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 U1461 and U1462. Bathymetric data are derived from the Geoscience Australia Australian bathymetry and topography grid, June 2009. The positions of multichannel seismic profiles are shown. Red circles = locations of preexisting industry wells.

Figure F3. Multichannel seismic profile across Site U1461. Top of green shading = inferred top of the Miocene. Fm = formation.

Figure F4. Lithostratigraphic summary, Holes U1461A–U1461D. See Figure **F7** in the Expedition 356 methods chapter (Gallagher et al., 2017) for lithology key.

Figure F5. Smear slide summary: composite record from Holes U1461C (0–443.88 m CSF-A), U1461B (443.88–877.64 m CSF-A), and U1461D (877.64–1088.92 m CSF-A). L* and natural gamma radiation (NGR): red = Hole U1461B, black = Hole U1461C, blue = Hole U1461D. See Figures **F6** and **F7** in the Expedition 356 methods chapter (Gallagher et al., 2017) for lithology, boundary, structure, and diagenesis keys. cps = counts per second.

Figure F6. Representative smear slide photomicrographs of each unit. A. Unit I: coarse bioclastic sediment with peloids (p) in a clay matrix with very fine grained micrite, diverse mollusk shell fragments (m), and benthic foraminifers (f) with accessory echinoid spine fragments (e) and sponge spicules (s) (356-U1461A-2F-2, 71 cm). B. Interval IIc1: coarse carbonate micrite with benthic foraminifers (f), poorly preserved shell fragments (m), and rare echinoid spine fragments (e); common accessories glauconite (g), chlorite (c), and quartz (q); and rare accessory euhedral dolomite rhombohedra (white arrow) (13H-5, 71 cm). C. Interval IIc2: peloid (p)-rich mudstone with foraminifers (f) as rare fossil accessories (17H-5, 71 cm). D. Unit III: dominant planktonic and benthic foraminifers (f) with well-preserved shell fragments (m) and rare echinoderm spines (e) in a micrite and clay mineral–rich matrix, with common accessories quartz (q) and glauconitized clasts (g) (356-U1461B-118X-3, 71 cm). E. Unit III: nannofossil-rich lower interval (356-U1461D-41R-6, 66 cm); plane-polarized light (PPL). F. Unit IV: large crystalline micrite (black arrows) sediment containing heavily cemented and sometimes glauconitized planktonic foraminifers (f), with silt-sized (<65 µm) quartz grains (q) as a rare accessory (60R-3, 120 cm).

Figure F7. Examples of (A) Subunits IIb and (B) IIc composed of unlithified cream mudstone with abundant macrofossils and peloids, Site U1461. Inset: examples of macrofossils (bivalves, gastropods, and echinoderms) and peloid-rich mudstone.

Figure F8. Representative thin section photomicrographs. A. Peloidal packstone with rare foraminifers (f) and a few bryozoan (br) and echinoderm (e) fragments; note thin concentric laminae indicating superficial ooids formed on peloid cores (arrows) (Interval IIb2; 356-U1461A-11F-3, 22–24 cm); cross-polarized light (XPL) (pore space appears black). B. Skeletal packstone with abundant planktonic and benthic foraminifers (f) and fragments of echinoderms (e), bryozoans (br), and bivalves (bi); rare (1%) silt-sized quartz (arrows) dispersed throughout the section (Interval IIc1; 13H-1, 24–26 cm); XPL. C. Wackestone with sand-sized bivalve (bi) fragments and foraminifers (f) (note large benthic foraminifer *Cibicidoides* spp. in lower right); moderate intraparticle porosity is partially filled with calcite spar cement; frequent peloids (arrows) occasionally coated with an opaque mineral; silt-sized quartz is scattered throughout the section (~1%) (Interval IId1; 356-U1461C-36F-5, 0–4 cm); XPL. D. Packstone to grainstone with peloids (arrows) and abundant foraminifers (f); note *Cibicidoides* (center); fine sand–sized quartz is scarce (Interval IId2; 356-U1461A-40F-1, 56–60 cm); XPL. E. Wackestone with scarce foraminifers, a single large benthic foraminifer *Amphistigena* (center), and rare quartz grains (Interval IIe1; 356-U1461B-50F-1, 17–20 cm). F. Wackestone with frequent benthic foraminifers *Cibicidoides* (c) and *Bolivina* (b); silt-sized quartz grains are rare (~1%); micrite is partially converted to microspar cement (Interval IIf1; 58F-1, 5–9 cm); XPL.

