# Appendix F3

## Australian Maritime Safety Authority 2012b

## AIMS Expert Opinion: Subsidence of Scott Reef

BROWSE FLNG DEVELOPMENT
Draft Environmental Impact Statement

EPBC 2013/7079
November 2014

Australian Government | Australian Institute of Marine Science

# AIMS Expert Opinion on SEWPAC comment relating to Subsidence of Scott Reef

## Comment from SEWPAC

While it is stated that climate change poses a larger threat to Sandy Islet and Scott Reef than subsidence alone, any subsidence would exacerbate the impacts of climate change, which could result in unacceptable impacts to Sandy Islet and the Green turtles that nest there. The 'negligible' risk rating applied in the draft EIS should be reconsidered in the Supplementary EIS. In addition, the three climate change/subsidence scenarios modelled take only the corresponding subsidence level into account (worst case sea level rise with worse case subsidence, intermediate case sea level rise with intermediate case subsidence, best case sea level rise with best case subsidence). What is unclear is how Sandy Islet and Scott Reef would be affected purely in relation to the sea level rise scenarios and with no subsidence. Similarly how would Sandy Islet and Scott Reef be affected by only subsidence and no sea level rise? And so on.

***Required***: An expert opinion on the above.

***Inputs:*** Cooper et al. (2010) Ecological implications of sea level rise on Scott Reef;

## Expert Opinion from AIMS:

### Summary

If subsidence occurred on its own, with no climate change impacts, then the overall impact on both the reef coral communities and on Sandy Islet would be expected to be insignificant or temporarily positive. There may be an initial period of increased coral cover on the reef flat and possibly an increase in the size or height of the cay during the period of subsidence, after which the reef would regain its former height in relation to the sea surface and the coral communities and cay would be expected to return to a state similar to that observed prior to the subsidence.

If no subsidence occurred, but climate change caused an increase in sea level and cyclone activity, then it is predicted that, for all except the most optimistic scenarios, significant adverse changes to both the coral communities and Sandy Islet will occur over time.

There is an infinite combination of climate change and subsidence combinations and there is little benefit to be derived from detailed examination of several additional scenarios. One additional scenario has been included in which the relative contribution of subsidence has been set to maximum levels. In all cases which involve both subsidence and climate change, the main consequence of the addition of subsidence into the analysis is for impacts that would occur anyway to be brought forward in time. For Sandy Islet, the diversity of factors that influence cay stability and persistence, including the high dynamic rate of sea level rise, make it impractical to reliably predict just how much earlier these impacts might occur.

## Detailed Response

In responding to the comments from SEWPAC we address three specific questions relating to the impacts of subsidence and climate change on the Scott Reef system:

1. What are the relative contributions of climate change and subsidence under different scenarios?
2. How would the addition of subsidence to the impacts of climate change affect the reef and islet?
3. What would be the impact of subsidence in the absence of climate change impacts?
4. Is there a scenario where the addition of subsidence to climate change would tip impacts over a threshold to create an unacceptable impact?

**What are the relative contributions of climate change and subsidence under different scenarios?**

While the relative contributions of subsidence to sea level rise are fairly small in the scenarios originally presented in Cooper et al. (2010) (Table 1), there are an infinite number of combinations which could be considered and in some of these the relative contribution from subsidence is much higher. We have added an additional scenario "Worst case for development impact" where the sea level rise is at the lowest end of expected values and subsidence is at the highest end. In this scenario, the net change in water depth (11.5cm) is not as high as the worst case scenario (19.5cm), however the relative contribution due to subsidence is at its maximum (50%). In these scenarios the relative contributions are calculated over the life of the project only. While subsidence will cease at the end of the project, sea level rise would be expected to continue to occur well past this date.

**Table 1**. Modification of Table 5 from Cooper et al. (2010) (blue text) to show the net change in water depth for each scenario due to subsidence only or SLR only over a 40 year timeframe. The per cent contribution of subsidence to the net change is also shown in column (e).

| Scenario* | (a) VAR (cm) | (b) Seafloor subsidence (cm) | (c) Net VAR (cm) | (d) SLR (cm) | (e) % of net change due to subsid. | Net change in water depth** (cm) (f) SLR & Subs. | (g) Subs. only | (h) SLR only |
|---|---|---|---|---|---|---|---|---|
| Best-case | 14.0 | 2.1 | 14.0 | 7.2 | 23% | **-4.7*** | **-11.9*** | **-6.8*** |
| Intermediate-case | 9.8 | 4.4 | 7.8 | 11.2 | 28% | **7.8** | **-3.4*** | **3.4** |
| Worse-case | 5.6 | 7.1 | 2.8 | 15.2 | 32% | **19.5** | **4.3** | **12.4** |
| Worst Development Impact | 5.6 | 7.1 | 2.8 | 7.2 | 50% | **11.5** | **4.3** | **4.4** |

*Negative values indicate that the potential for reef growth exceeds the rate of sea level rise or reef subsidence. Actual net change in all such cases on the reef flat would be zero since corals cannot grow above maximum sea level. (a) vertical accretion rates (VAR) (1.4 to 3.5 mm y-1, Collins et al. 2009), (b) average estimates of seafloor subsidence provided by Woodside, (c) Net VAR incorporating declines in coral growth of 0% for best-case, 20% for intermediate-case, and 50% for worse-case from Reynaud et al. (2003); Cooper et al. (2008); De'ath et al. (2009), (d) the lower to upper range of estimates for sea level rise (SLR) based on Scenario SRES B1 (1.8 to 3.8 mm y-1), and (e) the % of net change attributable to subsidence.

