

# Using informal knowledge to infer human-induced rarity of a conspicuous reef fish

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(Received 3 September 2003; accepted 1 March 2004)

## Abstract

There have been few contemporary extinctions in the sea, which suggests marine species are either less vulnerable to extinction than terrestrial species, or marine extinctions may have gone unnoticed. We consider whether a large conspicuous reef fish, the giant humphead parrotfish (*Bolbometopon muricatum*), is likely to have declined across much of its geographical range. Informal knowledge was used to determine the status of the giant humphead parrotfish. We first surveyed fishers' knowledge of this parrotfish at 12 lightly exploited islands in the Lau group, Fiji and then compiled a global inventory of available information. In the Lau islands, Fiji, fishers reported this parrotfish as previously abundant, but it had not been caught at six islands since at least 1990 and was considered rare at another four islands. The parrotfish had been captured recently (since the 1990s) at three islands where fishers did not target parrotfishes regularly. A compilation of giant humphead parrotfish records provided by local scientists at 39 locations in 31 Indo-Pacific nations suggested this fish is locally common only inside areas where fishing is prohibited and that it is currently globally rare. Local densities of the giant humphead parrotfish were negatively correlated to a categorical scale of fishing pressure across six Indo-Pacific locations. The retrospective discovery of local disappearances and global rarity of a distinctive and formerly prominent reef fish is consistent with the hypothesis that the capacity to detect disappearances of exploitation-vulnerable species in the sea is lower than expected.

## INTRODUCTION

For the last 1000 years humans have fished down coastal shelf and oceanic food webs (Jackson *et al.*, 2001; Wing & Wing, 2001; Myers & Worm, 2003). Despite these major and widespread impacts, no marine fish are known to have become globally extinct (Carlton *et al.*, 1999; Roberts & Hawkins, 1999; Dulvy, Sadovy & Reynolds, 2003). Also, few marine fishes ( $n = 160$ ) have been categorised as threatened under World Conservation Union Red List criteria (Hilton-Taylor, 2000). There are two possible explanations: marine fishes are less extinction prone than terrestrial species (McKinney, 1998) or their extinctions go unnoticed (Carlton *et al.*, 1999; Roberts & Hawkins, 1999; Dulvy *et al.*, 2003).

Marine species were previously considered to be resilient to extinction due to large geographical ranges, high fecundity and broadcast spawning (Hudson & Mace, 1996; Mace & Hudson, 1999; Powles *et al.*, 2000). This orthodoxy has been challenged as a number of fecund and wide-ranging fish populations are threatened with extinction (Roberts & Hawkins, 1999; Hawkins, Roberts &

Clark, 2000; Sadovy, 2001; Reynolds, Dulvy & Roberts, 2002; Dulvy *et al.*, 2003; Sadovy & Cheung, 2003). Some species have declined to the point of near extinction at a local scale, e.g. common skate (*Dipturus batis*) in the Irish Sea (Brander, 1981). Not only are fishes vulnerable to declines and disappearances, but they do not recover as rapidly as previously thought (Hutchings, 2000, 2001*a,b*). Recent comparative studies suggest there is little difference in extinction risk or resilience between marine fishes and either freshwater fishes or birds, mammals and butterflies (Hutchings, 2001*a*; Dulvy *et al.*, 2003; Reynolds, 2003). If extinction vulnerability of marine species is higher than previously thought, it seems timely to consider why marine extinctions might go undetected.

The relative paucity of marine extinctions could be interpreted as evidence that extinctions have not occurred. However, this assumes that all marine extinctions were documented as they happened. If this were correct there should be no lag between the extinction date and the detection date. Evidence for any time lag between the extinction date and the date of detection indicates underestimation of marine extinctions. Assuming date of last sighting approximates to the date of extinction and the reporting date approximates to the detection date, then a reporting lag can be estimated. A review of 133 marine extinctions recorded at local, regional and global scales found a reporting lag of approximately 50 years

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between the date of last sighting and the reported date of extinction (Dulvy *et al.*, 2003). Most disappearances (80% of the total) were detected retrospectively using indirect historical comparative methods (Dulvy *et al.*, 2003). Direct detection methods may be used to monitor declines and minimise reporting lag, however census power decreases as the remaining number of individuals decline. This is illustrated by the uncertainty surrounding the degree of collapse of Baltic and Canadian cod populations (*Gadus morhua*) and the barndoor skate (*Dipturus laevis*) (Hutchings, 1996; Myers, Hutchings & Barrowman, 1997; Casey & Myers, 1998; Jonzén *et al.*, 2001; Dulvy *et al.*, 2003). The evidence for reporting lags, indirect detection and low power of direct census methods are consistent with the hypothesis that marine extinctions may have gone undetected.

