend to be less wide ranging than large ones and so may be less likely to occur over a broad range of habitats. The finding of a higher level of habitat specificity among restricted-range species is unsurprising, since narrow specialization may limit opportunities for colonizing other reefs and so expanding the range. Narrow habitat requirements suggest that populations of species may be relatively small and potentially at a greater risk of local extinction than more widespread species who are able to live in a broader range of habitats. While this may be so, we found that restricted-range species are often common within their ranges with 58% of species being classed as common/abundant.

Nevertheless, a significant fraction of species were rare or uncommon and a number of them now face extinction. For example the Banggai cardinalfish, *Pterapogon kauderni*, is a rare species with comparatively low fecundity and dispersal due to the unusual characteristic of looking after its young. It mouthbroods the eggs while they develop and, once released from the mouth, the fry gain protection among the spines of the *Diadema* sea urchins in which adults shelter. It was first described in 1933 but was not rediscovered in the wild until 1994 (Allen & Steene, 1995). Shortly after this intensive collection for aquaria commenced. While the species now thrives in captivity, its status in the wild is precarious, with heavy collecting continuing (G. Allen, pers. comm.). The wrasse *Anampses viridis* was described from Mauritius in 1839 (Randall, 1972) but has not been seen in recent years despite intensive sampling. It may now be extinct, possibly a victim of sedimentation and nutrient pollution that has been degrading the reefs of Mauritius since the nineteenth century (Bryant *et al.*, 1998). Reefs around the neighbouring island of La Réunion have also been affected (Cuet *et al.*, 1988; Naim, 1993). *Apolemichthys guezi* is a rare, fairly deepwater (60–80 m) angelfish endemic to this island. On a recent trip to La Réunion, John Randall (pers. comm.) failed to see a single individual in 6 weeks of diving at 60–80 m. A further casualty may be the damselfish *Chrysiptera niger,* known only from Tufi Inlet at D'Entrecasteaux, Papua New Guinea, which was not recorded on a recent expedition to the area, despite intensive searching (G. Allen, pers. comm.).

Extreme rarity may predispose a species to extinction but even common species can disappear. For example prior to the severe 1982–1983 El Niño, *Azurina eupalama* was a moderately common, plankton-feeding damselfish endemic to the Galapagos (Allen & Robertson, 1994; S. Jennings, pers. comm.). However it disappeared during this El Niño and has not been seen since (Jennings, Brierley & Walker, 1994; Grove & Lavenberg, 1997). Perhaps this regional disturbance had such a great impact on its food source and habitat that the fish has become extinct. There is a small possibility that this species still persists in the waters around the nearby island of Cocos, although this island was also severely affected by the El Niño. However, we are not aware of any recent surveys from this island.

The above cases raise the possibility that extinctions have already occurred and we feel that other extinctions could soon happen if nothing is done to halt the present trends of reef habitat degradation. For example, the angelfish *Chaetodontoplus caeruleopunctatus* is rare and only found in the Philippines. It is exploited for the aquarium trade and lives among some of the world's most severely degraded reefs (Gomez *et al*., 1994). In the same region, the coral-feeding wrasse *Labropsis manabei*, is known only from the Ryukyu Islands off southern Japan, Taiwan and the Philippines. Throughout its range it faces decline due to severe reef degradation. The species was originally described from a few small populations around the island of Okinawa, but shortly afterwards the reefs suffered an outbreak of the coral-feeding starfish *Acanthaster planci*, and the fish disappeared from this site along with the coral (Randall, 1980).

Coastal development impacts threaten other species directly. *Chromis pelloura* is a damselfish known only from an isolated population occurring at depths of around 35–50 m in the far northern region of the Gulf of Aqaba. It has not been observed further south in the

Gulf despite searches of deep water habitat using scuba and submersibles. The range of this fish is surrounded by rapidly developing and industrializing coast, with the ports of Aqaba and Eilat nearby. The species could be very vulnerable, not only to habitat degradation but also to pollution impacts on its planktonic food. Also at risk from coastal development is the splendid toadfish, *Sanopus splendidus*. This species is only known from a single reef in Belize and the Mexican island of Cozumel, which is a rapidly developing tourist destination in the Caribbean.

