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18A Evaluating management success

Effects of a network of NTZs after 15 years in Nabq, Sinai, Egypt

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Abstract. The effects of a network of small No Take Zones (NTZs) established in 1995 within the Nabq Managed Resource Protected Area upon the abundance of commercially important fish was re-assessed during 2011-12. UVC results showed that the abundance of lethrininds, lutjanids and serranids remained significantly higher in NTZs than on fished reefs, and higher than before reserve establishment. However abundances had declined in comparison with the high levels of 2000, as had catch per unit effort (CPUE) recorded by local Bedouin fishers, from a peak of 1.31 kg/net.hr in 2000 to 1.02 kg/net.hr in 2010. These changes are likely due to a more than twofold increase in fishing pressure, and increasing non-compliance of fishermen with the NTZ restrictions, especially at Nakhlet El-Tal and South Ghargana. The initial success of the NTZs in building-up fish stocks within the NTZs and replenishing adjacent fishing grounds between 1995 and 2000 was dependent on the awareness and support of the local fishing community. With increasing fishing pressure by a new generation of young fishers, community-based management initiatives are required to restore environmental awareness and maintain sustainable levels of use of coral reef resources.

Key words: reef fisheries, no-take zones, coral reef fish, South Sinai, community based management

Introduction

During the last 3 decades, increasing fishing pressure on coral reefs has been reported globally. This has been fueled by the rapid increase of human populations, urbanization, development of coastlines and advances in fishing gear technology (Roberts *et al.* 2001). The impacts of heavy fishing pressure upon reef fish communities include the rapid removal of large predatory species (notably Serranidae, Lethrinidae and Lutjanidae), leading to both a reduction in standing biomass and in mean individual size of targeted species (Bell, 1983; Russ, 1985; Ayling & Ayling, 1986; Watson & Ormond, 1994). Reduced individual size in turn could diminish the reproductive output of the stock (Bohnsack, 1990). Further, changes in relative abundance of different species due to heavy fishing can radically alter the trophic structure of the reef community (Russ & Alcala, 1989; Roberts & Polunin, 1993) through significant impacts upon prey species as well (McClanahan & Muthiga, 1988). Coral assemblages may also be impacted directly through the physical damage that can result from heavy fishing.

In the face of such impacts No-Take Zones (NTZs) have increasingly been recognized as an effective fisheries management tool, especially given developing concern for ecosystem-based management (Bohnsack *et al.* 2000). They have now been established at numerous locations worldwide with the resultant reduction in fishing mortality typically leading to a build-up of biomass and mean size of targeted fish species immediately outside as well as inside the reserves (Halpern, 2003). As a result it is increasingly considered that paired with traditional effort-based fisheries management tools, the establishment of no-fishing marine reserves has the potential to replenish stocks of commercially targeted fish species on overfished reefs (McClanahan, 1994).

In the Egyptian Red Sea, the rapid increases over the past two decades in tourism development, urbanization, shipping and oil exploration have placed considerable pressure on the coral reef ecosystem of the northern Red Sea (Pilcher & Abou Zaid, 2000). To safeguard the most valuable areas and representative marine habitats and to protect biological diversity Egypt has declared 6 Protected Areas along its Red Sea coastline, 3 of which are located along the South Sinai coast of the Gulf of Aqaba: Ras Mohammed, Nabq and Abu-Gallum. The coral reefs in Ras Mohammed were declared as no-fishing areas throughout the MPA. In addition smaller NTZs have been established on an experimental basis in the Nabq Managed Resource Protected Area (MRPA) located immediately north of the city of Sharm El Sheikh. The Nabq MRPA was declared in 1992 and it extends along the southern

Gulf of Aqaba coastline for approximately 35 km (Figure 1). Bedouin who live within the MRPA may continue to use traditional grazing areas and fishing grounds, so long as such use is sustainable. The fishery involved small-scale use of nets and hand-lines on and immediately off the generally well-developed coastal fringing reef.