Coral reef organisms face a number of threats, such as coral bleaching and the direct and indirect effects of fisheries exploitation (Hughes *et al.*, 2003; Dulvy, Freckleton & Polunin, 2004; Hawkins & Roberts, 2004). Coral reef fishes are relatively simple to census using SCUBA, however the level of training required, diving logistics and safety limit the number of replicates, while the timing of sampling, the size of samples and their accuracy limit the power to detect species-specific trends (Mumby *et al.*, 1995; Thompson & Mapstone, 1997, 2002). This may be particularly acute for large rare species, some of which may be highly aggregated and found at extremely low densities, e.g. <1 individual/10 000 m<sup>2</sup> (our unpublished data). The point census and strip transect techniques commonly used to survey reef fish assemblages are typically based on small replicate areas (~100–250 m<sup>2</sup>), and only a relatively small area ~1000–2000 m<sup>2</sup> can be covered on each dive (St. John, Russ & Gladstone, 1990; Jennings & Polunin, 1997; Samoily & Carlos, 2000; Gust, Choat & McCormick, 2001; Dulvy *et al.*, 2002; Thompson & Mapstone, 2002). Consequently power to detect changes in the abundance of single reef fish species may be low without complex designs and high levels of replication, especially against the relatively high background of daily, monthly and annual variation in densities (e.g. Galzin, 1987; Thompson & Mapstone, 2002). Consequently suitable census data, at the appropriate temporal and spatial scales, are typically unavailable for determining whether a reef fish has actually gone extinct, e.g. the Galapagos Damsel fish (*Azurina eupalama*) and the green wrasse (*Anampses viridis*; Hawkins *et al.*, 2000).

Informal traditional knowledge may be used to detect declines or marine extinctions (Johannes, 1998). Local fishers' traditional knowledge has been used to detect and confirm the near extinction of the giant yellow croaker (*Bahaba taipingensis*) in China (Sadovy & Cheung, 2003). Large-scale comparisons of local densities have the potential for improving detection because the wider range of species abundances should provide greater statistical power due to the larger effect size (Cohen, 1988).

Here we use both methods to make inferences on the conservation status of the potentially threatened giant humphead parrotfish (*Bolbometopon muricatum*)

(Donaldson & Dulvy, 2004). The giant humphead parrotfish is the largest species of parrotfish, reaching 130 cm in length and 46 kg maximum weight and is long-lived reaching > 28 years (Randall & Bruce, 1983; Couture & Chauvet, 1994; Kitalong & Dalzell, 1994). It is one of the largest bony fishes (teleosts) found on coral reefs (Lieske & Myers, 1994; Myers, 1999). It is unusual among the predominantly herbivorous parrotfishes in that it feeds on live corals, a large individual can consume 2–5 tonnes of coral per year. Consequently this species may have a 'keystone' role in the regulation of reef growth (Bellwood, Hoey & Choat, 2003). We conducted a questionnaire survey of traditional knowledge to determine the status of the giant humphead parrotfish at 13 islands in the Lau group, Fiji. This survey prompted us to collate all available information on the status of this species throughout its geographical range in the Indo-Pacific Ocean.

## METHODS

### Questionnaire survey of giant humphead parrotfish catches

Group questionnaire surveys at 14 villages on 12 islands were conducted by an interviewer using the regional dialect. Respondents were drawn from either the paramount village or the primary fishing village of each island and interviewed as a group. An average of ten respondents were questioned at each island including chiefs, village government representatives and fishers having a good knowledge of local fishing activity and practices. Group interviews provided an overview and consensus of fishing practices and catches because the human populations were small and Fijian society is strictly hierarchical. Two specific questions were asked. Respondents were asked to state the last time a giant humphead parrotfish had been captured on their island. The frequency of capture of all parrotfishes (Scaridae) was determined by asking villagers to choose from three categories: 'regularly' on every fishing trip, 'occasionally' on every second or third fishing trip and 'rarely' once or twice a year.

