KOINON

The NORI-D Reserve

Four findings on the resource and reserve estimates behind TMC USA's consolidated application to NOAA

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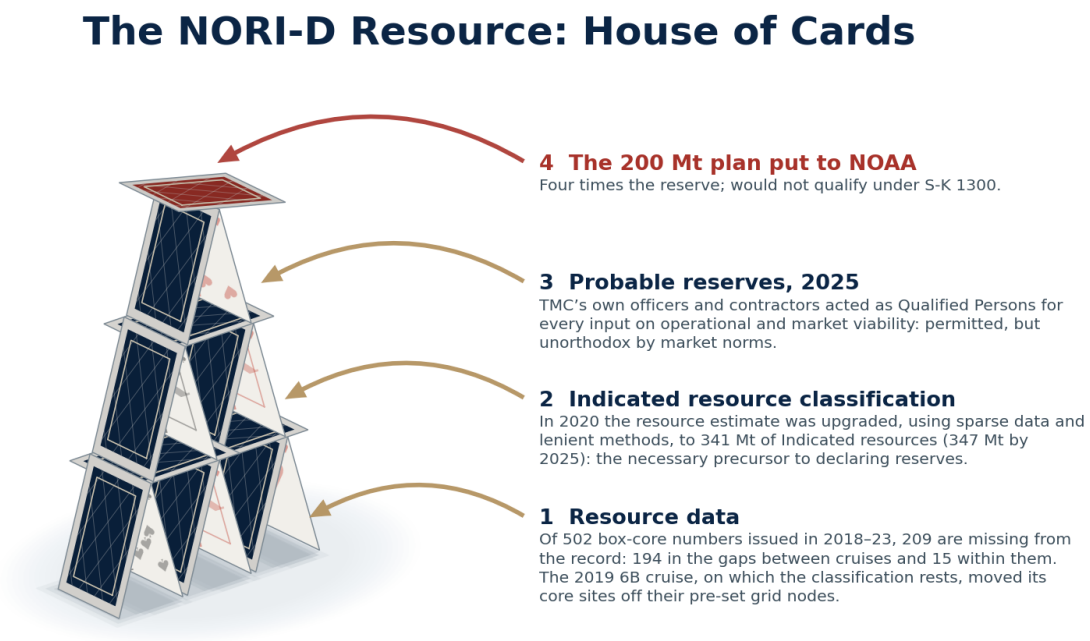
Prepared for the Natural Resources Defense Council, in connection with its comment on NOAA docket NOAA-NOS-2026-1751



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1. Purpose and status

This note examines the tonnage that TMC USA asks NOAA to license, from the box cores on which it rests to the twenty-year schedule it is meant to support, and reaches four findings. It is written to support the feasibility sections of NRDC's comment under 15 CFR 971.214(d), and it confines itself to what the applicant's own documents say and to computations that anyone can repeat from the tables printed in them.[1]

Each finding is stated in section 2 and argued in its own section (3 to 6), with the figures and tables that bear on it. Background is in the appendices. Footnotes carry the citations and the arithmetic.

Where a Koinon computation is reported, its method and accuracy are given in Appendix E. The computations are offered as tests of the record, not as findings about anyone's conduct.[2]

Three earlier critiques of the PFS are drawn on where they bear on the findings. Steven H. Emerman's report for the Deep Sea Mining Campaign, Greenpeace International and MiningWatch Canada (February 2026) examines the PFS against SEC and comparable rules, with particular attention to the use of resources beyond the reserve in the economic case and to the independence of its authors. Iceberg Research, a short-seller, published its reading of the PFS a fortnight after its release (18 August 2025) and was the first to note that the resource cut-off rests on second-generation equipment costs and that the economic case rests on resources as well as reserves. Barnard and Trytten's techno-economic assessment for the National Ocean Protection Coalition (August 2025) makes the same two points from a mining-engineering standpoint. None of the three examines the box-core sampling, the variogram or the classification, which are the subject of Findings 1 and 2; they are quoted in Findings 3 and 4.[3]

2. Summary of findings

Polymetallic nodules abound in the NORI-D licence area. But presence and abundance alone do not amount to resource and reserve estimates that meet mining industry and investment norms.

Preliminary analysis of the data put forward by The Metals Company in its application to NOAA highlights four areas of uncertainty: whether the box cores on which the resource rests are a complete and fair record of the ground, given that failed landings in 2019 went unrecorded and the following cruise moved most of its sites; whether the confidence claimed for the whole block rests on the data or on the choice of test; whether the reserve is anything more than a resource with the operator's own assumptions attached; and how a twenty-year schedule four times the size of the reserve can be licensed on the S-K 1300 standard the applicant itself invokes.

[1]The three documents are: the Prefeasibility Study (PFS), "Technical Report Summary of Prefeasibility Study of NORI Area D, Clarion Clipperton Zone", AMC Consultants Pty Ltd, report date 30 July 2025, effective 4 August 2025, TMC Form 10-Q Exhibit 96.1; the Initial Assessment (IA), "Technical Report Summary, Initial Assessment of TOML and NORI Properties", same firm and dates, Exhibit 96.2; and the Application, TMC USA's consolidated application for an exploration licence and commercial recovery permit for TMC USA-A, published by NOAA on 19 August 2026 as NOAA-NOS-2026-1751-0002 (503 pages, partly redacted). Section and table references are to these.

[2]The pre-cruise sampling plans, the Bluefield cruise reports, the AUV track files and the 2012 backscatter grid are not public. Section 7 lists them as documents NOAA could require.

[3]Emerman, S.H., Implications of The Metals Company Pre-Feasibility Study for Next Steps by the Company, Malach Consulting, submitted 21 January 2026, revised 22 and 25 February 2026, 88 pp. Iceberg Research, The Pre-feasibility Study Assumptions Confirm that TMC's Economics don't Work, 18 August 2025. Barnard, M. and Trytten, L., A techno-economic assessment of seabed mining — American Samoa and global implications, National Ocean Protection Coalition, August 2025. Iceberg Research holds a short position in TMC and says so; its observations are used here only where they can be checked against the PFS text.

Finding	What the record shows	Consequence
1. Resource sampling record incomplete	Campaign 6A, the first 2019 cruise, attempted 121 core landings and numbered 106, of which 105 are reported (BC_106 is missing without explanation); the 15 that came up empty or nearly so are not in the data. The PFS states that the second cruise (6B) then moved its sites away from that kind of ground, and 70% of its 101 cores lie more than 100 m off the planned lattice, 36 of them by more than 500 m. Koinon's tests for directed placement are inconclusive at the resolution of the public data.	A lattice gives an unbiased tonnage only if every node is recorded. Whether the core set is a fair sample of the ground counted in the resource cannot be checked until the failure positions, drop logs and sampling plans are produced.
2. Resource classification at the lenient end	AMC raised Indicated from 34 Mt in its 2018 estimate to 341 Mt in 2020 by adding cores at 10 km, wider than the 7 km spacing that had earned Indicated before. The result rests on AMC's choice of test, one year's production over 400 km², and on a 140 km regional trend; short-range continuity was measured at two to three sites of one ground type. Common methods that Koinon judges reasonable give 4–62 Mt Indicated.	Within the latitude the codes allow, but at its lenient end. On reasonable alternatives Indicated and Inferred change places: the block total is unaffected; the reserve base is not.
3. Reserve volume and classification insecure	AMC certifies the resource model and the reserve geometry. Every modifying factor — pick-up, recovery, speed, cost, economics — is signed by TMC officers, several resting on Allseas simulations and assumptions, measured on the flattest ground, with no cut-off and no dilution term. AMC records the collector as not finalised and its performance as not determined. Fine mapping supports about 3 Mt of the 51.	The 51 Mt Probable reserve is an Indicated resource with a mine plan attached, and the reserve QP says as much.
4. Production plan would not qualify under S-K 1300	The application schedules 202.5 Mt over twenty years on 51 Mt of reserve, justified by a 46% "production conversion factor" applied to unconverted resource and 40 Mt from a block with no resource estimate. Before the SEC that case could appear only as a cautioned Initial Assessment.	The applicant borrows S-K 1300 for its inputs and abandons it at the output. NOAA is free to hold it to the standard it chose: 51 Mt, exhausted in 2034, the seventh year of collection.

That the resource tonnage might approach TMC's estimate of 363 Mt, as an order of magnitude, is not the focus of analysis. The argument is chiefly about the sampling record, classification, conversion and operability, not about whether the nodules exist.

3. Finding 1 — Resource sampling record incomplete

Claim. The resource estimate rests on 273 pre-mining box cores from four cruises. The record of those cores is incomplete in a way the PFS itself discloses: in 2019 the first cruise (6A) numbered 106 of 121 landings and reported 105, the failures being on poor ground, and the second cruise (6B) moved its sites away from such ground. A lattice estimates the mean without bias only if every node is recorded. Whether the omissions bias the tonnage depends on whether the avoided ground is also left out of the resource, and the public record does not allow that to be checked.

3.1 The four cruises

The PFS prints the coordinates and the wet nodule weight of every core, which allows the sampling to be mapped and tested independently; Koinon has extracted them, with their table and page references,

into the accompanying workbook.[4] The four cruises agree on the mean and differ on the spread: 6B has the lowest mean and the widest distribution.

Campaign	Vessel and contractor	n	Mean	SD	CoV	Cores <4	Cores <12	Cores >25
2018 C3	Maersk Launcher; Fugro	45	17.8	5.7	0.32	1	7	4
2019 6A	Maersk Launcher; Leap, Bluefield	105	18.2	4.5	0.25	1	6	5
2019 6B	Maersk Launcher; Leap, Bluefield	101	16.9	6.1	0.36	5	19	9
2022 7A (test site)	Hidden Gem; Allseas	22	17.4	3.5	0.20	0	0	1
All pre-mining		273	17.5	5.3	0.30	7	32	19

Table 1. Abundance per core by cruise, wet kg/m², from the PFS coordinate tables. Koinon's split of the 2019 cores by cruise follows the campaign identifiers in those tables.