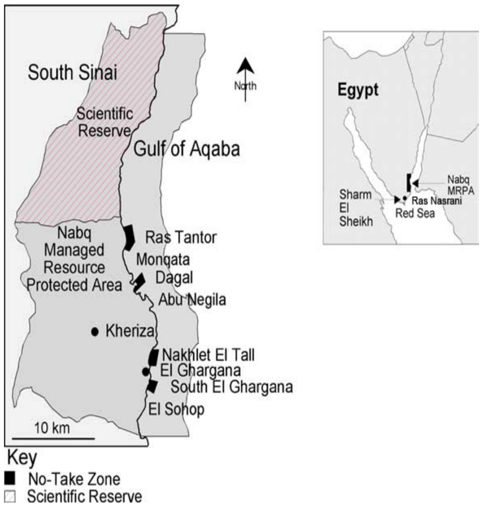

Figure 1: Map of the Nabq MRPA with NTZs shown in solid black and named. The inset picture shows the location of Nabq in Southern Sinai, Egypt, in relation to the northern Red Sea.

Preliminary surveys of the reef fishery were undertaken in 1994-95 by the Egyptian Environment Affairs Agency (EEAA) in collaboration with the University of York (UK). The main objective was to assess the status of the fishery (Galal, 1999), and to provide recommendations for its sustainable management. In 1995, in consultation with the local Bedouin fishing community, a network of small no-take zones (NTZs) was established. The major aim was to apply a precautionary management measure to regulate fishing effort and protect fish stocks and coral reefs. Fishing gear regulations were also introduced to reduce direct damage to corals and prevent overfishing of juveniles. In addition the northernmost 15 km section of coast was declared a scientific reserve zone with restricted access and no fishing. It was anticipated that this network of different size, small NTZs should be a suitable experimental design to examine the extent and mechanisms of stock and catch enhancement, as well as providing benefits to both reef biodiversity and indigenous people.

After five years of closure, commercially targeted species (mainly lethrininds, lutjanids and serranids) showed within NTZs significant increases in both size and abundance, with CPUE in the neighboring fished areas increasing by about two-thirds (Galal *et al.* 2002). In 2002 a more detailed study showed that the abundance of predatory fish species was significantly higher at shallow depths inside the South Ghargana NTZ than in adjacent fishing grounds (Ashworth & Ormond, 2005), with gradients of fish abundance declining moving away from the center of the NTZ and into the neighboring fishing grounds.

However more recently there were anecdotal reports that fishing effort was notably increasing, and that not all the local fishermen were respecting the boundaries of the NTZs since 2002. Therefore this study was undertaken to assess the extent of change in the state of the fish stocks and fishery after 15 years of initial establishment of NTZs.

Material and Methods

Fish abundance

The abundance of commercially important reef fishes was estimated by underwater visual census (UVC). Underwater counts included all recorded species belonging to three commercially important fish families, namely, groupers (Serranidae), emperors (Lethrinidae) and snappers (Lutjanidae) (Table 1). Two replicate sites were surveyed within each of 5 NTZs during April, 2011 and 5 sites were surveyed in fished areas in April, 2012. At each surveyed site, fish were counted along 4 band transects (200 x 10m) running parallel to the reef face. Transects were located along the following reef zones within each site: mid lagoon or reef flat (0-3m depth), reef edge, (0 – 8m depth), reef slope (8 – 15m depth) and deep reef slope or outer reef (15 – 20m depth). The transects that were previously measured and marked during previous surveys were located at 9 sites. The markers were not found at the other sites, where transects were re-measured and re-marked. Shallow transects were surveyed using snorkeling gear while deeper counts were conducted using SCUBA. As the bottom topography at some sites is characterized by a gentle slope seawards (e.g. Nakhlet El-Tall, Marsa Abu Zabad) at these reef slope and outer reef transects were located more than 300m away from the shoreline.

Serranidae	**Lethrinidae**	**Lutjanidae**
Cephalopholis argus	*Lethrinus mahsena*	*Lutjanus ehrenbergi*
Cephalopholis hemistiktos	*Lethrinus nebulosus*	*Lutjanus bohar*
Cephalopholis miniata	*Lethrinus obsoletus*	*Lutjanus monostigma*
Epinephelus fasciatus	*Monotaxis grandoculis*	*Macolor niger*
Epinephelus tauvina		
Variola louti		

Table 1: Fish species from 3 commercially important fish families in the Nabq fishery recorded during UVC surveys.

