playback of pre-hatching calls elicited digging behaviour in eight of the females (Figure 1B and Supplemental Data), while this response happened only one time during the playback of noise sequences (Wilcoxon paired test, $n = 10$, $P = 0.012$, $Z = 2.52$). In summary, our experiments show that pre-hatching calls of the Nile crocodile carry relevant information for both embryos and mother. While still inside the egg, juveniles are responsive to nearby calls; egg vocalizations may act to fine-tune hatching synchrony as in some species of birds [4,6]. The other key effect of egg vocalizations is to stimulate the adult female to open the nest. With crocodile juveniles being highly susceptible to predation [1,3], both hatching synchrony and maternal assistance certainly increase the fitness of newborns.

Supplemental data

Supplemental data including audio and video files are available at http://www.current-biology.com/cgi/content/full/18/12/R513/DC1

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Rapid increase in fish numbers follows creation of world's largest marine reserve network

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No-take marine reserves (NTMRs) are much advocated as a solution to managing marine ecosystems, protecting exploited species and restoring natural states of biodiversity [1,2]. Increasingly, it is becoming clear that effective marine conservation and management at ecosystem and regional scales requires extensive networks of NTMRs [1,2]. The world's largest network of such reserves was established on Australia's Great Barrier Reef (GBR) in 2004. Closing such a large area to all fishing has been socially and politically controversial, making it imperative that the effectiveness of this new reserve network be assessed. Here we report evidence, first, that the densities of the major target species of the GBR reef line fisheries were significantly higher in the new NTMRs, compared with fished sites, in just two years; and second, that the positive differences were consistent for multiple marine reserves over an unprecedented spatial scale (>1,000 km).

Australia's Great Barrier Reef Marine Park (GBRMP) has an area of 344,400 km^2 and is an international icon that generates AU$5.8 billion annually from tourism and fisheries [3]. In mid-2004, the Australian Government rezoned the GBRMP. After extensive planning involving identification of bioregions and stakeholder consultation, ≥20% of each of 70 bioregions within the park was placed into the world's largest network of NTMRs [4] covering 115,395 km^2 (33.4% of the GBRMP) and spanning $14°$ of latitude. Because of the intense community interest, and as livelihoods were affected [4], monitoring the effects of the new reserve network was imperative. Thus, an integrated and spatially extensive program was established to assess its value in protecting both biodiversity and exploited species.

A team from James Cook University used underwater visual census to survey reef biota at 18 sites in new coral reef NTMRs and in an equal number of control areas that remained open to fishing in three inshore island groups (10–30 km off the coast and spanning 4.5° of latitude; see Figure S1 in the Supplemental data available on-line with this issue) before and again 1.5–2 years after implementation of the NTMRs (see Supplemental data). Concurrently, sites on 28 pairs of no-take and open offshore reefs (30–200 km from the coast) in five GBRMP regions (spanning 7.5° of latitude, see Figure S1) were surveyed 1.5–2 years after implementation by the Australian Institute of Marine Science. All offshore survey reefs were initially open to fishing but one reef per pair was declared a NTMR in mid-2004, while the other remained open to fishing. Inshore and offshore surveys used similar methods (see Supplemental data).