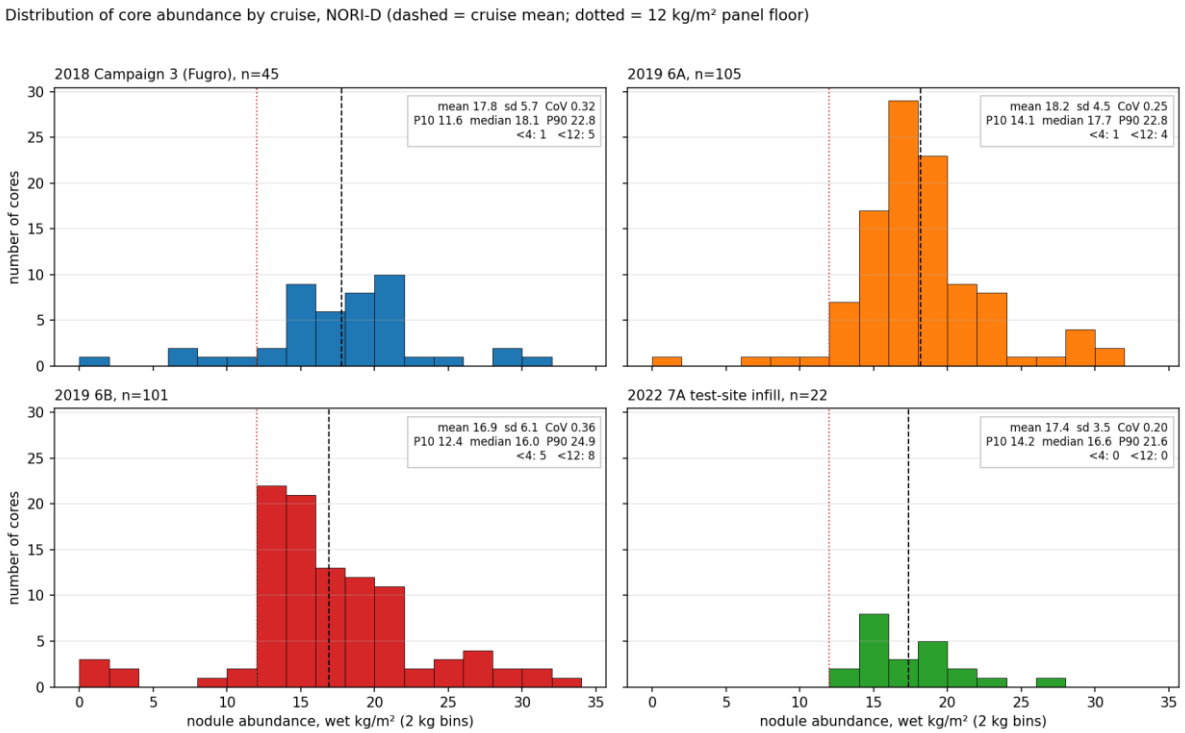


Figure 1. Distribution of core abundance by cruise. The 2018 and 6A histograms are compact; 6B carries both more near-empty cores and more of the richest.

3.2 Do the cores sit on their lattices?

For each cruise Koinon fitted the best rotated square lattice by least squares and measured each core's departure from its nearest node.[5] The results separate the cruises sharply.

[4]PFS Table 7.3 (p.90, Campaign 3), Table 7.4 (pp.107–123, Campaign 6), Table 7.5 (p.124, Campaign 7A), Table 7.6 (p.126, Campaign 7B); UTM zone 11N. Workbook: NORI-D_box_cores_lattice_analysis.xlsx, sheets Cores, Lattice_Fits, Departures, Summary. 287 cores are tabulated for NORI-D in PFS Tables 7.3–7.6: 273 pre-mining samples usable for abundance and 14, taken in 2022 after the test collector had passed, which record what it left behind. Six further cores from Campaign 8A (Table 7.8) are not used here. Together the cores sample about 216 m² of a 25,200 km² block, one core per 87 km².

[5]Orientation, spacing and origin were allowed to float; the fit was run from a grid of starting orientations by Nelder–Mead. Random points over the same extent fit no better than 2–3 km RMS. RMS, root mean square, is the typical size of the departures, weighting large ones more heavily; the median is the middle value. Method in Appendix E.

Cruise	Best-fit lattice	Median departure	RMS	Within 100 m	Within 300 m	Beyond 500 m	Largest
2018 C3	6.96 km, az. 76°	18 m	19 m	45 of 45	45	0	37 m
2019 6A	9.85 km, az. 31°	56 m	526 m	97 of 105	100	3	5.1 km
2019 6B	9.84 km, az. 31°	294 m	705 m	31 of 101	51	36	2.0 km

Table 2. Departure of each core from its nearest lattice node. The two 2019 cruises were planned on the same 10 km lattice; the 2018 cruise on a 7 km lattice.

The 2018 cruise landed every core within 37 m of its node, which is the USBL positioning tolerance TMC describes.[6] In mid-2019 Campaign 6A, on the same ship with the same corer and contractors, sits on its lattice to a median of 56 m. Campaign 6B, six weeks later with the same ship, corer, positioning system and contractors, placed seven in ten of its cores more than 100 m from a node, 36 of them by more than 500 m and up to 2 km, and none within 50 m. The displaced points cluster near nodes rather than at half-nodes, so this is not an infill pattern, and the 6A precision shows it is not equipment imprecision. The PFS gives the reason in its account of the geological model: during 6A, 15 landings recovered nothing or very little, on hardground associated with slopes of 6° or more, and 6B sites were then "selected to avoid areas within 150 m of slopes ≥ 6°", using interpretations of the 2018 AUV sonar and camera data, after which failures fell to seven.[7]

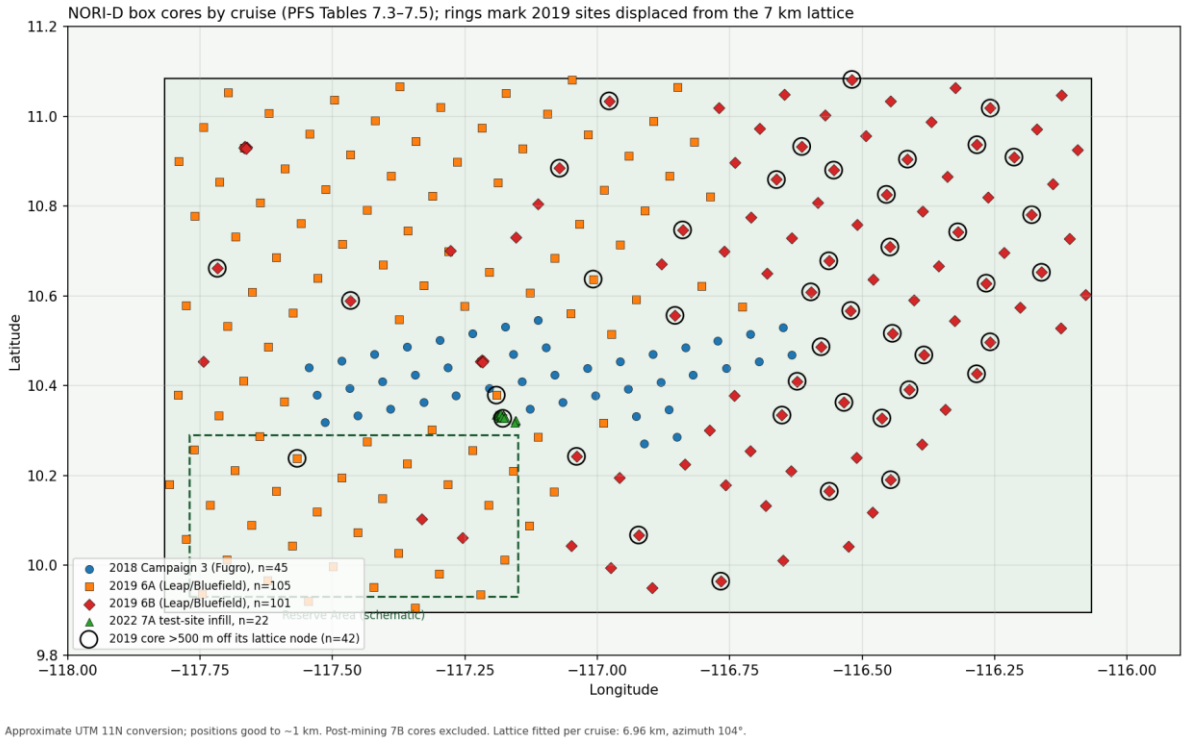


Figure 2. Cores by cruise; rings mark 2019 sites more than 500 m from their lattice node.

3.3 Why it matters for the tonnage

The reason matters more than the displacement, because of how much rests on 6B: it is the nearest cruise for about 45% of the sampled area of NORI-D and about 42% of its abundance-weighted

[6] PFS s.7.2.4 states that the 2018 grid was designed before mobilisation, without reference to the geophysical data, "to avoid any bias", and that each drop was landed within a 35 m target circle. That is an attestation; the plan itself is not published.

[7] The 6B cores are concentrated in the east and north of the block, on ground that enters the mine plan after about year eight (Figure 2). Only two of the nineteen 6B cores inside the reserve polygon are displaced.

resource.[8] A box core that lands on hardground and comes up empty is a correct measurement of poor ground. In 6A such landings were not given core numbers: 121 landings were attempted and 106 numbered (BC_046 to BC_151; BC_106 is absent from Table 7.4), and only one of the 105 6A cores in PFS Table 7.4 reads below 4 kg/m², against five of 101 in 6B; were 6A's true rate the same as 6B's, a result that low would arise by chance about 3% of the time. The PFS describes omitted samples only as "disturbed samples, considered to be unreliable" (s.7.3.5). Leaving poor ground out of the sample is defensible only if it is also left out of the resource. The PFS excludes slopes of 6° or more, but keeps hardground on gentler slopes inside it (the "AH (hard)" domain, 2.7% of the area). If the 15 failed 6A landings had been recorded at near zero, the 6A mean would fall from 18.2 to about 16 kg/m², below 6B, and the four cruises would no longer agree on the mean. Koinon does not claim that is the right correction; the point is that the effect is material and cannot be checked from the published record, while the documents that would settle it exist and have not been produced.[9]

Figure 2b sets out the whole sampling record in sequence, cruise by cruise, against the dates of the resource estimates. Of 502 box-core numbers issued from 2018 to 2023, 293 cores are reported and 209 numbers are missing: 194 in the gaps between cruises' number ranges and 15 within them. The PFS gives some explanation for six of the 209. The 159 earlier Pioneer samples carry no box-core numbers and are excluded from the estimate.

[8]Voronoi partition of the convex hull of the cores (21,200 km²) by nearest core; shares by area C3 11%, 6A 44%, 6B 45%, 7A under 1%. Weighted by the abundance of the nearest core: C3 11%, 6A 46%, 6B 42%. Inside the reserve polygon the shares are C3 26%, 6A 33%, 6B 40%, 2022 1%, but only two of the 6B cores there are displaced.

[9]The pre-cruise sampling plans with planned coordinates, to set against the "actual location" columns of PFS Tables 7.5–7.6, and the Bluefield factual reports MAE001-FAC-01 and -02 with their drop logs, which would also show whether any drop yielded no tabulated sample. A 10 km lattice over NORI-D has roughly 260 nodes and the 2019 cruises cored 206 of them; the PFS does not say which nodes were omitted or why.

