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Review

Effects of dredging on critical ecological processes for marine invertebrates, seagrasses and macroalgae, and the potential for management with environmental windows using Western Australia as a case study

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ABSTRACT

Dredging can have significant impacts on benthic marine organisms through mechanisms such as sedimentation and reduction in light availability as a result of increased suspension of sediments. Phototrophic marine organisms and those with limited mobility are particularly at risk from the effects of dredging. The potential impacts of dredging on benthic species depend on biological processes including feeding mechanism, mobility, life history characteristics (LHCs), stage of development and environmental conditions. Environmental windows (EWs) are a management technique in which dredging activities are permitted during specific periods throughout the year; avoiding periods of increased vulnerability for particular organisms in specific locations. In this review we identify these critical ecological processes for temperate and tropical marine benthic organisms; and examine if EWs could be used to mitigate dredging impacts using Western Australia (WA) as a case study. We examined LHCs for a range of marine taxa and identified, where possible, their vulnerability to dredging. Large gaps in knowledge exist for the timing of LHCs for major species of marine invertebrates, seagrasses and macroalgae, increasing uncertainty around their vulnerability to an increase in suspended sediments or light attenuation. We conclude that there is currently insufficient scientific basis to justify the adoption of generic EWs for dredging operations in WA for any group of organisms other than corals and possibly for temperate seagrasses. This is due to; 1) the temporal and spatial variation in the timing of known critical life history

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stages of different species; and 2) our current level of knowledge and understanding of the critical life history stages and characteristics for most taxa and for most areas being largely inadequate to justify any meaningful EW selection. As such, we suggest that EWs are only considered on a case-by-case basis to protect ecologically or economically important species for which sufficient location-specific information is available, with consideration of probable exposures associated with a given mode of dredging.

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1. Introduction

Dredging is the excavation and relocation of sediment from an area to improve navigational access, for land reclamation and to allow for the development of coastal infrastructure (PIANC, 2010). Dredging can impact marine ecosystems in numerous ways. Dredging can increase turbidity and sedimentation above natural background peak and duration levels, reducing light availability and potentially burying benthic communities (EPA, 2011). In addition, dredging can also impact the physical environment by altering bathymetry, potentially causing erosion under benthic communities (Erftemeijer and Lewis, 2006). Dredging can also impact water quality by releasing contaminants or excess nutrients in sediments, particularly when conducted over contaminated sediments (Filho et al., 2004). The spatial and temporal scales of potential impacts also depend on durations and intensities of exposure, which vary depending on selection of dredge plant and local bathymetries, hydrodynamics and sediment properties, and areas are often classified around dredging activities based on estimated impact severity (e.g. areas of high impact/moderate impact/influence, EPA, 2011). Dredging can therefore have adverse impacts on the marine environment, particularly on sessile benthic communities, if not managed effectively (Rogers, 1990; Desprez, 2000; Erftemeijer et al., 2012). In order to understand the vulnerability it is important to first understand their life history characteristics (LHCs) and identify sensitive life history stages (e.g. reproductive periods). We define vulnerability as "the extent to which a species experiences field effects of a stressor at the population level, as result of their species-specific ecological traits governing potential exposure to this stressor, toxicological sensitivity, and population recovery capacity" (sensu De Lange et al., 2010). Due to high spatial and temporal variability in the occurrence of ecologically critical periods, this knowledge is limited for many regions and many species.

Environmental windows (EWs) are a management strategy used to minimize the impacts of dredging on specific marine flora and fauna through temporal restrictions on intensive dredging activities, both at the sediment excavation site and at the sediment