Catch and effort

Catch landings from 7 different areas within the Nabq fishing grounds were sampled during 2010 by trained Bedouin Community Rangers. The date, site, fishing effort and total weight of each species were recorded. Fishing effort was recorded, after interviewing the fishermen involved, as the number and type of nets and/or hooks, number of fishermen involved and active soak time. Sample catches were directly weighed upon landing and the total weight of each catch was logged. CPUE was calculated as:

$$[CPUE] = W/\ TN$$

where W is total catch wet weight, *N* is the number nets of standard length, and *T* is the active soak time (i.e. the number of hours that the fishing gear was actually active, excluding the setting and collection times).

Fishing density records (total number of fishermen) were regularly logged by Bedouin Community Rangers during a previous survey in 1997 (Galal, 1999) then in 2009 by Protected Area environmental researchers (NPA, 2009). On a number of days each month the total number of fishermen, gear used and specific location of fishing activities were recorded at all fishing grounds. Fishing density records from 1997 (N=133) and from 2009 (N=82) were analysed and tested for spatial and temporal variations in fishing pressure.

Results

Fish abundance

UVC results from the present survey revealed that mean fish abundance (of the three families surveyed) at sites in NTZs was 94% higher than at fished sites outside the NTZs (Figure 2). At the same time mean abundance of these families at the fished sites was significantly lower in 2011-12 than recorded at the same sites in 1995 (Galal *et al.* 2002) (Wilcoxon signed-ranks test, P<0.05). Moreover, seven of the fourteen surveyed fish species were significantly less abundant in fished zones in 2011-12 than in 1995 (Table 2). Total fish abundance inside NTZs was lower in 2011-12 than in 2000 (Figure 2) (though not significantly so), but was significantly higher than in 1995 (Wilcoxon signed-ranks test, P<0.05). A majority of the recorded species was still more abundant in NTZs in 2011-12 than in 1995 (Table 2).

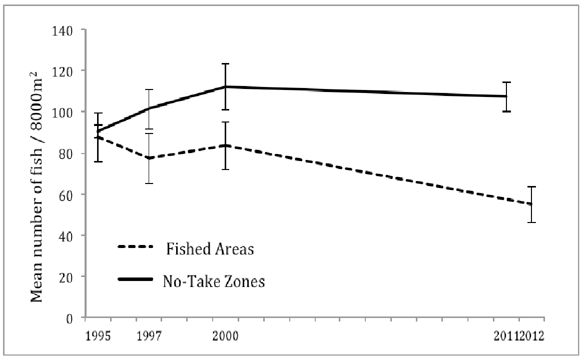

Figure 2: The mean abundance of economically important predatory species (serranids, lethrinids and lutjanids), in NTZs and fished areas in 1995, 1997, 2000 and 2011-12. Error bars represent s.e.m.

	1995		2011 / 2012	
Species	Fished	NTZs	Fished	NTZs
L. mahsena	19.3 ±6.0	11.3 ±0.8	8.2 ±1.8	14.9 ±1.3
L. nebulosus	2.8 ±1.0	5.8 ±0.3	6 ±1.9	9.2 ±1.9
L. obsoletus	16.9 ±6.7	10.5 ±0.7	5 ±1.1	14.1 ±0.8
M.grandoculis	3.5 ±0.9	3.2 ±1.0	3.4 ±1.2	5.9 ±0.8
L. bohar	7.1 ±1.8	6.2 ±0.7	6.6 ±1.4	6.5 ±0.6
Other lutjanids	7.1 ±2.4	3.4 ±0.4	8.6 ±1.9	5.4 ±0.4
C. argus	4.8 ±1.0	4.1 ±0.6	0.8 ±0.4	6.4 ±0.8
C.hemistiktos	2.9 ±1.5	4.9 ±0.9	0.4 ±0.2	5.7 ±0.6
C. miniata	7.8 ±1.5	21.9 ±1.5	3.6 ±1.3	17.2 ±1.7
E. fasciatus	12.9 ±2.9	15.3 ±1.1	10 ±0.9	14.5 ±0.9
E. tauvina	1.8 ±0.4	1.4 ±0.2	0.2 ±0.2	2.2 ±0.3
V. louti	1.0 ±0.3	2.5 ±0.3	2.2 ±0.4	5.1 ±0.8

