Figure F1. Map of the northwest shelf showing major basins and location of modern and "fossil" reefs. Stars = Expedition 356 sites, green circles = Deep Sea Drilling Project/Ocean Drilling Program sites and other core locations referred to in text, yellow circles = industry well locations (Angel = Angel-1; G2/6/7 = Goodwyn-2, Goodwyn-6, Goodwyn-7; A1 = Austin-1; M/MN1 = Maitland/Maitland North-1; TR1 = West Tryal Rocks-1). WA = Western Australia, NT = Northern Territory, SA = South Australia, QLD = Queensland, NSW = New South Wales.

Figure F2. Bathymetric map showing the seafloor around Sites U1458 and U1459. Bathymetric data are derived from the Geoscience Australia Australian bathymetry and topography grid, June 2009. Positions of multichannel seismic profiles are shown. The Houtman Abrolhos reef complex is the most southerly reef system in the Indian Ocean. Red circles = locations of preexisting industry wells.

Figure F3. Multichannel seismic profile across Sites U1458 and U1459. Top of green shading = intended depth of penetration and is of Eocene age. SP = shotpoint.

Figure F4. Lithostratigraphic summary, Site U1459. Lithification, core image, graphic lithology, texture, lithostratigraphic units, age, structures and diagenesis, and facies show composite record from Holes U1459B and U1459C. See Figures **F6** and **F7** in the Expedition 356 methods chapter (Gallagher et al., 2017) for lithology, structure, diagenesis, and facies keys. b*, MSP, and NGR: red = Hole U1459A, black = Hole U1459B, blue = Hole U1459C. cps = counts per second. Age boundaries are based on biostratigraphy depths listed in Table **T8**.

Figure F5. Smear slide summary, Site U1459. See Figure **F7** in the Expedition 356 methods chapter (Gallagher et al., 2017) for lithology key. A. Hole U1459A. (Continued on next two pages.)

Figure F5 (continued). B. Hole U1459B. (Continued on next page.)

Figure F5 (continued). C. Hole U1459C.

Figure F6. Thin section images in plane-polarized light (PPL), Unit I (left: 356-U1459A-2X-CC, 6–9.5 cm, right: 4X-1, 19–21 cm). Bioturbated skeletal packstones with planktonic and benthic foraminifers, bryozoans, echinoderms, and mollusks. Skeletal grains show intense bioerosion borings. Primary porosity is low. Pores are coated with thin layers of microcrystalline and fibrous dogtooth cement.

Figure F7. Smear slide photomicrograph, Unit II (356-U1459B-3F-2, 124 cm). Abundant sponge spicules with foraminifer fragments and other calcitic skeletal grains in a fine micrite matrix.

Figure F8. Thin section images, Unit II (356-U1459B-3F-1, 20–22 cm). Moderately to strongly bioturbated foraminifer-rich skeletal packstone. Foraminifer tests are partly dissolved and often filled with a thin layer of microcrystalline sparitic calcite cement. Note that bryozoans are dominant in other parts of the thin section. Porosity is low and moldic. Left: PPL. Right: cross-polarized light (XPL) (pore space appears black).

Figure F9. Thin section images, Unit III (356-U1459A-13F-3, 47–49 cm). Foraminifer-rich packstones with echinoderms and small amounts of silt-sized glauconite and quartz grains. Foraminifers are about the size of medium sand grains. Microsparitic cement is present throughout the unit. Porosity is moderate and mostly moldic. Recrystallization of micrite to sparite might have decreased primary porosity. Left: PPL. Right: XPL (geopetal structure in the middle of the image and pore spaces appear black).

Figure F10. Smear slide photomicrograph, Unit IV (356-U1459B-23F-2, 71 cm). Sand-sized planktonic and benthic foraminifers with other skeletal carbonates embedded in a fine micritic matrix. Note glauconite grains and partial glauconitization of foraminiferal tests.

Figure F11. Representative thin section images, Unit IV (356-U1459B-25F-1, 90–92 cm). Unlithified skeletal packstone with planktonic and benthic foraminifers. Large echinoderm fragments dominate the sediments. Coarse sand–sized angular to irregular intraclasts are present, including fine skeletal fragments in a dark micrite matrix. Left: PPL. Right: XPL.