** Net change is calculated as follows: **(f)** = (b)+(d) - (c); **(g)** = (b) - (c) ; **(h)** = (d) - (c) .

**What would be impacts of subsidence in the absence of climate change impacts?**

In the various scenarios, climate change impacts have been included through reductions to the maximum rates of vertical reef growth (coral mortality due to cyclones and coral bleaching; reduced growth due to ocean acidification and temperatures exceeding those for optimum growth) and sea level rise. In the absence of these factors, subsidence on its own, is predicted to cause no more than a 4.3cm increase in water depth above the corals at Scott Reef over 40 years. It is likely that the impact of this change will be negligible (somewhat better than the Intermediate case scenario described in section 5.4.3 of Cooper et al. 2010). After 40 years, subsidence is assumed to halt and (in the absence of climate change impacts) corals would grow back to the surface over a period of 12 years or so.[1]

**How would the addition of subsidence to the impacts of climate change affect the reef and islet?**

The nature and mechanisms of the impact of subsidence on Scott Reef and Sandy Islet is identical to sea level rise. Both tend to increase the water level above the reef. Consequently the combined impacts of subsidence and sea level rise are purely additive rather than synergistic. In addition, since subsidence is predicted to occur for a maximum of 40 years, its primary impact will be to increase the rate at which the impact increases in severity over this time and to bring forward the time at which any theoretical impact threshold is reached. For all scenarios, except the best case, Sandy Islet would eventually (over 50-100 years) be washed away and the coral reef would be drowned and stop growing (over hundreds to thousands of years). The effect of subsidence would only be to make this happen a bit earlier.

**Is there a scenario where the addition of subsidence to climate change impacts would tip impacts over a threshold to create an unacceptable impact?**

Sandy Islet is clearly the most significant aspect of this assessment of impacts since it is more likely to change in response to small changes in water level and since it is a nesting site for Green turtles, which are an endangered species. The report by Cooper et al. (2010) did not specifically examine the risk to green turtles but it indirectly addressed this issue by assessing the impacts on the stability and persistence of Sandy Islet.

While this question of thresholds is highly relevant, it is not possible to address it in a quantitative manner for two reasons. First, there is no accepted threshold of acceptability for impacts on coral reefs or turtle nesting that can be used as a basis for comparison of impacts. Nor has any threshold been provided by SEWPAC. Second, it was beyond the scope of the Cooper et al. (2010) report commissioned by Woodside to quantitatively model the likely impacts of various scenarios on the ecology of Scott Reef or the stability and viability of Sandy Islet as a turtle nesting ground. The best that can be provided with the existing information is a qualitative expert opinion on the different types and severities of impacts that might occur.

[1] The time would be 12 years if the reef grows at a constant rate. Since growth will slow as the reef reaches the surface the total time taken will be longer than 12 years.

Cooper et al. have discussed the range of likely impacts for three levels of impact in which water depth over the reef does not change, or increases by 7.8 or 19.5 cm. Given the necessarily qualitative nature of their discussion of possible impacts, there would be no value in further refining these to predict specific impacts for intermediate water depths.

Under the Worst Development Impact, water depth would rise to 11.5 cm above the reef, a depth about half way between the intermediate and worst case scenarios. Under this scenario there might be a risk for the Islet to become less stable due to erosional processes associated with increased wave height, although the most important factor influencing the persistence of the Islet is the frequency of category 5 cyclones.

Under this impact scenario we estimate that there is a low, but non-negligible risk that Sandy Islet could be reduced significantly in size or lost for significant periods. However these impacts would still occur in the absence of subsidence albeit over a longer time period. Given the highly variable nature of sea level rise, cyclone occurrence and sediment dynamics it is not possible to reliably predict the timing of any major changes to Sandy Islet in either case.

Under the Worst Case scenario, water depth would rise by 12.4cm over a 40 year timeframe, even in the absence of subsidence, and so could cause non-negligible impacts. However the addition of subsidence to create a total increase in depth of 19.5cm would have the effect of bringing forward by several years impacts which would occur anyway due to sea level rise.

## References

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Cooper TF, Lough JM, Oliver JK, Brinkman R (2010b) Effects of sea level rise on Scott Reef. Report to the Browse Joint Venture Partners. Australian Institute of Marine Science, Perth, WA

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