Table 2: Mean abundance of each species in NTZs and in fished areas in 1995 and 2011-12. Values represent the mean number ± s.e.m of fishes recorded by UVC per $8000m^2$ (4 x $2000m^2$ transects)

Catch and effort

The mean CPUE in fishing grounds at Nabq in 2010 was found to have decreased by more than 20% in comparison with 2000, although to be still significantly higher than before reserve establishment in 1995 (Mann–Whitney U-Test, $P<0.05$) (Table 3).

Fishing site	**1995**	**2000**	**2010**
North Nabq	0.65	0.91	0.94
Ghargana village	0.45	0.75	0.69
Marsa Abo Zabad	0.11	1.56	0.90
Lighthouse	0.19	1.34	1.07
Maria Schroeder	0.75	1.30	1.22
Abo Negailla	0.44	0.92	1.04
Al-dakkal	1.22	0.73	-
Shora El Manquatta	0.49	1.66	1.30
Wadi Ghorabi	2.79	2.63	-
Mean CPUE (kg net^{-1} h^{-1})	0.79	1.31	1.02

Table 3: Catch per unit effort (CPUE; kg net^{-1} h^{-1}) at each of the major fished sites in Nabq during 1995, 2000 and 2010 presented as mean values.

At the same time mean fishing density in 2009 was found to have increased significantly to 14.47 fishermen / day compared to 6.95 fishermen / day in 1997 (Figure 3). Records of fishing activities indicated considerable levels of non-compliance with fishery regulations and NTZ boundaries. Poaching in 2009 was mostly recorded in two of the NTZs: South Ghargana and Nakhlet El-tal NTZs (Figure 4).

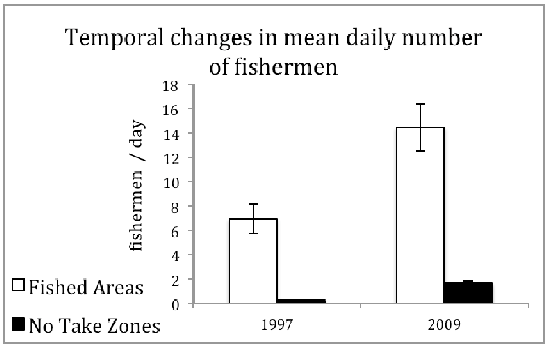

Figure 3: Fishing pressure in the Nabq fishery presented as the mean daily number of fishermen in the Nabq fishing grounds and NTZs. Values are presented as means ± s.e.m (Source: Galal 1999; NPA 2009).

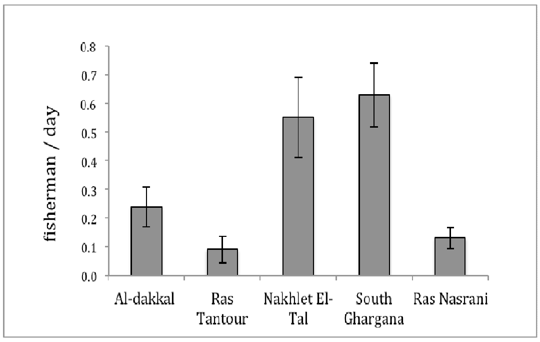

Figure 4: Fishing pressure inside NTZs in 2009 (noncompliance to reserve closures) plotted as the mean daily number of fishermen recorded inside NTZs ± s.e.m. (Source: NPA, 2009).