Figure F12. Thin section images, Subunit Va (356-U1459B-33F-2, 100–103 cm). Nonskeletal packstone with abundant peloids. Early stage dolomitization is present. The peloidal grains show no signs of compaction. Occasionally, microspar cement fills pore spaces between grains. Coarse silt–sized quartz grains are abundant. Echinoderm fragments are the dominant bioclast particles. Left: PPL. Right: XPL (pore space appears black).

Figure F13. Smear slide photomicrograph of abundant silt-sized euhedral dolomite crystals in the lower part of Hole U1459B Subunit Va (34F-2, 71 cm). Dolomite crystals are frequently the dominant sediment component in this interval. Example of a detrital glauconite grain shown in the upper middle of the image.

Figure F14. XPL smear slide photomicrograph from a quartz sand–rich interval in the lower part of Hole U1459B (40F-2, 50 cm; Subunit Vb). Quartz dominates the sand-sized fraction. Euhedral dolomite crystals dominate the silt-sized fraction.

Figure F15. Representative thin section images, Subunit Vb (356-U1459B-50X-CC, 6–12 cm). Medium sand-sized calcilithite (sandstone with carbonate rock fragments), with silica cemented throughout. Porosity is mostly interparticle and rarely intraparticle. Silica cement (chalcedony to quartz) fills the pores between the grains and even inside the grain and in some cases replaces the carbonate cement, which seems to be deposited earlier than silica cements. Bioclast fragments (low percentage) are still recognizable. Rock fragments are carbonate type (mostly fine grained and micritic). Left: PPL. Right: XPL (pore space appears black).

Figure F16. PPL smear slide photomicrograph showing typical mineralogical composition of Unit VI (356-U1459C-18R-1, 59 cm). Dolomite dominates the sediment with brown glauconite. Bright dark green (likely detrital) glauconite is visible in the center and the lower left of the image. Opaque phases are likely artifacts caused by metal flakes detached during the scraping the lithified rock with a spatula.

Figure F17. XPL photomicrograph of Figure **F16** showing the absence of quartz or other lithic grains within the sediment in this interval. Brownish to multicolored grains are dolomite, whereas dark greenish-brown grains are glauconite.

Figure F18. Thin section images, Unit VI (356-U1459C-17R-1, 60–64 cm). Highly porous fine to medium crystalline dolostone with glauconite. The size and shape of dolomite crystals changes from fine anhedral to medium euhedral. Medium sand–sized glauconite grains make up the noncarbonate component. Secondary intercrystalline porosity is estimated at ~10%–15%. Left: PPL. Right: XPL (pore space appears black).

Figure F19. PPL smear slide photomicrograph of nannofossil-rich clay layer (356-U1459C-29R-1, 40 cm) showing the generally fine, clay- to fine silt–sized clay and micrite grains between abundant nannofossils. The larger (~20 µm) euhedral rhomboidal crystal in the lower left represents an example of the isolated dolomite crystals present throughout Unit VII.

Figure F20. XPL smear slide photomicrograph of Figure **F19** (356-U1459C-29R-1, 40 cm; Unit VII). Abundant nannofossils with their distinctive extinction pattern, also illustrating the minor amounts of both clay and micrite that occurs together with the nannofossils in the clay- and fine silt–sized fraction.

Figure F21. Thin section images, Unit VII (356-U1459C-32F-1, 131–133 cm). Chertified dolomitic skeletal limestone. The primary skeletal limestone

shows two phases of diagenesis and replacement: (1) dolomitization, resulting in growth of fine crystalline dolomite throughout the sediment and replacement of biogenic components; and (2) chertification, which changed the texture and components of the rock. Only the largest components of the dolomitized carbonate rock are unaffected. Smaller components of the dolomitized carbonate rock were partially removed by chert (chalcedony). Left: PPL. Right: XPL (pore space appears black).