The possible extinction of *Azurina eupalama* in the Galapagos provides an example of vulnerability to natural impacts, in this case an intense El Niño event. Many other species restricted to isolated islands or reefs may also be very vulnerable to broad-scale climatic, oceanic, or even geological disturbances. For example, Clipperton Atoll in the eastern Pacific covers only 3.7 km^2 and supports eight fish species unknown elsewhere. About 100 years ago the lagoon became closed to the surrounding ocean, perhaps causing unknown extinctions (Robertson, 1996). Local extinctions at Easter Island on the sub-tropical fringe of the southern Pacific also suggest the possibility of climate-related species loss. During his first visit to Easter Island in 1969, John Randall (pers. comm.) found the parrotfish *Leptoscarus vaigiensis* and a species of chub of the genus *Girella* to be common in meadows of the seaweed *Sargassum*. On two subsequent trips, the first 16 years later, *Sargassum* had become scarce and these species had disappeared. Several other species of fish, such as the butterflyfish *Chaetodon litus*, are endemic to Easter Island. Although they are common now, their continued existence might be precarious if they are susceptible to influences from climate change. The intense, global-scale coral bleaching and mortality that occurred in 1998 (ISRS, 1998) could threaten many restricted-range species.

The examples highlighted above probably represent just a fraction of the coral reef fish species that have come close to extinction. Our sample under-represents very small species, since the best known, and therefore usually larger, species were those whose ranges could be most accurately mapped (McAllister *et al*., 1994). Some of the most speciose families are dominated by small fishes such as blennies (Blenniidae), gobies (Gobiidae) and dottybacks (Pseudochromidae), but only a handful of them were included in the study. Given the positive relationship we observed between body size and range size, it is likely that these families and others hold many more restricted-range species, some of which may already be in trouble from human impacts.

This study focused entirely on threats to restricted-range fishes, but more widespread species are also at risk when over-exploited for food. For example, a recent study of the widespread groupers (Serranidae) found that: three species were Critically Endangered, three Endangered and 44 Vulnerable (Roberts *et al*., in press *a*). Since they are typically small, few restricted-range species are in danger from over-fishing for consumption, although they may be caught as by-catch or face substantial direct threats from the aquarium trade. Given the combination of threats to reefs and reef fishes globally we conclude that both restricted-range and widespread coral reef fishes are now in danger of extinction. Indeed for some it seems the battle is over and that we are witnessing the first of further extinctions to come.

Acknowledgements

This work was supported through grants to the IUCN Species Survival Commission and the Center for Marine Conservation in Washington, DC. Thanks to the donors, Amie Brautigam and Roger McManus for making this work possible. We are very grateful to many people for their expert help, especially Ronald Fricke, Jack Randall, Al Edwards, Simon Jennings, Robert Myers, Akinobu Nakazono, Michel Kulbicki, Chris Burridge, Rudie Kuiter, Hiroyuki Motomura, Jerry Allen and David Greenfield. Other contributions and thoughts greatly appreciated came from Rick Winterbottom, Jerry Kemp, Dave Cook, Tim McClanahan, Jeff Leis, Chuck Birkeland, Uwe Zajonz, Bob Sluka, Sarah Curran, Clive Roberts and Fiona Gell.

The late Sir Peter Scott provided the initial impetus for our study of coral reef fish diversity and his data on reef fish distributions form a significant element of the data set used to build the Coral Reef Fish Specialist group database. Lady Philippa Scott and the Sir Peter Scott Trust for Education and Research in Conservation have generously supported our work throughout the 10 years it has taken to complete. We are also very grateful to our other sponsors, including Ocean Voice International, USAID, the Curtis and Edith Munson Foundation, IUCN Sir Peter Scott Fund, World Conservation Monitoring Centre, UK Darwin Initiative/TMRU, British Ecological Society/Coalbourn Trust and University of York. Special thanks to those who generously gave of their time and data to ensure our database was as accurate as humanly possible. Among them we are indebted to Arturo Acero, Gerry Allen, Shih Chieh-Shen, Pat Colin, Paul Dalzell, Alastair Edwards, Bill Gladstone, Martin Gomon, Rudie Kuiter, Jeff Leis, Phil Lobel, Jack Randall, Barry Russell and Richard Winterbottom. Thanks also to Dave Bailey, David Balayla, Vicky Storey and Sarah Hornby who assisted with data analysis. Special thanks to Don McAllister for his everlasting commitment, enthusiasm, patience, and for being a total pleasure to work with.

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