Discussion

The UVC counts of the 3 commercially important families (groupers, snappers and emperors) show that the buildup in fish numbers that occurred inside NTZs up to 2000 had been reversed by 2011. Nevertheless UVC counts in NTZs in 2011-12 were still more than 90% higher than in neighboring fishing grounds. The more detailed study of the South Ghargana NTZ in 2002 showing greater fish abundance inside the reserve than in adjacent fishing area confirmed this result (Ashworth & Ormond, 2005). These findings supported the view that NTZs can function to protect stocks of the more vulnerable K-selected predatory fish species that tend to be more easily overfished (McClanahan, 1994).

NTZs have also been increasingly shown to provide benefits to fisheries by preventing severe overfishing and sustaining recruitment to adjacent fishing grounds. Emigration, or spillover, of adults from NTZs can occur as stocks build up within them (Russ & Alcala, 1996; Ashworth & Ormond, 2005), and enhanced larval disbursement could occur as a result of an improved reproductive success of the increased spawning stock (Bohnsack, 1993). In the Nabq fishery, mean CPUE remains higher in 2010 than when the NTZs were first established in 1995, even though there has been a more than 20% fall in CPUE compared to the values recorded by Galal *et al.* in 2000. And given the increased numbers of fishermen total catch from the fishery may now be higher than in 2000 or 1995, although whether such an increased yield proves sustainable remains to be seen.

These changes in the fishery appear clearly related to changes in fishing pressure, the result of a doubling in the numbers of fishermen and a large increase in non-compliance with the NTZ regulations. The extent of poaching varied between NTZs, but was found to be especially high at South Ghargana and Nakhlet El-Tal. The levels there appear to be comparable to the 15% annual exploitation rate reported elsewhere as capable of negating any reserve effect (Sethi & Hilborn, 2007). Poaching in NTZs seems likely to have been stimulated by a number of factors: first a twofold increase in the number of local and visiting Bedouin seeking to fish in the area; second a strongly elevated demand for fresh fish to supply the greatly increased numbers of hotels and restaurants in Sharm El Sheikh; third, a tendency for the high fish densities that can build up within NTZs to attract fishermen willing to poach, an issue considered in a wider context by Byers and Noonburg (2007).

Most recently, surveys by the University of Glasgow at Ghargana NTZ in 2011 suggested that the previously reported benefits of the NTZ have now been negated (Bailey D, pers. comm.). However present levels of non-compliance to NTZ closures should not discourage area managers of their present and future use as a potentially valuable fisheries management tool.

It is widely accepted that the extent of environmental awareness and support for fisheries conservation measures among a fishing community constitute a principal factor affecting the success of marine fishing reserves (Russ & Alcala 1996, 1999; Roberts *et al.* 2001). The social acceptability of local Bedouin fishermen to new fishing restrictions in 1995 was substantially raised by an environmental education initiative pursued for some five years after the establishment of the NTZs. Numerous meetings between Nabq MRPA managers and fishermen groups in traditional settings discussed the principles, values, number, location and size of proposed NTZs. Consultation concluded in an agreement amongst the fishermen group leaders and the wider Bedouin community to refrain from fishing in NTZs and to support reserve closures. The employment of Bedouin community rangers in Nabq MRPA by the EEAA also played a key role both in raising awareness of the likely long-term benefits of eliminating fishing mortality in NTZs, and in making all fishermen aware of the restrictions. The participation of the fishing community was key to gaining their support and compliance, although their willingness to collaborate was greater than might be anticipated due the cultural tradition and awareness among Sinai Bedouin of respecting nature and conserving resources (such as trees and grazing) against future need.

Currently however it would be valuable to raise the awareness of the younger fishing community and re-educate them about the expected benefits of sustainable fisheries and the operation of NTZs. The fact that fishermen complaints, that stocks and catches are declining, are becoming more common should assist these efforts. However other fisheries management measures to reduce fishing effort could include seasonal closures, gear type regulations, a licensing and quota system, restricting licences to Bedouin resident within the Nabq MRPA, rather than permitting fishing by any visitor. At the same time further research is still required to improve scientific knowledge of how effectively to manage NTZs (Sale *et al,* 2005; McCook *et al.* 2009). Studies should also consider assessing whether the existing NTZs could be reduced in size or conversely enlarged so as to achieve maximum sustainable yields while protecting representative marine habitats.

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