Figure F22. Photomicrographs of calcareous nannofossils, Site U1459. A. *Braarudosphaera bigelowii*. B. *Pseudoemiliania lacunosa*. C. *Reticulofenestra pseudoumbilicus*. D. *Helicosphaera intermedia*. E. *Pontosphaera discopora*. F. *Discoaster brouweri*. G. *Discoaster surculus*. H. *Discoaster challengeri*. I. *Discoaster neohamatus*. J. *Discoaster berggrenii*. K. *Sphenolithus abies*. L. *Sphenolithus moriformis*. M. *Cyclicargolithus abisectus*. N. *Reticulofenestra scrippsae*. O. *Cyclicargolithus floridanus*. P. *Ericsonia formosa*. Q. *Reticulofenestra umbilicus*. R. *Isthmolithus recurvus*. S. *Cribrocentrum reticulatum*. T. *Coccolithus eopelagicus*. U. *Discoaster saipanensis*. V. *Chiasmolithus altus*. W. *Chiasmolithus grandis.*

Figure F23. Planktonic foraminifer abundance, Site U1459. 0 = barren, 1 = very rare, 2 = rare, 3 = few, 4 = common, 5 = abundant (see **Biostratigraphy and micropaleontology** in the Expedition 356 methods chapter [Gallagher et al., 2017] for definitions).

Figure F24. Preservation of planktonic foraminifers, Site U1459. Good (Core 356-U1459A-6F; 34.99 m CSF-A): mostly no dolomitization. Moderate (Core 356-U1459B-18F; 92.56 m CSF-A): small-scale fine dolomitization. Poor (Core 34F; 165.26 m CSF-A): dolomitized. Very poor (Core 39F; 186.92 m CSF-A): heavily dolomitized. See **Biostratigraphy and micropaleontology** in the Expedition 356 methods chapter (Gallagher et al., 2017) for further explanations.

Figure F25. Dominant benthic foraminiferal species and assemblages at Site U1459 with paleodepth based on planktonic/benthic ratio (%P) and bathymetric zone interpretation. Assemblage bathymetric zones were smoothed to generate a synthesis, resulting in slight differences from hole summary data. For raw bathymetric zonation see Table **T10**. This figure is available in an **oversized format**.

Figure F26. Typical Eocene planktonic foraminifers in 356-U1459C-29R-CC through 40R-CC, including *Subbotina* sp., *Acarinina* sp., and *Globigerinatheka* sp.

Figure F27. Benthic foraminifer diversity (number of species) and benthic percentage of total foraminifers, Site U1459. Analyzed samples from Holes U1459A–U1459C are combined by CSF-A.

Figure F28. Hydrocarbons in headspace gases, Site U1459.

Figure F29. Alkalinity, pH, and salinity, Site U1459. Dashed line at 120 m denotes depth at which many of the measured geochemical parameters exhibit a change in trend or slope.

Figure F30. Major element interstitial water geochemistry (bromide, calcium, chloride, magnesium, sulfate, potassium, sodium, phosphate, and ammonium), Site U1459. Dashed line at 120 m denotes depth at which many of the measured geochemical parameters exhibit a change in trend or slope.

Figure F31. Minor element interstitial water geochemistry (boron, barium, iron, lithium, strontium, and silicon), Site U1459. Horizontal dashed line at 68 m denotes depth at which many of the plotted geochemical parameters exhibit a change in trend or slope.

Figure F32. Bulk sediment geochemistry (calcium carbonate, TOC, and TN), Site U1459.

Figure F33. AF demagnetization results from archive-half SRM measurements at 3 depths, Hole U1459B. Orthogonal projections (Zijderveld diagram), equal area projections, and demagnetization behavior plots show NRM data measured after each demagnetization treatment. Equal area projection: solid circles = positive inclination, open circles = negative inclination. Orthogonal projection (Zijderveld diagram): solid squares = declination data with *x*- and *y*-axes corresponding to the four cardinal directions, open squares = inclination data with *y*-axis corresponding to up–down and *x*-axis corresponding to north–south. PCA analysis: Horizontal = declination (D), vertical = inclination (I), MAD = maximum angular deviation.

Figure F34. AF demagnetization results for discrete samples at 3 depths, Holes U1459B and Hole U1459A. Orthogonal projection (Zijderveld diagram) and equal area projection of NRM vector measured after each demagnetization treatment. Horizontal = declination, vertical = inclination. Equal area projection: solid circles = positive inclination, open circles = negative inclination. Normalized magnetization behavior plots show highest magnetization intensity (M_{max}) = 1 on *y*-axis with AF demagnetization strengths shown after each measurement on *x*-axis.