### Status of giant humphead parrotfish in Indo-Pacific Oceans and Red Sea

All available information was collated from national statistics, taxonomies, checklists and information provided by local scientists (see Acknowledgements, below). Where possible we extracted local-scale density estimates from the available information and correlated these to fishing intensity to test for a possible link between exploitation and parrotfish densities at the large scale. A subjective categorical scale of fishing intensity was used based on published catch rates, fin-fish yields, the authors' experience of the sites and discussion with regional scientists. The four point categorical scale used was: (0) no known fishing, (1) subsistence fishing for personal consumption, (2) light artisanal fishing with possible sale, (3) heavy artisanal fishing, including the use of habitat destructive methods (such as use of poisons or explosives)

**Table 1.** Date of last capture of the giant humphead parrotfish and the frequency with which all parrotfish were targeted, based on a questionnaire survey of traditional knowledge in the Lau Islands, Fiji

Island <sup>†</sup>	Village	Number of respondents	Date of last capture	Frequency of parrotfish targeting	Other comments on abundance and fisheries
Moala	Naroi (p)	7	Question not asked	Regularly	Occasionally captured but only caught at night
Matuku	Yaroi (p)	~ 20	Question not asked	Regularly	Occasionally captured
Totoya	Udu	4	Cannot remember last capture	Regularly	Perceived to be no longer present
Kabara	Naikeleyaga (p)	~ 30	1970s	Regularly	Reported as no longer available at this island, only caught at other uninhabited associated fishing grounds (Vuaqava)
"	Lomati	5	1980s	Regularly	Not seen in recent years
"	Udu	4	Not present	Occasionally	Parrotfishes only caught at another uninhabited associated fishing ground (Marabo) controlled solely by this village
Fulaga	Muanicake (p)	3	Last seen in late 1960s	Regularly	Species was perceived to have disappeared, which was one reason for the imposition of a night-time spear fishing ban
Namuka	Namuka (p)	3	Not known	Regularly	Rarely caught
Komo	Komo (p)	14	Christmas 1998	Occasionally	It was reported that it takes a few individual parrotfish of this species (~ 7) to feed the whole village
Oneata	Waiqori (p)	15	c. 1970s	Regularly	Not caught within living memory and some respondents were in their 50s–60s. The species is known on the basis of reports from fishers from other islands, but no-one had ever seen it themselves
Lakeba	Tobuo (p)	4	March 1999	Occasionally	Previously captured using inshore fish drive with leaf scares, now it is believed to be scarce due to spear fishing
Vanuavatu	Taira (p)	10	c. 1980s	Regularly	Rarely seen, 'last caught about 10 years ago'
Tuvuca	Tuvuca (p)	20	1996	Larger spp. captured occasionally and smaller spp. captured regularly	This species is regarded as very rare compared to 5–10 years ago, despite the recent capture of one individual
Cicia	Tarakua (p)	2	1980s	Regularly	A fisherman noted without prompting that this species was declining

<sup>†</sup> Each island comprised a single fishing ground or *qoliqoli*, apart from Kabara where some villages had sole access to other island *qoliqoli* (Marabo and Vuaqava).

(p), denotes a paramount village, the seat of the chief and associated hierarchy and government administration.

adjacent to densely populated areas. A fifth category of fishery, 'heavy artisanal fishing without use of destructive gears', could be considered, however none of the sites used in this study fell into this category. Measures of fishing activity, such as fish yield or catch per unit effort (CPUE) measures, could not be used to calculate a fishing pressure scale as both under- and overexploited reefs can exhibit similar yields or CPUE values (Dalzell & Adams, 1997) and other quantitative data such as fishers or boats per unit area were not available.