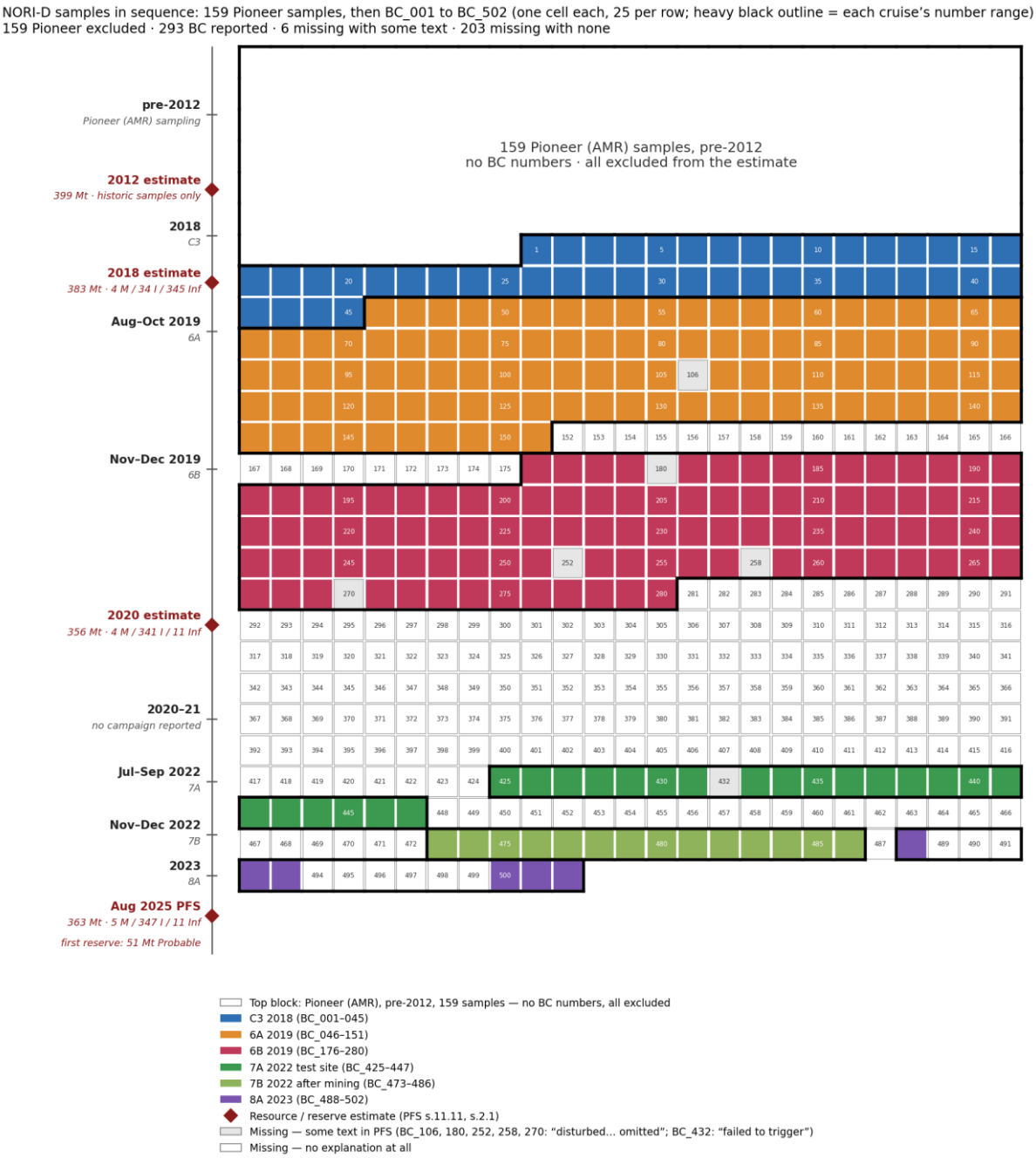


Figure 2b. NORI-D samples in sequence: 159 Pioneer samples, then BC_001 to BC_502, one cell each, 25 to a row; heavy outlines mark each cruise's number range. Coloured cells are reported cores; grey cells are missing numbers for which the PFS gives some explanation, white cells missing numbers with none. Diamonds mark the resource and reserve estimates. Koinon compilation from PFS Tables 7.3–7.6 and s.11.11.

6B's re-siting adds to the question rather than answering it. None of its 36 sites more than 500 m from their node lies within the 2018 survey area, so the 2018 AUV imagery cannot have guided them at sea; the off-node landings come in spells rather than at random through the cruise (30 runs of on-node and off-node cores where chance gives about 44, $p \approx 0.001$), which fits sites planned against the terrain before sailing; and twelve lattice nodes that 6A left empty were later cored by 6B. Which nodes were moved, and from what, is in the sampling plans and drop logs.

Figure 2c follows the cruise in the order of PFS Table 7.4, on the assumption that the table lists the cores as they were taken. The first nineteen drops are all off node; by chance that would happen about once in 2,500 cruises at the start, or once in 75 for a run of nineteen anywhere in the cruise. Twelve of the first fifteen drops were at nodes 6A had left empty within its own ground. After drop 63, at the

eastern edge of the block, the order crosses about 170 km to the north-west corner and then 70 km to the centre, to take two clusters of four cores around earlier rich cores: 6A's BC_089 (30.2 kg/m²) and the 2018 core BC_004 (23.4). The clusters average 30.0 and 22.5 kg/m², against 16.1 for the rest of the cruise, and they supply the 20 cluster pairs of section 4.2.

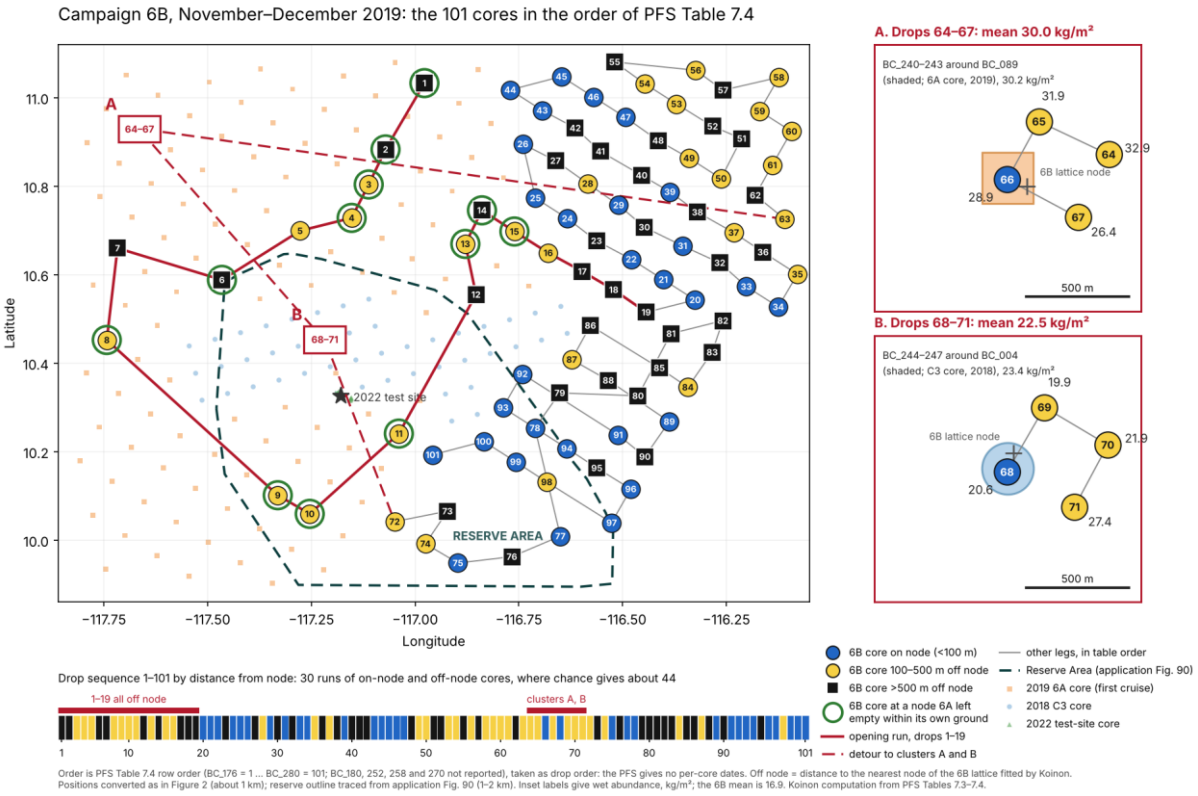


Figure 2c. Campaign 6B in the order of PFS Table 7.4, taken as drop order. Red: the opening run and the detour to clusters A and B, shown at true scale in the insets. Green rings: nodes 6A left empty within its own ground. The strip gives the whole sequence by distance from node. Koinon computation from PFS Tables 7.3–7.4.

One further observation runs the other way and belongs in the record. Across 45 cores on an exact 7 km lattice in 2018, and 100 more on an exact 10 km lattice in 6A, the readings fall in a band of roughly 10 to 25 kg/m² with only two near-empty cores. Had the seabed been a mosaic of nodule fields and bare mud at scales below the grid, a lattice placed without reference to the ground would have hit the mud a good deal more often. The exactness of those two cruises is therefore evidence for continuity of presence, if not of abundance.[10]

3.4 Tests of directed placement

Koinon tested whether the displaced 6B cores moved towards brighter backscatter, using the only backscatter map in the public record (PFS Figure 7.2, about 340 m per pixel against TMC's 30 m grid). The displaced cores sit on slightly brighter ground than their surroundings (mean rank 0.60, $p \approx 0.04$), but so do the 6B cores that stayed on their nodes (0.59), and the effect weakens once nodes on volcanic cones are excluded. Shifting each cruise's whole lattice at random within one grid cell found no cruise placed on brighter ground than chance. Nor do the cores show selection for richness: those moved more than 500 m average 16.4 kg/m², those kept on node 16.9.

[10]The seven cores below 4 kg/m² are 2.6% of the 273. On the 2018 and 6A lattices the count is two of 150. The argument bears on presence; a moderate-amplitude variation at sub-grid scale, of the kind the variogram itself describes, is not excluded by it.

But these results are inconclusive rather than negative; the 30 m backscatter grid TMC has is approximately 50 times more granular than data published, and the 6B drop logs would settle them. Methods are in Appendix F.

4. Finding 2 — Resource classification at the lenient end

Claim. AMC classifies 347 of the 363 Mt as Indicated in the 2025 estimate, on cores spaced 7–10 km apart. In its 2018 estimate, with cores at 7 km over a small central area, it classified 34 Mt as Indicated and 345 Mt as Inferred; in 2020, after the 2019 cruises added cores at 10 km across the rest of the block, Indicated rose to 341 Mt. The classification rests on AMC's choice of test and of the volume it is applied to, and on a broad regional trend, not on continuity measured at the sample spacing. On common methods that Koinon judges reasonable, Indicated falls to between 4 and 62 Mt.

The significance is structural. Under S-K 1300 only Measured and Indicated resource can be converted to reserve, so a large Indicated base is the first step of a two-step manoeuvre: classify the block Indicated, then convert a sub-set of it to Probable reserve and cite the reserve in support of the permit. Finding 3 concerns the second step; this finding concerns the first, without which the second cannot be taken. Figure 3 shows at one scale the ground on which the classification actually rests.

