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TITLE: Projected atoll shoreline and run-up changes in response to sea-level rise and varying large wave conditions at Wake and Midway Atolls, Northwestern Hawaiian Islands

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ABSTRACT:

Atoll islands are dynamic features that respond to seasonal alterations in wave conditions and sea level. It is unclear how shoreline wave run-up and erosion patterns along these low elevation islands will respond to projected sea-level rise (SLR) and changes in wave climate over the next century, hindering communities' preparation for the future. To elucidate how these processes may respond to climate change, extreme boreal winter and summer wave conditions under future sea-level rise (SLR) and wave climate scenarios were simulated at two atolls, Wake and Midway, using a shallow-water hydrodynamic model. Nearshore wave conditions were used to compute the potential longshore sediment flux along island shorelines via the CERC empirical formula and wave-driven erosion was calculated as the divergence of the longshore drift; run-up and the locations where the run-up exceed the berm elevation were also determined. SLR is projected to predominantly drive future island morphological change and flooding. Seaward shorelines (i.e., ocean fronted shorelines directly facing incident wave energy) were projected to experience greater erosion and flooding with SLR and in hypothetical scenarios where changes to deep water wave directions were altered, as informed by previous climate change forced Pacific wave modeling efforts. These changes caused nearshore waves to become more shore-normal, increasing wave attack along previously protected shorelines. With SLR, leeward shorelines (i.e., an ocean facing shoreline but sheltered from incident wave energy) became more accretive on windward islands and marginally more erosive along leeward islands. These shorelines became more accretionary and subject to more flooding with nearshore waves becoming more shore-normal. Lagoon shorelines demonstrated the greatest SLR-driven increase in erosion and run-up. They exhibited the greatest relative change with increasing wave heights where both erosion and run-up magnitudes increased. Wider reef flat-fronted seaward shorelines became more accretive as all oceanographic forcing parameters increased in magnitude and exhibited large run-up increases following increasing wave heights. Island end shorelines became subject to increased flooding, erosion at Wake, and accretion at Midway with SLR. Under future conditions, windward and leeward islands are projected to become thinner as ocean facing and lagoonal shorelines erode, with leeward islands becoming more elongate. Island shorelines will change dramatically over the next century as SLR and altered wave climates drive new erosional regimes. It is vital to the sustainability of island communities that the relative magnitudes of these effects are addressed when planning for projected future climates.

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