## RESULTS

Fishers and other villagers in the Lau Islands, Fiji, reported that historically this parrotfish was occasionally captured

in daytime using 'leaf drives', where a net of twisted coconut leaves is used like a seine or purse net to encircle a shallow area of back reef within the lagoon. More often the parrotfish was captured using hand spears and spear guns at night. Fishers reported that this parrotfish aggregates in large numbers and shelters in reef caves and on sandy lagoon areas rendering it relatively easy to capture. The respondents reported that the giant humphead parrotfish had rarely been captured in the Lau Island group in the past decade. Local fishers reported the last date of capture was prior to the 1990s at six islands (Table 1). This species was captured recently (1990s) only at the three islands where parrotfishes were targeted only occasionally (Table 1). We did not have the opportunity to question the last capture date directly at three islands, however, from subsequent

discussion we found that the inhabitants regarded the giant humphead parrotfish as rare (Table 1).

Information on the status of the giant humphead parrotfish was available for 39 locations in 31 Indo-Pacific nations (Table 2). The biogeographical range of giant humphead parrotfish included the Red Sea and western Indian Ocean to halfway across the Pacific Ocean, including Micronesia and Melanesia and western Polynesia. It seems that the giant humphead parrotfish was never present at Hawaii, the Cook Islands, Galapagos Islands, Lord Howe, Kermadec and Norfolk Islands. The parrotfish was abundant only in Australia's Great Barrier Reef Marine Park and Papua New Guinea and locally common in Western Samoa and at Sipidan Island, Malaysia. It was previously common in the Micronesian states of Yap and Palau in the 1980s but at all of the other locations it was uncommon or rare and is possibly locally extinct in Guam, the Marshall Islands and parts of Fiji.

In areas where the giant humphead parrotfish was common it has comprised a substantial proportion of fisheries landings. This parrotfish was the second most important commercial reef fish in Palau, 13 tonnes being sold between 1976–1990, which accounted for 10% of all landings (Kitalong & Dalzell, 1994). It comprised 5% of the landings from a small-scale artisanal fishery in 1980 in the lightly populated Tigak islands, Papua New Guinea (Wright & Richards, 1985). In Fiji in 1990, the giant humphead parrotfish was the fifth most important species in terms of domestic commercial landings. A total of 230 tonnes was sold comprising 5% of all species sold. It was the second most important reef fish landed, after coral trout (*Plectropomus* spp.), which comprised 6.5% of total landings (Anonymous, 1990). It is now extremely unusual to see this species sold in the main market in Suva, Fiji; one of the authors (N. K. D.) noted only one individual being sold between 1999–2000. A fisheries development programme was initiated at a small remote island, Kia Island, Fiji. (Anonymous, 1970). For the year up to July 1968 the experimental fishery yielded 22.3 t of giant humphead parrotfish, which comprised 70% of the total catch (Anonymous, 1970). This indicates a catch rate of  $\sim 300$  kg of giant humphead parrotfish per km of fringing reef per year. Assuming the fringing reef was 100–300 m wide and 75 km in length then the standing biomass was  $> 1\text{--}3$  g per m<sup>2</sup>, excluding lagoonal habitat.

Quantitative abundance data were available for only six locations (Table 3). Local densities of the giant humphead parrotfish were negatively correlated to the fishing intensity index ( $t = -4.6$ ,  $P < 0.01$ ). This parrotfish appeared to be locally extinct at the small study sites in Tanzania and the Philippines, which we have scored as having the highest levels of fisheries exploitation.

## DISCUSSION

### Rarity in the giant humphead parrotfish

We present evidence based on questionnaires of traditional knowledge to infer that the giant humphead parrotfish is

locally extinct in some of the Lau Islands, Fiji. A key assumption of this approach is that the reported date of last capture reflects the absence of this species rather than a change in fisher behaviour or food preference. This was corroborated to some extent by fishers' perceptions that this species was no longer present or available. Also we observed only one shoal of 11 giant humphead parrotfish during 100 h of fish community census on the outer fringing coral reefs. This shoal was seen at Lakeba, an island where fishers do not target parrotfishes regularly and where the questionnaire survey revealed that this species had recently been captured (Table 1).