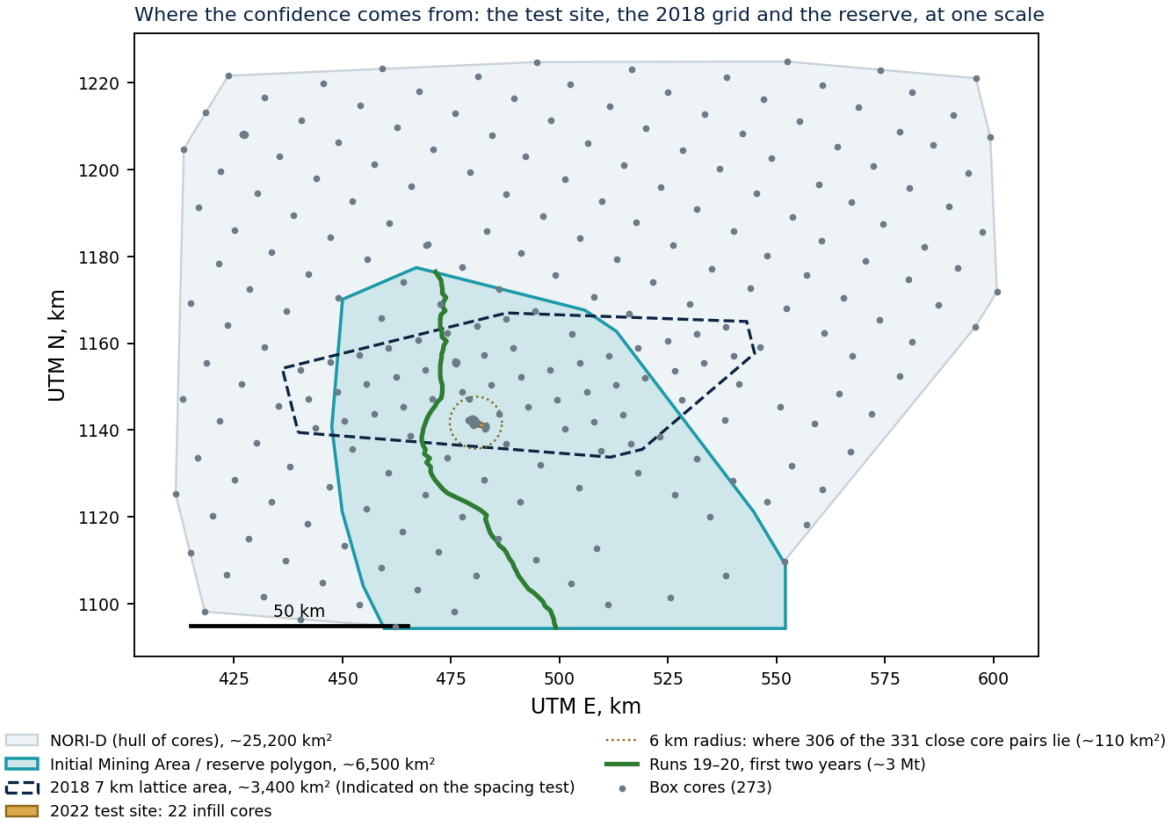


Figure 3. The 2022 test site, the 6 km radius around it within which nearly all the close core pairs lie, the 2018 lattice area, the reserve polygon and the first production strip, drawn at one scale over the cores.

4.1 How the estimate is made

The resource was estimated by simple kriging. Estimation points were laid across NORI-D at 500 m spacing, about 100,000 of them over the block; at each, abundance was computed as a weighted average of the surrounding cores, the weights derived from a variogram that describes how quickly two samples stop resembling each other as the distance between them grows. The points are not data; they are the places at which the estimate is evaluated, and the PFS does not publish them, only the panel

map and the classified totals. The point estimates were then averaged, 49 at a time, into 3.5 km panels of about 12 km², about an eighth of the 100 km² block AMC uses for a quarter's production, and the PFS reports that no panel falls below 12 kg/m².[11]

In brief, kriging estimates abundance where no core was taken by forming a weighted average of the surrounding cores. Near cores receive large weights and distant ones small weights, and two cores close together share a weight because they carry much the same information. How fast the weight falls with distance is set by the variogram, which is fitted from the cores themselves. Where cores lie within the variogram's range the estimate leans on the nearest of them; where none does, every neighbour receives a small, nearly equal weight and the estimate reverts towards the mean. A worked example on real cores is in Appendix D.

4.2 What the variogram is fitted from

A variogram is built from pairs of cores. For every pair the half-squared difference in abundance is computed and the pairs are binned by the distance between them; the curve through the bins is the variogram, and the distance at which it levels off is the range. What matters for classification is the curve at distances below the grid spacing, because it is that part which says whether a core 7–10 km away tells you anything about the ground in between. Table 3 counts the pairs available to fit it from all 273 pre-mining cores, as used in the 2025 PFS. Table 3a counts the pairs available in 2020, from the 251 cores of 2018 and 2019, for the estimate that first classified most of the block as Indicated.[12]

Separation, km	Pairs	Involving a test-site core	Grid-only pairs	Semivariance, (kg/m²)²
0–1	131	110	21	11.0
1–2	70	69	1	11.4
2–3	35	34	1	14.1
3–4	55	55	0	8.7
4–5	18	18	0	9.4
5–6	22	20	2	14.1
6–7	114	18	96	27.6
7–8	27	17	10	38.6
8–9	43	11	32	12.3
9–10	382	35	347	25.2
10–12	116	43	73	38.9
12–20	1,336	348	988	27.1
20–50	8,856	1,648	7,208	25.5
over 50	25,909	3,327	22,582	28.9

Table 3. Core pairs by separation. "Test-site core" means one of the 22 infill cores of 2022. The variance of all 273 readings is 27.7; the semivariance reaches that plateau at about 6 km. Koinon's computation from the PFS coordinate tables. The PFS variogram also draws on photo-based abundance estimates and laboratory duplicates, which are not counted here.

Separation, km	Pairs	Involving a 6B cluster core	Semivariance, (kg/m²)²
0–1	21	20	7.5

[11] PFS s.11.7–11.9 and Figure 11.29; tonnage-weighted mean 17.4 kg/m². 25,200 km² at 0.25 km² per point is about 100,000 points.

[12] 273 pre-mining cores give 37,128 pairs. The PFS (Table 11.6) fits a nugget of 10%, a first range of 6 km along the 075° trend and 3 km across it, and a longer second structure, and states (s.11.9) that 70% of the variance occurs within 3 km.

Separation, km	Pairs	Involving a 6B cluster core	Semivariance, (kg/m²)²
1–2	1	0	2.6
2–3	1	0	0.0
3–4	0	0	–
4–5	0	0	–
5–6	2	0	12.8
6–7	96	11	31.4
7–8	10	5	80.0
8–9	32	3	10.0
9–10	347	25	25.1
10–12	73	8	39.7
12–20	988	74	27.1
20–50	7,208	426	27.3
over 50	22,596	1,400	30.0

Table 3a. Core pairs by separation using only the 251 cores of 2018 and 2019, the data available for the 2020 estimate. Below 6 km there are 25 pairs, 20 of them involving the eight cores of the two 6B clusters; between 1 and 6 km there are four. The variance of all 251 readings is 29.1. Koinon's computation from the PFS coordinate tables.

On the data available in 2020, the 251 cores of 2018 and 2019, there are 25 pairs below 6 km: 21 below 1 km, 20 of them from the two 6B clusters, and four between 1 and 6 km (Table 3a). By 2025 there are 331 pairs below 6 km, and 306 of them involve at least one of the 22 infill cores taken at the test site in 2022, before test mining, when Allseas sampled the ground it was about to traverse at a few hundred metres' spacing. The 6 km range, and the statement that 70% of the variance lies within 3 km, are therefore, in the 2025 PFS, properties measured within about 110 km² in one corner of the block and applied to 25,200 km². The PFS notices the difficulty in its own way. Its variogram is directional: it gives a range of 6 km along a 075° trend and 3 km across it, that is, it finds the nodule field grainier in one direction than the other; and it then concedes that this pattern "might be, at least in part, an artefact of the sparseness of the sampling".[13]

The 20 cluster pairs that carried the short range in 2020 come from two clusters placed by 6B: four cores each, 300–500 m around an earlier core, one landing within 20 m of it. Both centres were above-average cores (30.2 and 23.4 kg/m², against a mean of 17.5) on smooth plain. Close-spaced clusters are a recognised way to measure short-range variability, but two sites of one ground type cannot show how it behaves elsewhere, and between 1 and 6 km the 2018–19 cores offer only four pairs. Any range between about 1 and 7 km fits them about equally well.

4.3 The classification test, and the counter-case

S-K 1300 classifies a resource by the confidence the sampling gives in tonnage and grade. Indicated means confidence sufficient to support a prefeasibility study and a mine plan, and eligible for conversion to Probable Reserve; Inferred means the evidence implies continuity without verifying it, and cannot become reserve.[14] AMC's test for Indicated is explicit and it is a statement about scale: the probability, from conditional simulation, that abundance over one year's production, set at a 20 km

[13] PFS Table 11.6 and s.11.9. A lattice aligned with the regional trend cannot distinguish the grain of the deposit from the grain of the grid. Grades, by contrast, have ranges above 20 km and are well constrained; abundance is the variable that matters and the one the sampling constrains least.

[14] 17 CFR 229.1301. AMC assigned Measured where camera transects infill the cores to 3.5 km, Indicated where cores sit on the 7–10 km grids, and Inferred in the south-east, which the PFS calls "largely unsampled" without saying why the grids stopped there.

block of 400 km² (a quarter's production, 100 km², for Measured), lies within ±15% of the estimate at 90% confidence.[15]

The counter-case is the convention most resource geologists apply when the variogram is under-informed: Indicated where the sample spacing is within the range, Inferred beyond it.[16] On that test, and on several other common methods, most of the block sampled at 7–10 km would be Inferred. Table 4b runs fifteen versions of the four families of method against AMC's variogram and sampling, and gives Koinon's view of whether each is reasonable on these data.

	As declared, 2025 (PFS Table 11.7)	Reasonable alternatives (Table 4b)
Measured	5 Mt	0–18 Mt
Indicated	347 Mt	4–62 Mt
Inferred	11 Mt	276–352 Mt
Eligible for reserve conversion	352 Mt	4–80 Mt
Probable reserve on the current mine plan	51 Mt	not recomputed

Table 4. The inversion. Block total 363 Mt in both columns; what changes is how much of it may be planned on. Ranges are the versions marked reasonable in Table 4b, on the 2020 basis.

Version	Measured	Indicated	Inferred	Reasonable on these data? (Koinon)
1. SPACING AGAINST RANGE				
1a Spacing ≤ 6 km range	0	4	352	Yes: the standard test
1b Spacing ≤ distance to 80% of variance (32 km)	4	341	11	Doubtful: 32 km comes only from the regional trend
1c Spacing ≤ two thirds of range	0	4	352	Yes, but strict
2. SAMPLES WITHIN SEARCH RANGE				
2a ≥3 samples within one range	0	4	352	Yes
2b ≥2 samples within one range	1	18	337	Yes
2c ≥3 samples within twice the range	4	119	233	Lenient
2d ≥2 samples within twice the range	19	317	20	Doubtful: two cores up to 12 km away
3. KRIGING STATISTICS (3.5 km panels)				
3a Slope of regression ≥ 0.8	61	284	11	Doubtful: slope inflated by the trend
3b Slope of regression ≥ 0.9	0	61	295	Yes
3c Kriging efficiency ≥ 0.5	18	62	276	Yes
3d Kriging efficiency ≥ 0.3	80	265	11	Lenient
3e As 3a, without the 140 km structure	0	17	339	Check only, not a method
4. PRODUCTION VOLUME (±15% at 90% confidence)				
4a Year block, 20 km (AMC)	4	341	11	Doubtful: most lenient volume; rests on the trend
4b Half-year block, 14 km	4	34	318	Yes

[15]PFS s.11.10. Koinon reproduced the logic on a synthetic seabed with TMC's parameters: the block mean was recovered almost exactly; the mean over a reserve-sized area was uncertain to ±2%; the mean over one 98 km × 2 km lane to ±7%; and about 6% of 4 km panels were truly below 12 kg/m² although the kriged surface showed none. The "no panel below 12" is smoothing, not observation.