Figure F35. CLG analysis of IRM curve from one discrete sample (356-U1459A-2X-CC). LAP = linear acquisition plot, GAP = gradient acquisition plot, SAP = standardized acquisition plot.

Figure F36. Magnetostratigraphic data set, Hole U1459B. Magnetic inclination and intensity from AF demagnetization measurements of archive-half sections after background and tray correction with polarity interval correlations (black = normal, white = reversed, gray = unidentified).

Figure F37. Color reflectance ratios (L*, a*, and b*, see **Physical properties** in the Expedition 356 methods chapter [Gallagher et al., 2017] for definition), MS, and NGR results, Site U1459.

Figure F38. Bulk density, grain density, porosity, and *P*-wave velocity, Site U1459. Dots = WRMSL, squares = discrete samples.

Figure F39. Thermal conductivity, penetrometer, and shear strength results, Site U1459.

Figure F40. Hole U1459C diameter (caliper) and HSGR measured by triple combo; NGR from Hole U1459B whole-round cores; and elemental uranium, thorium, and potassium concentrations estimated from Hole U1459C HSGR spectra. gAPI = American Petroleum Institute gamma radiation units.

Figure F41. Hole U1459C diameter (caliper) and MS measured by triple combo, WRMSL MS (blue = Hole U1459A, black = Hole U1459B, red = Hole U1459C), and elemental potassium concentration estimated from Hole U1459C HSGR spectra.

Figure F42. Representative FMS images measured by FMS-sonic, reflecting variations in resistivity through the logged formations, Hole U1459C.

Figure F43. Hole U1459C diameter (caliper) measured by FMS-sonic and sonic velocities from Hole U1459B discrete measurements and Hole U1459C wireline.

Figure F44. Correlation between Holes U1459A and U1459B based on color reflectance b*. Dashed arrows = tie points between cores, black boxes = core recovery, gray boxes = shift required to create as complete a sequence as possible. Gaps in cores limit certainty in correlation; however, the suggested shift (small arrows) may yield continuous sampling. Refer to Table **T16** for a detailed table of correlative depths.

Figure F45. Hole U1459A summary with NGR and color reflectance b*. Age-depth model was produced from biostratigraphic datums (dashed lines =

uncertainties in datum positions) (see **Biostratigraphy and micropaleontology**). The actual depth of datums determined in core catchers may be as deep as the maximum advance of the core barrel during drilling of that core or as shallow as the top of the core. See Figure **F7** in the Expedition 356 methods chapter (Gallagher et al., 2017) for lithology key. BF = benthic foraminifer, PF = planktonic foraminifer, NN = calcareous nannofossil. IS = inner shelf, MS = middle shelf.

Figure F46. Hole U1459B summary with NGR and color reflectance b*. Age-depth model was produced from biostratigraphic datums (see **Biostratigraphy and micropaleontology**). See Figure **F7** in the Expedition 356 methods chapter (Gallagher et al., 2017) for lithology key. OS = outer shelf, UB = upper bathyal.

Figure F47. Hole U1459C summary with the HSGR wireline log (note the scale break in this plot). Age-depth model was produced from biostratigraphic datums (dashed lines = uncertainties in datum positions) (see **Biostratigraphy and micropaleontology**). The actual depth of datums determined in core catchers may be as deep as the distance the core barrel advanced while drilling that core or as shallow as the top of the core. See Figure **F7** in the Expedition 356 methods chapter (Gallagher et al., 2017) for lithology key.

Figure F48. Site U1459 summary with NGR and the HSGR wireline log. Gray bar = approximate pipe depth in Hole U1459C; note the resulting dampened signal of the gamma log in the upper 72 m WMSF. Age-depth model was produced from biostratigraphic datums based on calcareous nannofossils (black = Hole U1459B, blue = Hole U1459C) (see **Biostratigraphy and micropaleontology**). Sedimentation rates are shown for Holes U1459A–U1459C. Basal sedimentation rate for Hole U1459B is extended and calculated based on the uppermost datum in Hole U1459C. See Figure **F7** in the Expedition 356 methods chapter (Gallagher et al., 2017) for lithology key. Benthic foraminiferal assemblages were smoothed to generate this synthesis, resulting in slight differences from data presented in hole summaries.