The larger scale compilation of informal knowledge also suggests that this species may be locally extinct at the Marshall Islands and possibly Guam (Table 2), however, this requires independent verification. It is still abundant in parts of the Great Barrier Reef, Australia and common or locally abundant in parts of Papua New Guinea and the Solomon Islands. This large conspicuous reef fish was formerly a prominent and abundant member of reef fish assemblages and catches, but is now encountered infrequently throughout large parts of its range.

### Is the rarity human-induced?

There are a number of lines of evidence to suggest that the global rarity of this parrotfish may be linked to human activities, in particular fisheries exploitation. Throughout its geographical range this species is locally abundant almost exclusively at locations protected from exploitation, e.g. the Great Barrier Reef Marine Park, Australia (Bellwood *et al.*, 2003), and in reserves in the Seychelles and Sipidan Island, Malaysia and at Wake Island, which was a US military air base until recently (Table 3). This parrotfish appears to also be abundant at the remote Rowley Shoals Marine Park in north-west Australia (Bellwood *et al.*, 2003) and it is common or locally abundant in parts of Papua New Guinea and the Solomon Islands, which are lightly exploited because human densities are low relative to the area of reef habitat and agriculture provides sufficient food (Ruddle, 1996; Spalding, Ravilious & Green, 2001; Aswani & Hamilton, 2004).

There are a number of other reports linking declines to exploitation at other lightly fished locations, such as Palau and Fiji. In the 1980s and early 1990s this parrotfish was a major component of landings from reef fisheries in Palau and mainland Fiji. Palau's population of the giant humphead parrotfish is currently regarded as relatively small and fragile and is now protected by an export ban and a national minimum size restriction of 25 inches (Anonymous, 1998). There is also independent historical evidence to suggest that the species was locally very abundant at Kia Island, Fiji in the recent past; unfortunately we were unable to access any information on contemporary abundance.

The giant humphead parrotfish is consistently rare or very rare at locations with very high human population densities, such as the Philippines, Tanzania

**Table 2.** Presence, abundance, status and exploitation of the giant humphead parrotfish in selected Indo-Pacific locations

Region	Country	Categorical abundance	Abundance data	Exploitation patterns	Source
Western Pacific	Australia	Abundant	Third most abundant (in biomass) large herbivore on outer GBR	Protected marine reserve system	H. J. Choat, pers. comm.
Micronesia	Guam	V. rare/extinct	Disappeared, absent or extinct	Exploited	Dalzell, Adams & Polunin, 1996; Myers, 1999; T. Donaldson, pers. comm.
Micronesia	Marshall Is.	V. rare/extinct	None known	Not known	Myers, 1999
Micronesia	Palau	Present	Rapidly declining, considered to be overexploited by questionnaire survey	Exploited	Johannes, 1981; Myers, 1999
Micronesia	Palau	Previously common	Moderately abundant, accounting for 10% of landings between 1976–1990, 13 t sold per year in this period. Landings peaked in 1985 and subsequently declined	Exploited exclusively using spear guns	Nichols, 1991; Kitalong & Dalzell, 1994
Micronesia	Yap, Federated States of Micronesia	Rare	0.6% of all parrotfish by number in 57 snorkel/SCUBA surveys	Parrotfish are primary target of fishers	Orcutt <i>et al.</i> , 1989; Myers, 1999
Melanesia	New Caledonia	V. rare	127 individuals out of a total of 155,178 parrotfish recorded by UVC	Commercially sold	M. Kulbicki, pers. comm.
Melanesia	PNG	Common (prior to 1985)	636 captured in a catch survey, 5.3% of a 22.5 t sample	Exploited	Wright & Richards, 1985
Melanesia	Solomon Is.	Locally abundant	Locally abundant at Marovo and Roviana lagoons. Large component of night-time spear fishing catches, populations have subsequently exhibited declines	Subsistence fishery	Samoilys <i>et al.</i> , 1995; Aswani & Hamilton, 2004
Melanesia	N. PNG	Rare (1984–86)	Seven caught in a trap survey of a total sample of 632 parrotfishes	Exploited	P. Dalzell, pers. comm.
Melanesia	Fiji (Kadavu)	Rare	None seen in ~168 h of UVC on outer reef	Artisanal and possible commercial	Jennings & Polunin, 1997
Melanesia	Fiji (Lau)	Rare/locally extinct	None caught at six islands for at least 10 years. Eleven seen of a total sample of 6000 parrotfishes	Subsistence only	Anonymous, 1994; This study
Melanesia	Fiji (Yadua taba)	Uncommon	Seen occasionally during UVC	Subsistence only	O. Taylor, pers. comm.
Melanesia	Fiji (Viti Levu)	Uncommon	Major component of catch (4.8%) sold in the domestic commercial market in 1990. Commercial market survey data indicates declining trend from late 1980s. Almost absent in market in 2000.	Artisanal and commercial	Anonymous, 1990; Ledua & Vuki, 1998
Melanesia	Vanuatu	Uncommon			Williams, 1990
SW Pacific	Lord Howe, Kermadec, Norfolk Is.	Absent Absent Absent	13 other parrotfish species present, but the bumphead parrotfish may never have been present		Francis, 1993
Polynesia	American Samoa	Rare	One individual recorded among c. 8000 fish sampled over 18 months	Exploited	M. Page & A. Green, pers. comm.
Polynesia	American Samoa	Rare	Two individuals recorded out of a total of 3115 individual parrotfishes.	Exploited	M. Page & A. Green, pers. comm.
Polynesia	Samoa	Locally very abundant	At Nu'utele Island UVC abundance = 20 g m <sup>-2</sup> , other parrotfish combined = 14 g m <sup>-2</sup>	Subsistence and artisanal	Samoilys & Carlos, 1991