[16]The CIM Mineral Resource and Mineral Reserve Estimation Best Practice Guidelines (2019) and the JORC Code (2012, Table 1, "drill hole spacing … sufficient to establish the degree of geological and grade continuity appropriate for the classification applied") both tie classification to demonstrated continuity at the sample spacing; variogram range relative to spacing is the usual quantitative expression of that test in practice. AMC's own geologists discuss the point for nodules in Parianos, Lipton and Nimmo (2021). Koinon has not surveyed regulatory cases and states the convention as practice, not as a rule.

Version	Measured	Indicated	Inferred	Reasonable on these data? (Koinon)
4c Year block, 10 km	0	4	352	Yes, but strict

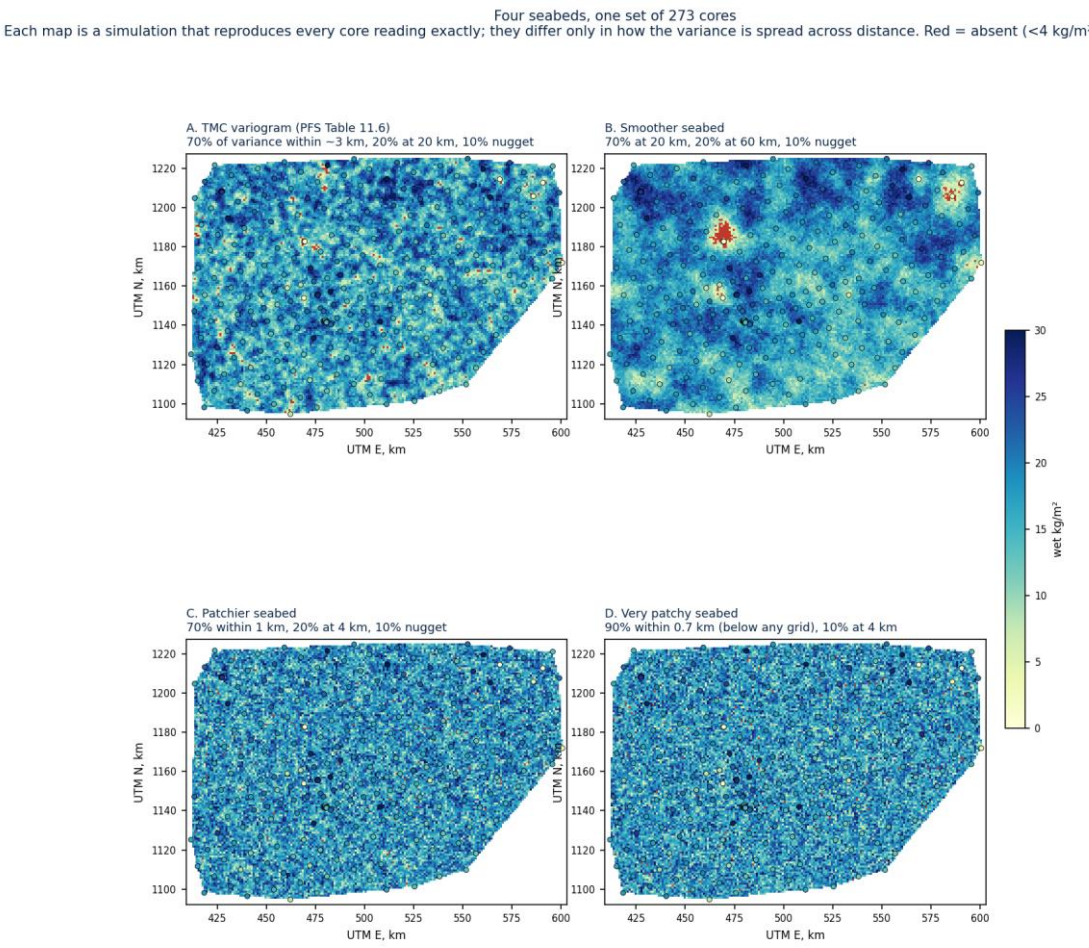
Table 4b. Classification of the 2020 resource under four families of method, Mt. Koinon reconstruction using AMC's variogram (PFS Table 11.6), idealised sampling grids at 3.5, 7 and 10 km, ordinary kriging on the ten nearest samples, and errors converted to abundance at a coefficient of variation of 0.30. Tonnage is assigned by sampling zone from PFS s.11.10: photo-infilled area 4 Mt, 2018 grid 34 Mt, 2019 grid about 307 Mt, sparse south-east 11 Mt. Row 4a reproduces AMC's 2020 result. Thresholds are typical values from the literature (Appendix F) and vary between companies; the last column is Koinon's judgement.

AMC's simulation test is a published method (Dohm 2005), and the classification lies within the latitude the codes allow. It sits at the lenient end of that latitude. Every version in Table 4b that reproduces AMC's result does so by crediting the 140 km structure in AMC's variogram, the broad decline in abundance from north-west to south-east, which carries 30% of the variance; remove it and Indicated falls to 17 Mt. A regional trend locates the average over large areas; it says nothing about the ground at the scale a collector mines. The PFS states that the abundance variogram shows "ranges greater than the average sample spacing" (s.11.2); its own Table 11.6 does not bear that out. The point for NOAA is that the confidence claimed for the whole block follows from the choice of test, and that the simulation results, with a sensitivity to the chosen production volume, can be required.

4.4 Simulated seabeds consistent with the cores

To test how far the cores constrain the ground between them, Koinon built four seabeds by conditional simulation. Each reproduces every one of the 273 core readings exactly and has the same overall spread of values; they differ only in the variogram, that is, in how the variation is arranged between the cores. Scenario A approximates TMC's own variogram; B is a smoother world; C and D are patchier ones in which most of the variation lies below the grid spacing.[17]

[17] Gaussian random fields on a 1 km grid over the hull of the cores, conditioned on the cores by kriging of the residual; point variance fixed at the sample variance of the cores (27.7); twenty draws per scenario for the totals and fifty for the panel statistics under scenario A. Appendix E.



Scenario	Total, Mt	Area <4	Area <12	Panels <12	Lowest panel	Lane spread
A. TMC variogram (PFS Table 11.6)	366 ± 7	0.6%	16%	6%	5.7	±6%
B. Smoother seabed	367 ± 4	0.6%	13%	9%	1.8	±9%
C. Patchier seabed	368 ± 7	0.5%	16%	0%	11.3	±2%
D. Very patchy seabed	366 ± 6	0.6%	16%	0%	11.9	±2%

Figure 4. Four simulated seabeds honouring the same 273 cores. Red marks ground below 4 kg/m². The table beneath gives the total, the share of area below 4 and 12 kg/m², the share of 3.5 km panels below 12, the lowest panel, and the spread of 2 km lane means.

Three things follow. The total does not move: 366–368 Mt over the hull, which is the point conceded in section 2. The area below 4 or 12 kg/m² barely moves either, because the cores fix the spread of point values and the variogram decides only how the lean ground is arranged, in scattered specks or in contiguous patches. What moves is the picture at the working scale. In Koinon's simulations under Scenario A, which approximates TMC's variogram, about 6% of 3.5 km panels fall below 12 kg/m² and the lowest sits near 6, although the kriged map shows none; against the 13.6 kg/m² that the PFS itself derives as the minimum average abundance at which the annual target can be met at the collector's top speed, 1.2% of kriged panels fall short but 14% of panels in those simulations.[18] The kriged panel is an expectation, the centre of what the cores allow; the map of expectations shows no panel below 12 because averaging removes the extremes. The mine plan is drawn on that map.

[18]Fifty simulations under scenario A: panels below 12, mean 6.0% (90% of runs between 4.5% and 8.3%); lowest panel median 6.0, range 1.9–7.5; panels below 13.6, 14%. Kriged panels on the same grid: 0.5% below 12, lowest 9.7, 1.2% below 13.6. The 13.6 figure is PFS s.12.2: with the nominal 0.4 m/s raised to the maximum 0.5 m/s, 0.4/0.5 × 17 = 13.6 kg/m² is "the minimum average abundance" at which production targets can be met.

Along the mapped first strip, a year of straight passes averages whatever lies on it, and the simulated annual yield is 1.62–1.65 Mt per collector in every scenario against a plan of 1.5 Mt; fine-scale patchiness does not break the first years' tonnage. Its effect is on what the strip is taken to prove: that the ground is uniform, that a zero cut-off is safe, that a pick-up efficiency measured on rich, flat ground applies to lean ground, and that the confidence earned on 110 km² extends to 25,200 km². For lanes laid across the wider reserve without fine mapping, the simulation gives a single lane's mean varying ±6% from one seabed to the next under TMC's variogram, a year of production a fifth richer or poorer than planned, with no slack in the schedule to absorb it.[19]

5. Finding 3 — Reserve volume and classification insecure

Claim. The 51 Mt Probable reserve TMC has declared draws its resource base from Finding 2 and every one of its modifying factors from the applicant and its collector contractor. AMC's independent contribution inside the reserve area is simply the resource model and a polygon; the conversion of resource to reserve is arithmetic on supplied assumptions, and the reserve Qualified Person's own report records that the principal assumption has not been tested.

5.1 What AMC certifies and what it does not

The PFS was prepared under SEC Regulation S-K subpart 1300, which permits employees of the registrant to act as Qualified Persons provided the affiliation is disclosed. The division of responsibility is set out in its Tables 2.1 and 2.2 and repeated for the reserve in section 12.1.2.[20]

Element of the reserve	Signed by	Nature of the contribution
Resource model: kriging, panel grades, 12 kg/m² floor, Indicated classification (s.11)	AMC Consultants Pty Ltd	Independent; wholly AMC's; Finding 2 applies
Reserve geometry: 4° slope screen on the 2012 bathymetry, exclusion zones and buffers, reserve polygon, lane layout (ss.12.3–12.5)	AMC	Geometric operations on the same bathymetry; no new evidence
Schedule and ramp-up, including the nodule recovery build-up (s.12.2.8)	AMC, on Allseas test-mining evidence	Arithmetic on supplied parameters
Probable rather than Proven classification, and the statement of risk (s.12.7)	AMC	Judgement that the supplied factors are sufficiently defined for Probable
Collector pick-up, recovery, speed, availability; collection modifying factors (ss.12.2.7, 12.2.9, 13)	Rutger Bosland, TMC	Formerly led Allseas' design, build and test of the collector
Production target, economic modifying factors, marketing (ss.12.2.12–14, 16, 21)	Anthony O'Sullivan, TMC	Applicant's officer
Capital and operating costs (s.18)	Adam Price, TMC	Applicant's officer
Environmental modifying factors (ss.12.2.1, 17)	Dr Michael Clarke, TMC	Applicant's officer

[19] Lane simulation on the traced runs 19–20 corridor (134 km of centreline) with the PFS operating constants: 15 m width, 0.4 m/s, 75% of annual hours, 85% field efficiency, 77% recovery; twenty seabeds per scenario. Lane mean 17.4–17.7 kg/m²; kilometres below 13.6, 19–24%; below 12, 10–15%; annual yield 1.62–1.65 Mt (±0.05–0.09).

