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Discussion

Comment on "New perspectives for the future of the Maldives" by Mörner, N.A., et al. [Global Planet. Change 40 (2004), 177–182]

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Mörner et al. (2004) raise a number of important issues concerning sea level change and island morphological adjustment in the Maldives. These issues have great relevance for atoll nations as they shed light on the potential stability of reef islands with respect to future sea level change. Given the high international profile of reef island vulnerability it is important that the data and conclusions of such studies are robustly examined.

In their article Mörner et al. (2004) contend that sea level has undergone a recent fall in the Maldives and imply that reef islands there are not likely to be inundated if sea-level were to rise as predicted by the IPCC (Church and Gregory, 2001). Here we raise a number of concerns with arguments and data presented by Mörner et al. (2004) that are central to the interpretations and conclusions presented in their paper. This discussion addresses: (1) the Last Interglacial and Holocene development of the Maldives; (2) the sea-level curve presented; and (3) evidence introduced to substantiate claims of recent sea-level fall.

(1) The introduction of Mörner et al. (2004) contains a number of unqualified and unreferenced assertions that necessitate comment. First, they state the surficial reefs of the Maldives were not dominated by catch-up reef growth in the mid to late Holocene but are of pre-Holocene age. Second, they report reef rocks of Last Interglacial age occurring close to and below sea level and up to +1.2–1.3 m. No evidence is given in support of either claim and both are contrary to published data on reef development in the Maldives. For instance, Risk and Sluka (2000) note that Holocene reef growth began about 6000 years ago and continued in catch-up mode at 3 to 10 mm/year (for the ensuing 3000 years) resulting in a total Holocene section of between 15 and 20 m. On Male, Woodroffe (1993) describes a Holocene reef sequence up to 17 m thick overlying the Last Interglacial reef. This evidence is in accordance with Purdy and Bertram's (1993) as well as Bianchi et al.'s (1997) interpretation that the contemporary Holocene reef

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morphology has been controlled by the antecedent karst surface resulting from the last glacial lowstand.

(2) Mörner et al. (2004, Fig. 1) present a new sea-level curve for the Maldives that encompasses the last 5000 years. This plot is potentially globally significant as detailed reconstructions of sea level history from this region are lacking. This curve is based on 12 data points derived from two sources. Seven of the dates are from Woodroffe (1993) who reports these samples as bulk sands, boulder conglomerates and only one in situ coral. This coral is a *Heliopora* with elevation with respect to present MSL of 0.0±0.3 m (2710±85 year BP). In our opinion this is the only reliable date from the Woodroffe (1993) dataset that could be used for sea level reconstruction. The remaining six samples are unreliable indicators of MSL and should not be included in Fig. 1. Five new dates are plotted by Mörner et al. (2004, Fig. 1) as evidence of past sea level positions. However, no information is provided on what materials were dated (in situ coral or unconsolidated sediments) or how their relationship to current sea level was established. Furthermore, conventions for reporting C-14 ages are not followed. Standard information is missing, notably the actual dates, error terms, lab codes and calibration details (if any). In the one exception, we are perplexed why human remains (reef woman) should be subject to a 'sea correction' of some 400 years when the ocean reservoir correction should be used for marine specimens only (e.g. Reimer and Reimer, 2000). Of particular concern is the assertion that there have been higher sea levels at 4000 and 800 years when the latter is based on a boulder conglomerate and evidence for the former is not reported. Moreover, Bianchi et al. (1997) state that relative sea level stands higher than present are not known from Felidu Atoll which is mid way between the islands investigated by Mörner et al. (2004). In our view, Fig. 1 should be disregarded as an accurate representation of the Maldives sea level history.

(3) Mörner et al. (2004) claim that their observational data sheds new light on the present to sub-recent sea level changes as expressed in Fig. 3. For instance, in Fig. 3A, it is claimed that a sub recent level of 1.2 m above MSL on Hulhudhoo Island indicates a higher sea level of +0.3 m. Our evidence from repeat surveys of seven profiles on Hulhudhoo in 2002 and 2003 demonstrate that the sub recent level falls within the dynamic range of the contemporary erosion and accretion zone. Therefore we reject the notion that the sub recent level represents a sea level +0.3 m higher than present. Our evidence also suggests that the 1.45-m island surface level also falls within this level of contemporary morphodynamic change and does not represent a +0.6 m higher sea level.

Beach rock positioned at 0.4–0.5 m above MSL is also used by Mörner et al. (2004) to infer sea level change. Using beach rock as a palaeo sea-level indicator has been widely discussed and used in a number of studies (e.g. Scoffin, 1977; Scoffin and McLean, 1978; Hopley, 1982). These studies show that contemporary beach rock can form well above mean sea level and as identified by Hopley (1982) can exceed mean high water spring tide level by several centimeters. For the Maldives, beach rock at +0.4–0.5 m places it in the intertidal range. Our data from 12 traverses surveyed across contemporary beach rock exposures on Goidhoo atoll in 1995/1996 show an elevation range of 1.2 m from −0.4 to +0.8 m above MSL. Consequently, the elevations of beach rock reported by Mörner et al. (2004) lie within the range of contemporary beach rock and cannot be used as an indicator of a higher sea level. In summary, we reject both the beach rock and morphological evidence for a significant sea level fall over the past 30 years.

We conclude that the sea level history and data presented by Mörner et al. (2004) is less than compelling and can be readily explained via an understanding of contemporary coastal processes. The region's sea level history remains uncertain. Consequently, we believe that this work does little to inform the international community on new perspectives of the future of the Maldives.

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