Informal knowledge to infer reef fish rarity

Table 2. Contd.

Region	Country	Categorical abundance	Abundance data	Exploitation patterns	Source
Polynesia	Cook Is.	Absent	Not thought to have ever been present	Parrotfish are primary target of fishers	Preston, Lewis & Sims, 1995; R. Walter, pers. comm.
Polynesia	Hawaii (NW)	Absent	Not thought to have ever been present		Randall <i>et al.</i> , 1993
Polynesia	Niue	Present		Parrotfish targeted using fish drives or spear guns	Dalzell, Lindsay & Patiale, 1993
Polynesia	Tuvalu	Uncommon	Has been observed on outer reefs (15–20 m)	Parrotfish captured in nets and fish drives	S. Sauni & N. Apinelu, pers. comm.
Polynesia	Tonga	Rare	None seen in ~200 h of UVC in western Ha'apai group in 2001. One 23 kg specimen reported as being landed in 1994 inshore fisheries statistics		Tulua, Kave & Matoto, 1995; N.K.D., pers. obs.
Polynesia	Wake Is., USA	Common		Unlikely that this species is exploited. Until recently that was a US military base without an indigenous population. All food is imported	Myers, 1999
E. Pacific	Galapagos	Absent	At least four parrotfish species present		Jennings, Brierley & Walker, 1994
C. Indian Ocean	Indonesia	Rare	Seen in Bali and Sulawesi. Low densities observed in the Tongean islands, central Sulawesi	Heavy artisanal and commercial fishing.	Tomascik <i>et al.</i> , 1997; Bellwood <i>et al.</i> , 2003; T. R. McClanahan, pers. comm.
E. Indian Ocean	Malaysia	Locally common	Locally common only at Sipidan	No fishing at Sipidan	D. Perrine, pers. comm.
E. Indian Ocean	Philippines	Rare	Only found in south (Negros Is.), and in Sulu Sea	Heavy exploitation of reef fishes, including destructive fishing	D. Watson, C. Kennaman & G. Broad, pers. comm.
C. Indian Ocean	Maldives	Uncommon	Juveniles and adults seen on fisheries surveys and tourist dives	Little exploitation of reef fishes	M. Saleem & R. Ekeheien, pers. comm.
W. Indian Ocean	Kenya	V. rare	Absent in UVC surveys		McClanahan, 1994
W. Indian Ocean	Madagascar	Present	Captured in artisanal catches		D. K. A. Barnes, pers. comm.
W. Indian Ocean	Mauritius	V. rare	Not seen in diving surveys	Heavy subsistence and artisanal fishing	R. Klaus, pers. comm.
W. Indian Ocean	Mozambique	Present	Captured in artisanal catches		D. K. A. Barnes, pers. comm.
W. Indian Ocean	Seychelles	V. rare	Rarely seen outside marine reserves		E. Grandcourt & S. Jennings, pers. comm.
W. Indian Ocean	Socotra Is., Yemen	Uncommon	Low abundance	Fisheries target pelagic species only	R. Klaus, pers. comm.
W. Indian Ocean	Somalia	Present	Seen on diving surveys		T. R. McClanahan, pers. comm.
W. Indian Ocean	Tanzania	V. rare	Not seen at Mafia Is. in 5000+ dives, rare in S. Tanzania		The Society for Environmental Exploration & I. Horsfall, pers. comm.
Red Sea		Locally common			T. R. McClanahan, R. Ormond & C. Roberts, pers. comm.