Figure F9. Boundary between Subunit IIc (unlithified cream mudstone) and Subunit IId (olive-green packstone), characterized by common bioturbation (356-U1461C-13H-5, 40–50 cm), abundant glauconite, macrofossils (13H-5, 60–90 cm), and cementation (13H-5, 90–100 cm). Bioturbation extends from 13H-4 through the upper 10 cm of 13H-6.

Figure F10. Thin section photomicrographs. A. Peloidal packstone with fine sand–sized peloids stained with opaque coatings (arrows) (Interval IIf2; 356-U1461D-3R-1, 58–62 cm). B. Skeletal packstone with abundant benthic and planktonic foraminifers (f) (including *Globigerinoides* and *Cibicidoides*) and bryozoan (br) and bivalve (bi) fragments; interparticle and intraparticle porosity is partially filled with sparitic cement (Unit III; 356-U1461B-82X-2, 18–22 cm); XPL. C. Skeletal grainstone with abundant planktonic (g) (e.g., *Globigerinoides*) and benthic (c) (*Cibicidoides*) foraminifers and a triserial agglutinated foraminifer (a); interparticle pores filled with clear spar cement and intraparticle pores filled with gray micrite (Unit III; 116X-7, 35–38 cm); PPL. D. Foraminiferal wackestone to packstone with sharp contact between *Globigerinoides* (g) packstone (top) and wackestone with rare planktonic foraminifers (bottom) (Unit III; 356-U1461D-56R-4, 65–67 cm); XPL. E. Finely laminated wackestone with curved boundary (arrows) between lower (benthic foraminifer rich) and upper (common planktonic foraminifers) wackestones; note dome-shaped cemented part (lower left) with colorless crystals characterized by high relief, poor cleavage, low-angle extinction, and second-order light blue interference colors (Unit III; 59R-1, 87–90 cm); XPL. F. Foraminiferal wackestone with subhorizontal bedding between fine-grained (bottom) and coarser grained (top) wackestones; planktonic foraminifers (e.g., *Globigerinoides*) are common (some foraminifer tests are broken) (Unit I; 60R-4, 44–47 cm).

Figure F11. Unit III, composed of lithified wackestone with common bioturbation, small benthic foraminifers, disseminated pyrite, and pyrite nodules (millimeter to centimeter scale), Hole U1461D. Unit III is also characterized by alternating olive-gray and light olive-gray intervals (1–2 m thick) and contains mud beds with subtle basal and top contacts and intraclasts suggestive of gravity flows (11R-2, 97–103 cm).

Figure F12. Unit IV mudstone and sand-sized grain beds with bioturbation, Hole U1461D. A. Sharp basal contact with bioturbated mud bed above normally graded sand bed (91–94 cm). B. Moderately bioturbated mud bed with wavy basal and top contacts (1–3 cm). C. Four mud beds with sharp, wavy, and bioturbated contacts (14–28 cm). D. Interbedded sand (1–2 cm thick) and mud (1–3 cm thick) beds. E. Massive homogeneous packstone with coarse sand–sized grains, coarse-grained sand beds, and clasts (9–11 cm). F. Coarse-grained sand bed with load cast and flame structures from mud bed below. G. Sand beds, 3–5 cm thick, within the massive packstone interval. H. Planar laminations within the coarse sand–grained packstone interval. I, J. *Zoophycos* isp. burrows common in Unit IV.