[20] Employee QPs are lawful under the SEC rule, which considered and declined an independence requirement; large producers routinely sign whole reports in-house, on the strength of years of reconciliation data from operating mines. Development companies without revenue ordinarily use independent firms for mining and costs because lenders insist on it. Canada's NI 43-101, as Koinon understands it, requires an independent QP for a first-time reserve; TMC files under the SEC rule, which has no such gate. Appendix A gives the full table and the individuals.

Element of the reserve	Signed by	Nature of the contribution
Slope and geo-obstacle model (s.12.2.4)	MARGIN	Contractor; model calibrated on the AUV-mapped tenth of the reserve
Economic analysis (s.19)	Lanasera Pty Ltd	Small consultancy; PFS s.12.6 nonetheless states that TMC undertook the economic evaluation

Table 5. Who signs which element of the reserve. Sources: PFS Tables 2.1 and 2.2, s.12.1.2, s.25.

The geology of the reserve is modelled no differently from the rest of the resource. What AMC adds is a polygon, a lane layout and a multiplication; the multipliers come from the operator. AMC did not review the collector as an input, and the reliance statement in section 25 does not list it, because it was not relied upon: TMC's own officer authored it as a QP. The reserve QP's statement of risk is the applicant's own consultant describing the state of the evidence:[21]

> *"the technology required for nodule collection is still in development and the design of the collector proposed for NORI Area D has not been finalized. As a result, the production-scale collector … has not been subjected to actual operating conditions in a production environment. Therefore, its effectiveness, robustness, and reliability … has not been determined and physical records for productivity, nodule recovery, collector speed, and availability are not available."* — PFS s.12.7

The arrangement has been noticed by every outside reader of the PFS. Emerman, having compared the SEC rule with the Australian, Canadian, European and South African codes, concludes:

> *"it is not non-compliant for a company that trades on NASDAQ to use company employees to write a Pre-Feasibility Study, although it would be non-compliant for a company that trades on the Toronto or Vancouver Stock Exchanges. On the other hand, the authorship by company employees of a mining project disclosure written in compliance with SEC regulations would certainly be an unusual practice. In fact, the author of this report has never before seen a mining project disclosure written by company employees for a company that was trading on a US stock exchange. On that basis, the lack of independence of the authors of the TMC Pre-Feasibility Study should be an occasion for pause and reflection."* — Emerman (2026), p.49

Iceberg Research made the same point about the outside firms: "The crucial sections of the PFS are written by either TMC employees or small consultants with one or two clients including TMC", and it traced each of the five firms named as QPs, finding MARGIN to be a sole proprietorship whose principal had been Nautilus's chief geophysicist, Lanasera and APYS Subsea to be operating from residential addresses, and Canadian Engineering Associates to have five employees.[22] The Canadian rule that Emerman contrasts is explicit: a qualified person "is not independent when the qualified person (a) is an employee, insider, or director of the issuer", and a first-time technical report must be prepared by independent QPs. TMC files under the SEC rule, which has no such gate.[23]

[21] PFS s.12.7 also notes that the five-year-experience requirement for a QP under S-K 1300 is one the QPs' ability to meet "is limited", and that the mine plan rests on hull-sonar surveys "of insufficient resolution to accurately identify all of the seafloor domains and fine-scale Geo-obstacles", so that more closely spaced data "will be required" before detailed planning outside the Initial Mining Area.

[22] Iceberg Research (2025a), quoted in Emerman (2026), pp.49–50. Barnard and Trytten (2025) add, at p.50 of Emerman: "significant portions of the PFS documentation were authored and approved by company insiders, an approach not allowed in many prominent mining jurisdictions. These sections include the capital and operating costs and market analysis including product pricing … More credibility would ensue if a practitioner from a major mining/project development engineering [firm]" had signed them. Koinon has not independently verified Iceberg's corporate-registry findings; the QP list itself is at PFS Table 2.1 (Appendix A).

[23] NI 43-101 Companion Policy s.1.5 and NI 43-101 s.5.3, as quoted in Emerman (2026), pp.28 and 49.

5.2 The arithmetic of 363 to 51

The reserve is confined to an Initial Mining Area of about 6,500 km², a quarter of NORI-D, chosen for flat ground near the 2022 test site.[24]

Step	Area	Tonnage	Source
NORI-D at 17.4 kg/m²	~25,200 km²	~440 Mt of seabed	Arithmetic
Less volcanic, drift and >6° domains		363 Mt resource	PFS Table 11.7
Initial Mining Area at 17.4 kg/m²	~6,500 km² (26%)	~113 Mt of seabed	Koinon trace of Figure 90
Less domain exclusions		~90 Mt resource ("approximately 25%")	Application s.6.2
Less 4–6° slopes, buffers, test patch, blocks <10 km		ground not traversed	PFS s.12.3
× 77% recovery (Type 1) / 62% (Types 2–3) × 85% field efficiency		51 Mt Probable	PFS Tables 12.6, 12.8
Conversion in the Initial Mining Area		57%	Application s.6.2.6
Conversion assumed for all of NORI-D		46%	Application s.6.2.6

Table 6. From resource to reserve. The 4–6° band is resource but not reserve because the first-generation collector is specified to 4°; the IA's second-generation system assumes 6°.

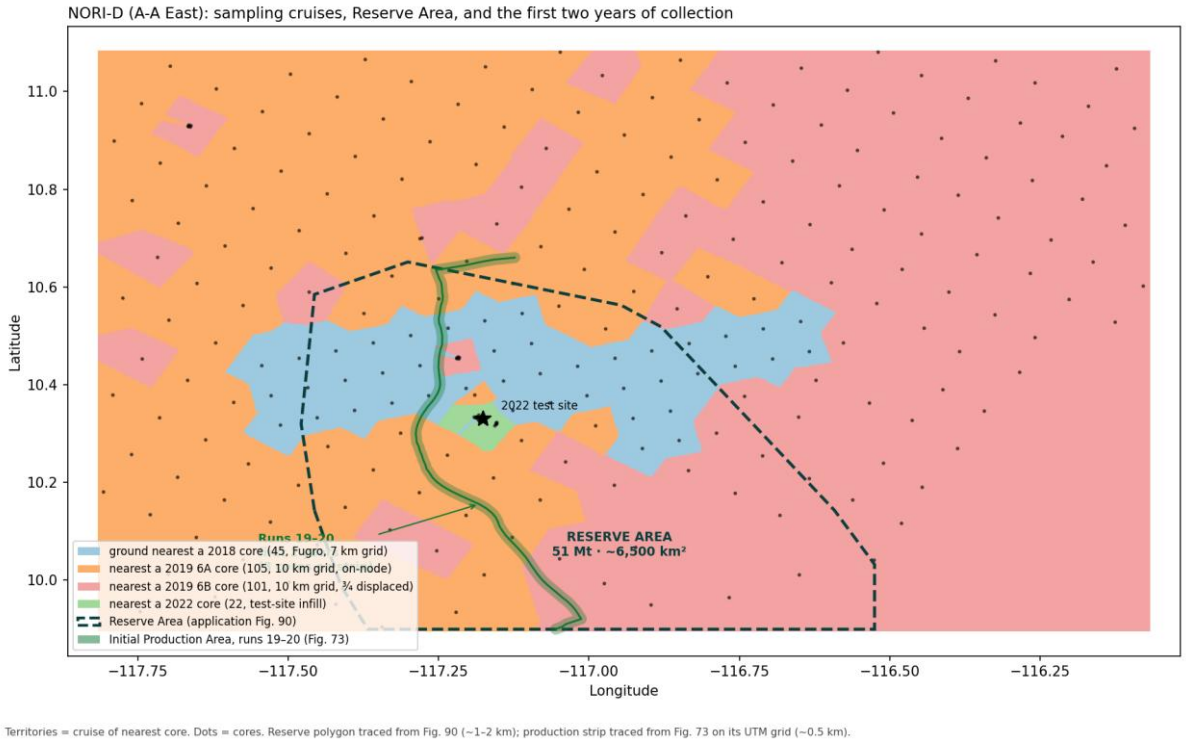


Figure 5. NORI-D coloured by the cruise of the nearest core, with the reserve polygon (dashed) and the first production strip, runs 19 and 20 (green). Polygon traced from application Figure 90 (accuracy 1–2 km); strip from Figure 73 (about 0.5 km).

[24]PFS s.12.3: "representative of the primary geoform and habitat types studied", "in reasonable proximity to the Test Mining area", "with consistent nodule abundance and lower probability of Geo-obstacles", slopes "generally less than 4°". Three names denote the one polygon: Initial Mining Area, Reserve Area and Project Zero. The Initial Production Area is the 98 km strip within it.

5.3 The modifying factors and where they were measured

Component (PFS Table 12.6, Type 1)	Factor	Evidence
Nodules within the 3–5 cm the nozzles reach	96.0%	AMC box-core analysis
Collector nozzle pick-up	84.3%	“Design specification”; Deltares tank trials; one 2 km test stretch
Hopper, hopper-jet, dewatering, transfer losses	99.5 × 98.5 × 98.0 × 99.0%	Allseas simulation
Nodule recovery, Type 1 (81% of the block by area)	77.0%	Product of the above; sea-trial support is five box-core pairs above 80%
Nodule recovery, Types 2 and 3 (larger nodules, 75 mm grizzly)	62%	A 20% relative reduction “considered conservative by the QP”
Field efficiency (turns, obstacles, re-traverses)	85%	Allseas assumption
Geo-obstacle loss	by probability class	MARGIN model, calibrated on about a tenth of the reserve area

Table 7. The multipliers. The application’s own post-mining box cores (Table 25) show individual recoveries from 8% to 96%, the low values attributed to umbilical control faults to be rectified in the final design.

Two features of the multiplication deserve notice. First, the reserve is declared at zero cut-off, on the reasoning that it is cheaper to keep collecting across a thin patch than to lift the machine, and sub-cut-off ground and “minor areas of Inferred Mineral Resources (approximately 3%)” are carried in as dilution, in undisclosed quantity.[25] The 4 kg/m² resource cut-off itself is borrowed from another study: the PFS states that it was “based on estimates developed for the second generation of collection systems described and assessed in the Initial Assessment … rather than the collection system evaluated for the Mineral Reserves in the PFS”, which Iceberg Research read as “TMC’s lower future costs … used to inflate resources even though these second generation collection systems are not expected before 2037”.[26] The 12 kg/m² floor is a statement about 3.5 km panels; the collector meets the seabed at 15 m widths, and the 84.3% pick-up was measured on a single stretch chosen for continuity. Nothing in the plan says what happens when a lane crosses lean, steep or unmapped ground. A cut-off is where geology meets economics; here that boundary is asserted away, and whether the reserve at large is economic at the collector’s own scale is precisely what it would test. The PFS in fact derives such a boundary and does not apply it: because collector speed can rise only from 0.4 to 0.5 m/s, it concludes that 13.6 kg/m² is the minimum average abundance at which the annual target can be met, while declaring the reserve at zero cut-off.[27]

Second, fine mapping covers little of the reserve. AUV sonar at 1 m and camera at 6 m altitude were flown over the 2018 survey area and over runs 19 and 20: about 600 km², some 2.5% of NORI-D and a tenth of the reserve polygon.[28] Runs 19 and 20 are the two 98 km lanes planned for the first two years; they yield about 3 Mt of the 51. The remaining 48 Mt lie in lanes laid on 30 m hull bathymetry that AMC itself says cannot resolve collector-scale obstacles.