GBR, Great Barrier Reef; UVC, underwater visual census; PNG, Papua New Guinea.

Categorical abundance is ranked as v. rare < rare < uncommon < common < abundant.

'Present' denotes insufficient data to categorise abundance, 'absent' denotes biogeographic locations where the parrotfish may never have been present.

**Table 3.** Local densities, exploitation patterns, categorical fishing pressures, and census details of the giant humphead parrotfish at six Indo-Pacific locations

Location	Species abundance (no. km <sup>-2</sup> )	Exploitation levels	Fishing pressure category	Details of census replicates	Source
Australia, GBR	3.046	No-take marine reserve	0	Three UVC transects, each 400 × 20 m	J. H. Choat, pers. comm.
Solomon Is.	1.399	Subsistence, mainly with handlines. Reef fishes are not an important source of revenue.	1	12 UVC 7-m radius point counts	Samoilys <i>et al.</i> , 1995
Fiji, Lau Is.	0.008	Heavy subsistence, spear and line fishing yielding 3.4–10.2 t/km <sup>2</sup> /yr.	2	Six UVC 7-m radius point counts and 1 UVC transect, each 15 × 140 m	Jennings & Polunin, 1995, 1996
Fiji, Mamanuca Is.	0.029	Artisanal and possibly commercial fisheries using spear and line fishing.	2	12 UVC 7-m radius point counts	Rawlinson <i>et al.</i> , 1994
Tanzania	0.000	Heavy artisanal and commercial exploitation using nets, handlines, some dynamite, and yielding 7–14 t/km <sup>2</sup> /yr.	3	Two UVC transects, each 5 × 100 m	McClanahan <i>et al.</i> , 1999
Philippines, NW Luzon, Bolinao	0.000	Very heavy artisanal and commercial exploitation, using nets, spears, lines, explosives and poisons, yielding 3–10 t/km <sup>2</sup> /yr.	3	Two UVC transects, each 10 × 100 m.	McManus <i>et al.</i> , 1992

UVC, underwater visual census.

and Indonesia. Overall we found a negative correlation between a categorical measure of fishing intensity and local density across the Indo-Pacific Ocean. Such a large scale approach assumes that census estimates from different geographical locations are comparable, but this assumption is challenged by the knowledge that abundance estimates may vary with time of observation, observer and geographical location in addition to fishing pressure (e.g. Thompson & Mapstone, 1997; Samoilys & Carlos, 2000). Despite these potential problems a similar approach has proven informative and was used to infer declining rates of parrotfish bioerosion on Indo-Pacific reefs (Bellwood *et al.*, 2003).

There are several reasons why the giant humphead parrotfish might be vulnerable to exploitation. Larger bodied species of fish tend to be more vulnerable to exploitation due to correlated demography and lower maximum population growth rates (Jennings, Reynolds & Mills, 1998; Jennings, Reynolds & Polunin, 1999; Reynolds, Jennings & Dulvy, 2001; Reynolds, 2003). This pattern holds both for temperate teleosts with relatively simple life histories and also for some reef fish with more complex life histories including parrotfishes (Jennings *et al.*, 1999). Both the nocturnal aggregative behaviour in shallow lagoon water or in reef caves and the daytime foraging of shoals in depths accessible by breath-hold and SCUBA divers may render this species vulnerable to capture throughout much of its adult life. Historically this species may have found refuge in deeper water and distant uninhabited reefs, however the widespread

availability of powered craft, spear guns and diving equipment may have increased the catchability of this species over the last 100 years (Johannes, 1981; Hamilton, 2003; Aswani & Hamilton, 2004). This species is highly prized by subsistence and artisanal communities in Palau and the Solomon Islands (Johannes, 1981; Aswani & Hamilton, 2004). In the Lau group, Fiji, the respondents noted that giant humphead parrotfish was often captured for ceremonial events suggesting this species has a high cultural significance. The combination of intrinsic vulnerability, relatively high catchability and high cultural (and/or monetary) value combined with evidence for decline and local extinction suggests that fishing may have resulted in global rarity of this functionally important fish species.