Figure F13. (A, H, I) PPL and (B–G) scanning electron microscope (SEM) photomicrographs of calcareous nannofossils from the upper 30 m of Holes U1461A and U1461C and deepest cored interval in Hole U1461D. A. Placoliths belonging to Noelaerhabdaceae (8.39 m CSF-A). B–C. Comparison of *Gephyrocapsa oceanica* and *Emiliania huxleyi*, Holes U1461C (8.39 m CSF-A) and U1461A (1.65 m CSF-A). D. Poorly preserved *E. huxleyi* specimen (17.65 m CSF-A). E. Matrix of micrometer-scale aragonite needles and *Gephyrocapsa* spp. (27.5 m CSF-A). F. Close-up of small *Gephyrocapsa* in micrometer-scale aragonite matrix (20.31 m CSF-A). G. Signs of overgrowth on *Calcidiscus leptoporus* (17.65 m CSF-A). H. (Reworked) *Triquetrorhabdulus carinatus* fragment (1023.8 m CSF-A). I. *Reticulofenestra pseudoumbilicus* in a matrix of micrite grains (bottom of Hole U1461D, 1088.8 m CSF-A).

Figure F14. PPL photomicrographs of calcareous nannofossils, Site U1461. A. *Gephyrocapsa oceanica*. B. *Gephyrocapsa caribbeanica*. C. *Gephyrocapsa omega*. D. *Pseudoemiliania lacunosa*. E. *Reticulofenestra asanoi*. F. *Gephyrocapsa* spp. (>5.5 µm). G. *Helicosphaera sellii*. H. *Helicosphaera carteri*. I, J. *Braarudosphaera bigelowii*. K. *Pontosphaera discopora*. L, M. *Calcidiscus macintyrei*. N. *Discoaster brouweri*. O. *Discoaster triradiatus*. P. *Discoaster pentaradiatus*. Q. *Discoaster surculus*. R. *Discoaster asymmetricus*. S. *Discoaster tamalis*. T. *Discoaster variabilis*. U. *Sphenolithus abies*. V. *Reticulofenestra pseudoumbilicus*. W. *Scyphosphaera apsteinii*. X. *Pontosphaera* sp. Y. *Ceratolithus cristatus*. Z. *Amaurolithus tricorniculatus*. AA. *Amaurolithus delicatus*. AB. *Amaurolithus primus*. AC. *Ceratolithus larrymayeri*. AD. Calcispheres (cysts of calcareous dinoflagellates; e.g., Young 1998).

Figure F15. Depth ranges of calcareous nannofossil age markers. Nannofossil preservation: poor (P) to very good (VG). Nannofossil abundance: few (F) to abundant (A). See **Biostratigraphy and micropaleontology** in the Expedition 356 methods chapter (Gallagher et al., 2017) for preservation and abundance definitions. A. Early to Late Pleistocene, as recorded between Holes U1461A, U1461B, and U1461C (upper 540 m CSF-A shown for Hole U1461B). Green bars = age-depth tie points and good correlation between holes. (Continued on next page.)

Figure F15 (continued). B. Early Pliocene to early Pleistocene, as recorded between Holes U1461B and U1461D between 600 and 1030 m CSF-A. Green bars = correlation between holes. The highest/lowest depth for each top/base event and its age is reported in Table **T6**.

Figure F16. Planktonic foraminifer abundance, Site U1461. 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 F17. SEM photomicrographs of typical preservation states of planktonic foraminifers, Site U1461. The depicted species is *Globigerinoides sacculifer* (or closely related to *G. sacculifer*). Samples deeper than 400 m CSF-A were ultrasonicated to remove secondary crystals. Depths are in CSF-A. Inset shows a magnification of a diagenetic overprint of inorganic calcite on the foraminiferal test.