[25] PFS s.12.4. The resource uses a 4 kg/m² cut-off. At panel scale the cut-off excludes nothing, since no panel is below 12; at collector scale, 15 m wide, the quantity of lean and Inferred ground inside the 51 Mt is not stated.

[26] PFS s.11.10 as quoted by Iceberg Research (2025a), in Emerman (2026), p.48. The point bears on Finding 2 as well: the resource base from which Indicated tonnage is counted is defined by the economics of a machine the PFS does not evaluate.

[27] PFS s.12.2: “collection speed can be increased up to 0.5 m/s to compensate for lower abundances. In practice this means an abundance of 0.4/0.5 x 17 = 13.6 kg/m² is the minimum average abundance” required to meet production targets.

[28] About 375 km² in 2018 (2,286 line km) and about 246 km² over runs 19–20 in 2023–24; Appendix C. The one place fine mapping was done after the lanes were drawn, it “resulted in identification of additional Geo-obstacles that were not detected in the initial broad scale bathymetric surveys” (PFS s.12.5).

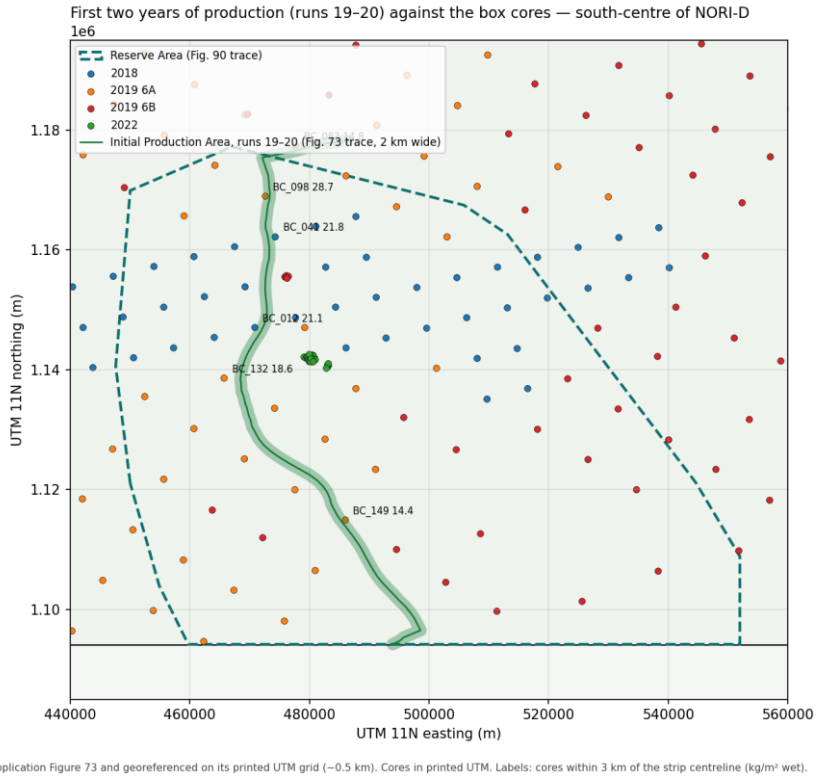


Figure 6. Runs 19 and 20 against the cores, in UTM; labels give abundance for cores within 3 km of the centreline. Three cores lie within 1 km of the strip.

5.4 Why probable resources

AMC classifies all of the reserve Probable rather than Proven, including the 0.8 Mt of Measured resource. Under S-K 1300 a Proven reserve requires both Measured resource and modifying factors known with high confidence; AMC's reason is the second condition. Nothing less is known about the seabed in the reserve than elsewhere; what is less certain than the geology is the machine, the costs and the plan that convert it, and that uncertainty caps the whole reserve at Probable.[29] In substance, then, the 51 Mt is an Indicated resource with a mine plan attached, certified as such by the firm that built the resource model, on inputs from the applicant.

Emerman reads the same tables and finds the dilution in them: the resource inclusive of reserves carries 11 Mt of Inferred, the resource exclusive of reserves 10 Mt, "so that 1 million wet metric tons of inferred resources have been converted into reserves", which the SEC rule forbids in terms: "an inferred mineral resource may not be considered when assessing the economic viability of a mining project, and may not be converted to a mineral reserve".[30]

[29] PFS s.12.5. The reserve is declared economic on "payback within seven years and Mineral Reserve life of just over seven years" (s.12.6), on a cash-flow model that assumes the four-vessel fleet and a 12 Mtpa plant. The PFS also lists the absence of NOAA permit terms among the reasons the reserve is only Probable and refers to a "proposed NORI Area D Commercial Recovery Permit Area": the reserve assumes the permit, and the application cites the reserve in support of the permit.

[30] Emerman (2026), p.30, quoting 17 CFR 229.1301. The PFS's own account (s.12.4) is that "minor areas of Inferred Mineral Resources (approximately 3%)" are carried into the reserve as dilution; 3% of 51 Mt is about 1.5 Mt. Emerman also reports 38 Mt as having "gone missing" between the 363 Mt inclusive resource, the 274 Mt exclusive resource and the 51 Mt reserve (p.31). Koinon reads that difference not as an arithmetic error but as the modifying-factor loss: about 89 Mt of resource in the Initial Mining Area becomes 51 Mt of reserve after slope, buffer and recovery deductions (Table 6). The point is not adopted here.

6. Finding 4 — Production plan would not qualify under S-K 1300

Claim. The application schedules 202.5 Mt over twenty years. About 3 Mt comes from runs 19 and 20, 51 Mt from the reserve, some 113 Mt from the rest of NORI-D, and about 39 Mt from TOML-F and the unsampled A-B block. The applicant invokes S-K 1300 for the resource estimate, the IA, the PFS and the reserve estimate. It does not formally invoke it for the schedule, which before the SEC could appear only in an Initial Assessment carrying the standard caution that it is preliminary, rests on Inferred material and may never be realised. But the NOAA application carries no such caution.

The point was made of the PFS before the application was filed, and the application enlarges it. Emerman's second finding is headed "The Economic Analysis is not Based on Mineral Reserves":

> *"the economic analysis in the TMC Pre-Feasibility Study is based on 51 million wet metric tons of mineral reserves plus another 113.1 million wet metric tons of mineral resources that were not converted into reserves. In fact, the Pre-Feasibility Study shows that, based on mineral reserves alone, the mining operation would terminate after eight years with zero profit. In other words, the economic viability of the mining project has been demonstrated based on mineral resources that have not been shown to be "economically viable". The requirement to ground the economic analysis in mineral reserves … is not a "gray area" in SEC regulations. It should go without saying that, if the economic analysis can be based upon mineral reserves plus whatever mineral resources are necessary to complete the analysis, then the consideration as to which mineral resources are mineral reserves would be a pointless exercise."* — Emerman (2026), p.47

The PFS sentence on which this rests is its own: "The project payback is 7 years and the Probable Mineral Reserve in the Initial Mining Area of 51 Mwmt is all mined by the end of year 7 (50.7 Mwmt) with a post-tax cumulative free cash flow of US$170.2M (year 7)". Iceberg Research drew the inference a fortnight after publication: "We believe TMC included resources because the NPV based solely on reserves was insufficient. The company stated that the 51mn wmt of reserve would generate only $170.2mn in undiscounted cash flow, an amount that would produce a negative NPV if discounted at 15%." Emerman adds that the PFS's term for the extra 113 Mt, "recoverable" resource, "does not occur anywhere in SEC regulations".[31]

[31] PFS s.19 as quoted in Emerman (2026), p.37; Iceberg Research (2025a) in Emerman, p.47; Emerman, p.48. Emerman's subject is the PFS mine plan of 164 Mt over NORI-D; the application before NOAA schedules 202.5 Mt over USA-A, adding TOML-F and the unsampled A-B block to the same 51 Mt reserve (Table 8).

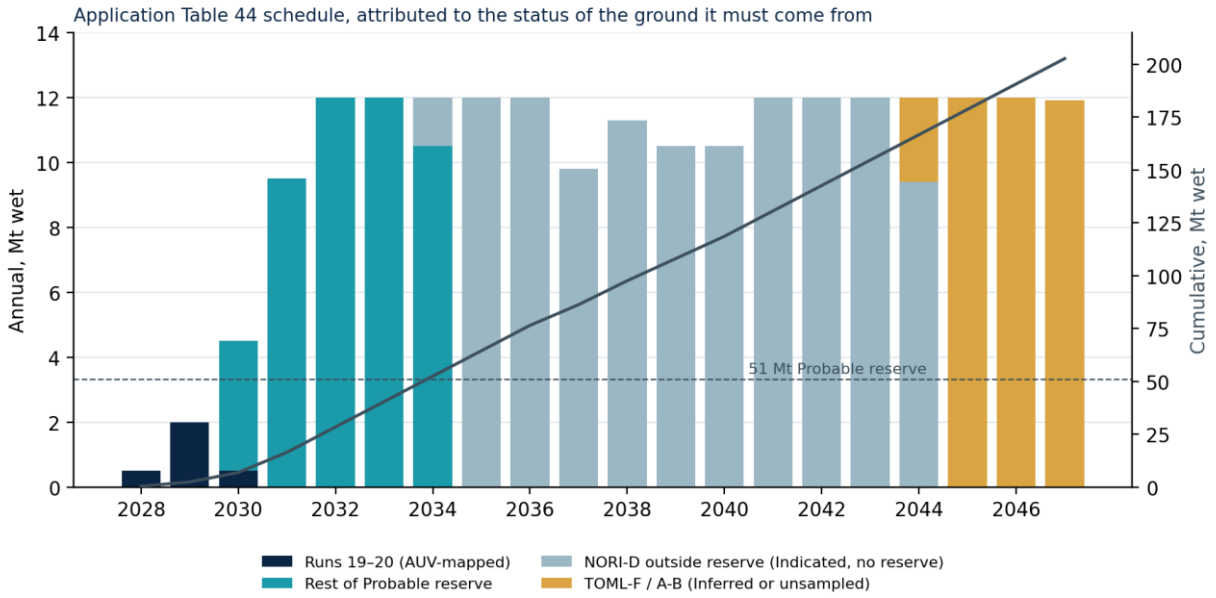


Figure 7. The application's annual schedule (Table 44), attributed in order to the ground it must come from. The reserve is exhausted in 2034; the remaining thirteen years draw on ground with no reserve status.