#### Informal data sources and detecting declines

We have inferred that the rarity of this parrotfish is due to exploitation. This inference was based on the informal questioning of groups of Fijian villagers and fishers followed by discussion with local scientists and government officials and a search of government statistics and other 'grey' literature. Here we used a relatively coarse questionnaire technique to access traditional ecological knowledge in Fiji, asking simple, unambiguous questions of groups of informants. This should not preclude the use of a more 'anthropological approach' such as the use of subtly designed questionnaires and application to

individual informants to gain further detail (Aswani & Hamilton, 2004).

We have attempted to evaluate this information as judiciously as possible (Sadovy & Cheung, 2003). As scientists, we would prefer to assess human impacts on the basis of quantitative abundance estimates throughout the species' geographical range and information on factors that may influence abundance, such as fishing intensity and catches, habitat quality and availability, competitors, predators and recruitment processes to satisfy a rigorous test of causality. Unfortunately the quantitative data required may be largely unavailable for a relatively scarce species that is rarely encountered by scientists conducting small-scale underwater visual census (UVC) work on coral reefs (Johannes, 1998; Sadovy & Cheung, 2003). This informal approach can be used to guide focused research and larger-scale UVC survey effort, which would be required to determine global estimates of abundance or at least an abundance index which would prove useful for guiding future conservation and management efforts.

There is an increasing awareness that the judicious use of informal data sources can provide a valuable additional perspective on the behaviour, ecology, abundance, exploitation and the current and historical status of a species (Johannes, 1981; Neis *et al.*, 1999; Johannes *et al.*, 2000; Sadovy & Cheung, 2003). A survey of fishers' knowledge and informal information sources was used to infer the near extinction of a large fish species, the Chinese bahaba, throughout its entire range along the Chinese coastline (Sadovy & Cheung, 2003). This species disappeared virtually unnoticed by both fishers and the scientific community. Similarly the induced rarity of *B. muricatum*, a large conspicuous reef fish, has also been overlooked. In data-poor situations retrospective searches may provide the only pragmatic method of inferring whether a species is naturally rare or has declined or disappeared as a result of human activity. Informal methods could aid efforts to provide a more accurate estimate of the contemporary marine extinction rate.

### Acknowledgements

We thank the staff of the Marine Studies Programme at the University of the South Pacific for providing facilities and support; the late Benedito Tikomainiusiladi for conducting the questionnaire survey; the Tui Nayau, chiefs and turaganikoro of all the islands for granting permission for this study and K. Wynn, R. Mitchell, D. Watson, C. Glendinning, A. Haddock, C. Gough and B. Vasconcellos for logistical support and field assistance. This compilation would not have been possible without the generosity of N. Apinelu, S. Aswani, D. K. A. Barnes, D. Bellwood, G. Broad, M. Calamia, J. H. Choat, P. Dalzell, T. Donaldson, R. Ekeheien, M. Francis, P. Geraghty, E. Grandcourt, A. Green, R. Hamilton, I. M. Horsfall, S. Jennings, C. Kennaman, R. Klaus, M. Kulbicki, P. Labrosse, T. R. McClanahan, R. F. G. Ormond, M. Page, D. Perrine, C. M. Roberts, Y. Sadovy, M. Saleem, M. Samoily, S. Sauni, O. Taylor, C. C. Wabnitz and R. Walter. We are particularly indebted to the late Robert

E. Johannes for providing his insights, and to Simon Jennings and two anonymous referees for their comments, which substantially improved this manuscript. The Natural Environment Research Council, UK, funded this study and Defra contract (MFD 0729) contributed to its completion.

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