Figure F18. Range of occurrence of planktonic foraminiferal marker species for the early Pleistocene–Pliocene interval, Holes U1461B and U1461D. Ages are based on published values (Table **T6**) (Gradstein et al., 2012).

Figure F19. SEM photomicrographs of planktonic foraminiferal age markers, Holes U1461A and U1461B. 1a, 1b. *Globorotalia tosaensis*. 2a, 2b. *Globorotalia truncatulinoides*. 3a, 3b. *Dentoglobigerina altispira*. 4a, 4b. *Globorotalia limbata*. 5a, 5b. *Sphaeroidinellopsis seminulina*. 6a, 6b. *Pulleniatina primalis*. 7a, 7b. *Globorotalia margaritae*. Depths are in CSF-A.

Figure F20. Optical and SEM photomicrographs of dominant benthic foraminiferal species and trends at Site U1461 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 **T8**. This figure is available in an **oversized format**.

Figure F21. Benthic foraminifer diversity (number of species) and benthic percentage of total foraminifers, Site U1461. Analyzed samples from Holes U1461A–U1461D are combined by CSF-A.

Figure F22. Hydrocarbons present in headspace gases, Site U1461. Methane, ethane, propane, and ratio of $C_1/(C_2 + C_3)$. Dashed line highlights a value of 1000, above which light hydrocarbons may derive from biogenic sources.

Figure F23. Alkalinity, pH, salinity, sodium, chloride, and sodium to chloride ratio, Site U1461.

Figure F24. Major constituents of interstitial water geochemistry (bromide, magnesium, calcium, sulfate, potassium, phosphate, and ammonium), Site U1461.

Figure F25. Minor element interstitial water geochemistry (boron, barium, iron, silicon, lithium, and strontium), Site U1461. Most iron concentrations in samples deeper than 300 m CSF-A were below detection level.

Figure F26. Bulk sediment geochemistry (calcium carbonate, TOC, and TN), Site U1461.

Figure F27. Magnetostratigraphic data set, Holes U1461B and U1461C. Magnetic inclination and intensity data from archive-half AF demagnetization measurements (20 mT AF demagnetization step) after background and tray correction with polarity interval correlations (black = normal, white = reversed, gray = unidentified). Measurements from the tops and bases of sections were omitted (see **Paleomagnetism** in the Expedition 356 methods chapter [Gallagher et al., 2017]). Hole U1461B is correlated with Hole U1461C.

Figure F28. Magnetostratigraphic data set, Hole U1461D. Magnetic inclination, declination, and intensity from archive-half AF demagnetization measurements (20 mT AF demagnetization step) after background and tray correction with polarity interval correlations (black = normal, white = reversed, gray = unidentified) and biostratigraphic datums (see **Biostratigraphy and micropaleontology**). Measurements from the tops and bases of sections were omitted (see **Paleomagnetism** in the Expedition 356 methods chapter [Gallagher et al., 2017]).

Figure F29. IRM acquisition curves for 8 discrete samples from Hole U1461B and their respective backfield IRM curves. Inset shows enlarged view of negative *x*-axis, showing the coercivity of remanence estimation for each sample.

Figure F30. AF demagnetization results for 3 discrete samples from different depths, Hole U1461C. Orthogonal projection (Zijderveld diagram) and equal area projection of NRM vector measured after each demagnetization treatment. Horizontal = declination (D), vertical = inclination (I). 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 F31. WRMSL MS, drift-corrected SHMSL MSP, and NGR results, Site U1461.

Figure F32. MS results, Site U1461. A. WRMSL MS. B. SHMSL MSP. C. Drift-corrected SHMSL MSP. D. Hole U1461B MS. E–G. Expanded views of Hole U1461B WRMSL MS, raw SHMSL MSP, and drift-corrected SHMSL MSP.

Figure F33. *P*-wave velocity, penetrometer, and shear strength results, Site U1461. Black = Hole U1461A, red = Hole U1461B, blue = Hole U1461C, green = Hole U1461D.