After 1.5–2 years of protection, the density of the primary target of reef line fisheries, coral trout (*Plectropomus* spp.), increased significantly in inshore NTMRs in the Palm (p < 0.05) and Whitsunday (p < 0.001) Islands (+68% and +65%; Figure 1A). Changes were small and non-significant (+2% and –6%) where reefs remained open to fishing. Reefs in the other inshore region, the Keppel Islands, suffered extreme coral bleaching during March 2006 and coral trout density declined on both open reefs (–23%) and NTMRs (–19%). However, coral trout density in NTMRs increased relative to open reefs in all three inshore regions, significantly so in the Whitsunday Islands and marginally so in the Palm Islands (Palms +65%, p < 0.10; Whitsundays +75%, p < 0.01; Keppels +4%, p > 0.10). Offshore, average coral trout density was also higher in NTMRs than on open reefs in all five regions (Figure 1B), significantly so in four and marginally so in the fifth
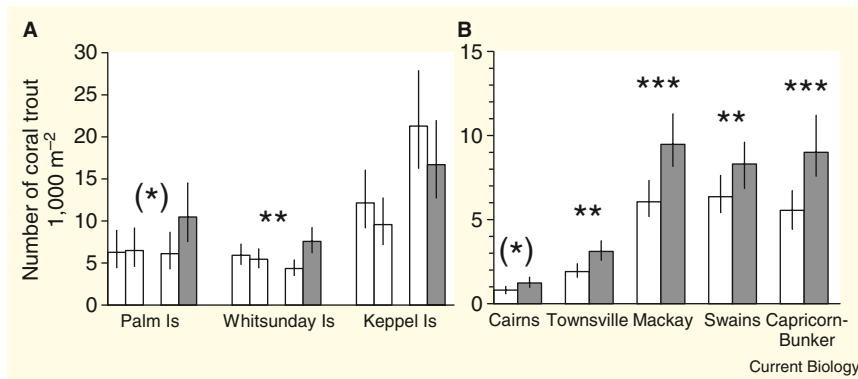
Figure 1. Densities of target fishes on open and no-take reefs.
(A) Mean density of coral trout on inshore reefs in three regions of the GBR. Each pair of bars represents the mean density on a set of reefs before and 1.5–2 years after rezoning. In each pair: first bar gives mean density prior to rezoning, second bar gives mean density 1.5–2 years post-rezoning. Open bars represent reefs open to fishing; shaded bars represent new NTMRs. For inshore reefs, the changes in densities of coral trout in open areas following rezoning were compared with changes in areas that were rezoned as NTMRs. (B) Mean density of coral trout on matched pairs of offshore reefs in five regions of the GBR 1.5–2 years after rezoning. Open bars represent reefs open to fishing; shaded bars represent new NTMRs. Values are geometric means (±1 standard error) derived from mixed-effects models (see Supplemental data). Since the densities of coral trout on offshore reefs prior to rezoning were not known, their densities on open reefs 1.5–2 years post-rezoning were compared with densities on paired new NTMR reefs. Asterisks indicate significant results (see Supplemental data), (·) indicates $p < 0.1$.

(Cairns +53%, $p < 0.10$; Townsville +64%, $p < 0.01$; Mackay +57%, $p < 0.001$; Swains +31%, $p < 0.01$; Capricorn Bunkers +64%, $p < 0.001$, see Supplemental data).

These results are likely due to decreased fishing mortality inside new NTMRs in compliance with the new zoning [4], rather than increased fishing outside reserves. In inshore areas, where most recreational fishing occurs, our data show increases in coral trout density inside reserves rather than decreases in adjacent fished areas after rezoning, which cannot be explained by changes in fishing effort outside reserves. Offshore, where most fishing is commercial, some of the displaced fishing pressure would have been offset by the large declines in commercial fishing effort and catch over the period 2000–2006, caused mainly by the introduction of a catch quota system that coincided with the rezoning.

In time, increased adult density in NTMRs may enhance recruitment both inside and outside NTMRs. The size and position of individual reserves in the network (see Figure S1 in the Supplemental data available on-line) and predictions of larval transport in the GBRMP [5] mean that there is considerable potential for export of coral trout larvae from NTMRs to fished areas. Such export would likely contribute to the long-term sustainability of the reef fisheries. Furthermore, coral trout, important predators of other fish, can influence reef fish biodiversity significantly [6].

The proportional increases in coral trout density in NTMRs were surprisingly consistent (density increased by 57–75% in six of eight regions). The spatial scale of this positive response is unprecedented, being based on multiple offshore NTMRs in five regions up to 1,000 km apart and multiple inshore NTMRs in three regions spread over 700 km. Previously reported effects of NTMRs on the GBR have been equivocal and regionally inconsistent [7]. Similar rapid effects have been documented for individual NTMRs [8], but never such a uniform positive response in multiple reserves over such a large geographic area. The conservation and management expectations of marine reserve networks [1,2,4] require a positive response to establishment of NTMRs across most of the network. Empirical demonstrations of such responses have been lacking until now, reflecting the worldwide scarcity of marine reserve networks and

programs to monitor them. Although preliminary, our results provide an encouraging message that bold political steps to protect biodiversity can produce rapid, positive results for exploited species at ecosystem scales.

Supplemental data
Supplemental data are available at http://www.current-biology.com/cgi/content/full/18/12/R514/DC1

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