Figure F34. Bulk density (dots = GRA, squares = MAD), grain density, and porosity, Site U1461. Grain density and porosity: black = Hole U1461A, red = Hole U1461B, blue = Hole U1461C, green = Hole U1461D.

Figure F35. Reflectance spectroscopy and colorimetry (L*, a*, and b*), Site U1461.

Figure F36. A. APCT-3 in situ temperatures, Holes U1461B and U1461C. B. Thermal conductivity (*k*) measured on Hole U1460A (black), U1461B (red), and U1461C (blue) cores and used in heat flow calculation. C. Thermal resistance (Ω) vs. temperature (*T*) (Bullard plot). D. Thermal conductivity from B with Hole U1461D (green) showing entire cored section. For B and D, only data with standard deviations <0.1 W/(m·K) are shown; standard deviation between individual measurements on same sample indicated by width of symbol.

Figure F37. Hole U1461D diameter (caliper) and HSGR measured by triple combo, NGR from Hole U1461B–U1461D whole-round cores, and elemental uranium, thorium, and potassium concentrations estimated from Hole U1461D HSGR spectra.

Figure F38. Hole U1461D diameter (caliper) and magnetic susceptibility measured by triple combo, Hole U1459B–U1461D SHMSL MSP, and elemental potassium concentration estimated from Hole U1461D HSGR spectra.

Figure F39. Hole U1461D diameter (caliper) measured by triple combo and bulk density, porosity, and mud resistivity (lines = Hole U1461D wireline, squares = Site U1461 discrete samples).

Figure F40. Hole U1461D diameter (caliper) measured by FMS-sonic caliper and sonic velocities from Site U1461 discrete sample measurements and Hole U1461D wireline.

Figure F41. NGR data for the continuous splice interval in Holes U1461A–U1461C together with the final splice record. Gray boxes = intervals used to construct the splice with core numbers noted, dashed vertical lines = intervals where tie points should be treated with caution (see text for details). A. 0–50 m CCSF-A. (Continued on next two pages.)

Figure F41 (continued). B. 50–100 m CCSF-A. Red dashed line = interval that interrupted the continuous splice; interval is characterized by coral and other gravelly rubble and yielded limited recovery in both Holes U1461A and U1461B. C. 100–150 m CCSF-A. (Continued on next page.)

Figure F41 (continued). D 150–200 m CCSF-A. E. 200–280 m CCSF-A.

Figure F42. Drilling to recover coring gaps, Holes U1461B–U1461D. Hole U1461B red and yellow = gaps in coring, Hole U1461C and U1461D red = gaps targeted for recovery, Hole U1461D yellow = gaps present in Hole U1461B and their positions in Hole U1461D.

Figure F43. Correlation between Holes U1461A, U1461B, and U1461C from 0 to 240 m CCSF-A (composite depth scale produced by correlating holes) as determined using Microsoft Excel to shift core sections, based on NGR data. Core numbers are shown. Level of certainty in the correlation: green = high confidence, red = low confidence.

Figure F44. Cores used to develop correlations between Holes U1461A, U1461B, and U1461C from 0 to 280 m CSF-A. Green arrows = strong correlation, red arrows = uncertain correlation. Arrows are placed relative to the core number and do not indicate exact depth of correlation. Intervals of strong (green bar) and weak (gray bar) correlation are also shown.

Figure F45. Correlation between Holes U1461A, U1461B, and U1461C from 240 to 340 m CCSF-A (composite depth scaled produced by correlating holes) as determined using Microsoft Excel to shift core sections, based on NGR data. Core numbers are shown. NGR values for Holes U1461B and U1461C were increased by 10 and 20 counts/s, respectively, for plotting purposes.

Figure F46. Comparison between NGR measured on Hole U1461B and U1461C cores with Hole U1461D wireline gamma log (HSGR). Note the two different depth scales (CSF-A for NGR and WMSF for HSGR). Solid lines = strong correlation points between Holes U1461B, U1461C, and U1461D with wireline data, dashed lines = weaker tie points, gray boxes = correlative interval of the wireline data. Core numbers are adjacent to the NGR data for reference. gAPI = American Petroleum Institute gamma radiation units. A. 200–400 m CSF-A. B. 400–600 m CSF-A. (Continued on next page.)

Figure F46 (continued). C. 600–800 m CSF-A. D. 800–1000 m CSF-A.

Figure F47. Hole U1461A summary showing core recovery, graphic lithology, lithostratigraphic units, age, and biostratigraphic data plotted against NGR and color reflectance b*. Biostratigraphic zone boundary ages are shown. Age-depth model was produced from biostratigraphic datums only (see **Biostratigraphy and micropaleontology**) and assumes a linear sedimentation rate between datums. See Figure **F7** in the Expedition 356 methods chapter (Gallagher et al., 2017) for lithology key. BF = benthic foraminifer, NN = calcareous nannofossil. IS = inner shelf.

Figure F48. Hole U1461B summary showing core recovery, graphic lithology, lithostratigraphic units, age, and biostratigraphic data plotted against NGR and color reflectance b*. Biostratigraphic zone boundary ages are shown. Age-depth model was produced from biostratigraphic datums only (see **Biostratigraphy and micropaleontology**) and assumes a linear sedimentation rate between datums. Sedimentation rates are calculated separately for calcareous nannofossils (green, solid circles) and planktonic foraminifers (blue, open circles) where the datums diverge. See Figure **F7** in the Expedition 356 methods chapter (Gallagher et al., 2017) for lithology key. PF = planktonic foraminifer. MS = middle shelf, OS = outer shelf, UB = upper bathyal.

Figure F49. Hole U1461C summary showing core recovery, graphic lithology, lithostratigraphic units, age, and magnetostratigraphic and biostratigraphic data plotted against NGR and color reflectance b*. Biostratigraphic zone boundary ages are shown. Age-depth model was produced from biostratigraphic and magnetostratigraphic data (see **Biostratigraphy and micropaleontology** and **Paleomagnetism**) and assumes a linear sedimentation rate between datums: circles = calcareous nannofossil datums, squares = paleomagnetic datums. See Figure **F7** in the Expedition 356 methods chapter (Gallagher et al., 2017) for lithology key. No samples were analyzed for benthic foraminifers shallower than ~380 m CSF-A.

Figure F50. Hole U1461D summary showing core recovery, graphic lithology, lithostratigraphic units, age, and magnetostratigraphic and biostratigraphic data plotted against NGR and color reflectance b*. Biostratigraphic zone boundary ages are shown. Age-depth model was produced from biostratigraphic and magnetostratigraphic datums (see **Biostratigraphy and micropaleontology** and **Paleomagnetism**): solid circles = calcareous nannofossils, open circles = planktonic foraminifers, squares = paleomagnetic datums. Sedimentation rates assume a linear sedimentation rate between datums. The position of the unconformity (red) in the Miocene is determined by the lithologic change in 51R-CC. See Figure **F7** in the Expedition 356 methods chapter (Gallagher et al., 2017) for lithology key.

Figure F51. Site U1461 summary showing core recovery, graphic lithology, lithostratigraphic units, age, magnetostratigraphy, biostratigraphy, NGR, and Hole U1461D wireline HSGR. Biostratigraphic zone boundary ages are shown. Age-depth model was produced from select biostratigraphic datums (see Table **T6**) color coded by hole (closed circles = calcareous nannofossils, open circles = planktonic foraminifers). Sedimentation rates assume a linear sedimentation rate between datums. Position of the unconformity (wavy line) in the Miocene is determined by the lithologic change in 356-U1461D-51R-CC. Benthic foraminiferal assemblages were smoothed to generate this synthesis, resulting in slight differences from data presented in hole summaries.