Source of tonnes	Mt wet	Share	Status of the ground	Years
Runs 19–20	~3	1.5%	Probable reserve; AUV sonar and camera; three cores on the strip	2028–29
Rest of the Initial Mining Area	~48	24%	Probable reserve; 100 cores; fine mapping over a tenth of the polygon	2030–34
NORI-D outside the reserve	~113	56%	Indicated resource, not converted; 46% conversion assumed; hull sonar the PFS calls insufficient	2034–44
TOML-F and A-B	~39	19%	Inferred (TOML-F) and unsampled (A-B); the IA assumes different equipment and a 2037 start	2044–47
Total (application Table 44)	202.5	100%		2028–47

Table 8. The split of the last 39 Mt between TOML-F and A-B is Koinon's subtraction; the application gives none. The rows sum to about 203 Mt against the 202.5 Mt of Table 44 only because each is rounded; the 3 Mt of runs 19–20 is not part of the 48 Mt.

6.1 How the application gets to twenty years

The governing law is the Deep Seabed Hard Mineral Resources Act of 1980, under which NOAA issued its exploration-licence rules (15 CFR Part 970) in 1981 and its commercial-recovery-permit rules (Part 971) in 1989, both revised in January 2026. Neither uses the word reserve. The area test is a "logical mining unit": under 970.203(d) and its 971 counterpart, an area of the seabed that can be mined in an efficient, economical and orderly manner, that is contiguous, and that, for a commercial recovery permit, could be depleted over the permit term of about twenty years.[32] The application fills that older frame with newer language, and its logical-mining-unit section shows how. The 51 Mt reserve does not appear in it. The twenty-year case is built by taking the 57% conversion achieved in the reserve area, on the flattest ground, generalising it to 46% across all 352 Mt of Measured and Indicated resource to yield 164 Mt; adding a "downside" that admits collection has only been demonstrated on the flat geoform, 52% of the area as classified from the 2012 hull-sonar bathymetry at about 30 m cells, which

[32] 15 CFR 970.203(d) and 971.203; application s.6.2.6 sets out the applicant's reading of the test. The 20-year figure is the permit term under 30 U.S.C. 1417.

at 46% gives about 166 Mt against a 203 Mt need; and closing the 40 Mt gap from A-B, where no resource estimate exists.[33]

Parameter	PFS (NORI-D)	IA (TOML-F)	Application (both, as USA-A)
Collector width and count per vessel	15 m, two	20 m, three	15 m, two
Nameplate per vessel	3 Mtpa	7 Mtpa	3 Mtpa
Slope limit	4°	6°	4°
Recovery	77% / 62%	78%	77% / 62%
Start of collection	2028	2037, after “a decade of experience”	2028; TOML-F within the term
Reserve	51 Mt Probable	None	Cites both; schedules 202.5 Mt

Table 9. The two studies, dated the same day and signed by the same QPs, assume different systems for the ground the application combines.

6.2 The terrestrial comparison

Under S-K 1300 and NI 43-101 a feasibility-level mine plan may be built only on reserves; a plan drawing on Inferred material is confined to an Initial Assessment or PEA and must carry cautionary language. Before permitting regulators, long-life plans on resource-plus-reserve are nonetheless not unusual on land, where approvals are sought on the expectation that reserves will be replaced by continued drilling as mining proceeds.[34] Three things distinguish this case. On land the replacement is institutional, not merely anticipated: the operator files an annual reserve statement, lenders hold covenants on reserve life, and grade control samples every bench before it is blasted. Whereas nothing in Part 971 obliges TMC to restate reserves annually or to reconcile what the collector lifted against what the model promised, and the application proposes no sampling programme in NORI-D beyond production itself.[35] Second, the legal test sits at the moment of licensing: NOAA must find that commercial recovery of the proposed quantity is feasible on the record before it, not that it may become so. Third, the cost asymmetry runs the wrong way: infill drilling on land costs a fraction of production; box coring from a chartered vessel at a few sites a day does not, and TMC has taken no core in NORI-D since 2022.

6.3 What follows

The applicant has chosen its standard. It invokes S-K 1300 some fifteen times in the application, for the resource, the IA, the PFS and the reserve, because that is the standard by which its investors and the SEC judge the same claims. Having borrowed the standard’s authority for its inputs, it cannot ask

[33] Application s.6.2.6. The section concedes that A-A “would nearly be (but not quite) sufficient to support a 20-year operation under this downside scenario”, and that there is “a high likelihood that nodule reserves can be defined” in A-B to meet the shortfall. TMC USA’s exploration plan for the second development area (s.5.2) proposes to define reserves there “sufficient to cover the first two production years”.

[34] A general observation from terrestrial practice, offered as context; Koinon has not surveyed permit applications for a precedent of this exact shape and would say so rather than assert one. The NORI-D reserve itself was first declared in the PFS with an effective date of 30 June 2025 (PFS Table 1.4), published 4 August 2025; no reserve existed before that date and none has been restated since. Emerman’s reading of the same rule is that a plan “carried further in time must be based on resources alone” once the reserve is exhausted at the end of Year 7, and that “nearly identical language” in the SEC and Canadian codes confines an economically viable project to reserves (pp.47–48).

[35] The application acknowledges annual reporting on “conformance to the conditions of the permit and associated recovery plan” (s.6.4.2); it does not propose reserve restatement or reconciliation.

NOAA to set the standard aside at the output. The finding NOAA must make under 971.214, that commercial recovery of the proposed quantity is feasible, is a judgement, and the reasonable exercise of that judgement is to hold the applicant to the discipline it chose: on that discipline the demonstrated case is 51 Mt, exhausted in 2034, the seventh year of collection, and the remaining 150 Mt is a preliminary assessment that the applicant's own rules would require to be labelled as such. The practical form of the finding is authorisation in tranches tied to declared reserves, with expansion conditional on published Indicated resources, annual reserve restatement and independent reconciliation of the first lanes.

7. Documents NOAA could require of the applicant

1. The pre-cruise sampling plans for Campaigns 3, 6A and 6B with planned coordinates, and the Bluefield factual reports MAE001-FAC-01 and -02 with drop logs (Finding 1).
2. The AUV track files and camera-line coverage, 2018–2024, as georeferenced data, and the 2012 multibeam bathymetry and backscatter grids (Findings 1 and 3).
3. The variogram pair data and the conditional-simulation results underlying the Indicated classification, and any infill sampling proposed to test the range outside the test site (Finding 2).
4. The reconciliation of test-mining tonnage (4,500 t collected, 3,000 t lifted) against swept area and pre-mining abundance, as a hectare-scale measurement of recovery; and the tonnage of sub-cut-off and Inferred material included in the reserve as dilution (Finding 3).
5. An independent review of the mining, cost and economic modifying factors by a Qualified Person not employed by the applicant or its collector contractor (Finding 3).
6. The basis on which the first-generation system is applied to TOML-F, where the applicant's own study assumes a second-generation system a decade later; and a reserve-based schedule for the term, with the conditions under which it would be extended (Finding 4).

Appendix A. The documents and who signs them

The PFS names five firms and four TMC officers as Qualified Persons. AMC Consultants Pty Ltd signs as a firm; no individual is identified for the resource or the reserve, which the SEC rule permits and NI 43-101 does not. The AMC geologists behind the earlier NORI and TOML estimates are known from the prior filings and from AMC's own literature: Matthew Nimmo was Competent Person for the 2012 TOML NI 43-101 (410 Mt Inferred) while at Golder Associates, and Ian Lipton was QP for the Solwara 1 NI 43-101 for Nautilus Minerals; both later at AMC, and both co-authors with TMC's John Parianos of a 2021 paper on nodule resource estimation. Whether either was responsible for the 2025 update is not stated in any filing; every AMC consent on EDGAR from 2021 to 2025 is signed by Robert Chesher as general manager of the Brisbane office on behalf of the firm.[36]

Qualified Person	Sections of the PFS
AMC Consultants Pty Ltd	1.4, 1.10, 1.13, 2, 4, 5, 7.3.6, 7.4, 7.5.1–7.5.3, 7.5.5, 7.6–7.8.2, 7.10–7.12, 8.2–8.3, 9, 11, 12.1, 12.2.5, 12.2.6, 12.2.8, 12.2.10, 12.3–12.5, 12.7, 20, 22.2, 22.4, 22.5, 24, 25
MARGIN – Marine Geoscience Innovation	6, 7.1, 7.2.1–7.2.7, 7.2.9, 7.2.10, 7.3.1–7.3.3, 7.3.5, 7.8.1, 7.9, 7.13, 8.1, 12.2.4 (sampling, geology, slope and geo-obstacle model)
APYS Subsea Ltd	7.2.8, 7.3.4, 7.5.4, 7.14, 12.2.2 (geotechnics)
Canadian Engineering Associates Ltd	1.7, 10, 12.2.11, 14, 15, 22.7 (processing)
Lanasera Pty Ltd (Brett Roughan, Principal, Oxley, Queensland)	1.12, 12.6, 19, 22.12 (economic analysis)
TMC the metals company Inc. (O'Sullivan, Clarke, Bosland, Price)	1.1–1.3, 1.5, 1.6, 1.8, 1.9, 1.11, 3, 7.1, 12.2.1, 12.2.3, 12.2.7, 12.2.9, 12.2.12–12.2.14, 13, 16–18, 21, 22.1, 22.3, 22.6, 22.8–22.11, 23

Table A1. PFS Table 2.1. Note that sampling and geology (sections 6 and 7.1–7.3) sit with MARGIN, not AMC, so the cruise conduct examined in Finding 1 has its own QP.

Anthony O'Sullivan is Chief Development Officer; Dr Michael Clarke, Environmental Manager; Rutger Bosland, Chief Innovation and Offshore Technology Officer, formerly of Allseas where he led the design, build and test of the collector; Adam Price, Project Controls Manager. The reliance statement in section 25 lists the matters on which the QPs relied on TMC without independent review: macroeconomic assumptions, marketing, legal, environmental and community matters. Collector performance and costs are not on the list because they were authored by TMC officers as QPs rather than relied upon.

Appendix B. The ground: what TMC USA-A is

The application area is 65,187 km² in one block, divided into A-A (41,008 km²) and A-B (24,179 km²). A-A East is NORI-D, the PFS ground, held by TMC's Nauruan subsidiary under an ISA exploration contract. A-A West is TOML-F, the eastern block of the Tongan subsidiary's contract, covered only by the IA. A-B has no ISA contract, no study and no samples; the application assigns it "200 Mt of exploration potential" by assuming 10 kg/m² over 20,000 km². The 619 Mt headline is East plus West.[37]

[36] Nimmo, "The 'competent person' in mine-site evaluation and reporting", ISA workshop on polymetallic nodule resource classification, Goa, October 2014; AMC Consultants, "Reporting of seafloor Mineral Resources"; TMC Form S-1/A Exhibits 23.4 and 23.5 (2022); Parianos, Lipton and Nimmo, "Aspects of Estimation and Reporting of Mineral Resources of Seabed Polymetallic Nodules", 2021.

[37] Application ss.2–3 and Figure 90; IA Table 11.1. The IA's own life-of-mine plan for TOML-F assumes three 20 m collectors per vessel, 7 Mtpa per vessel, slopes to 6°, 85% collection efficiency and a start in 2037 after "a decade of experience" on NORI-D.

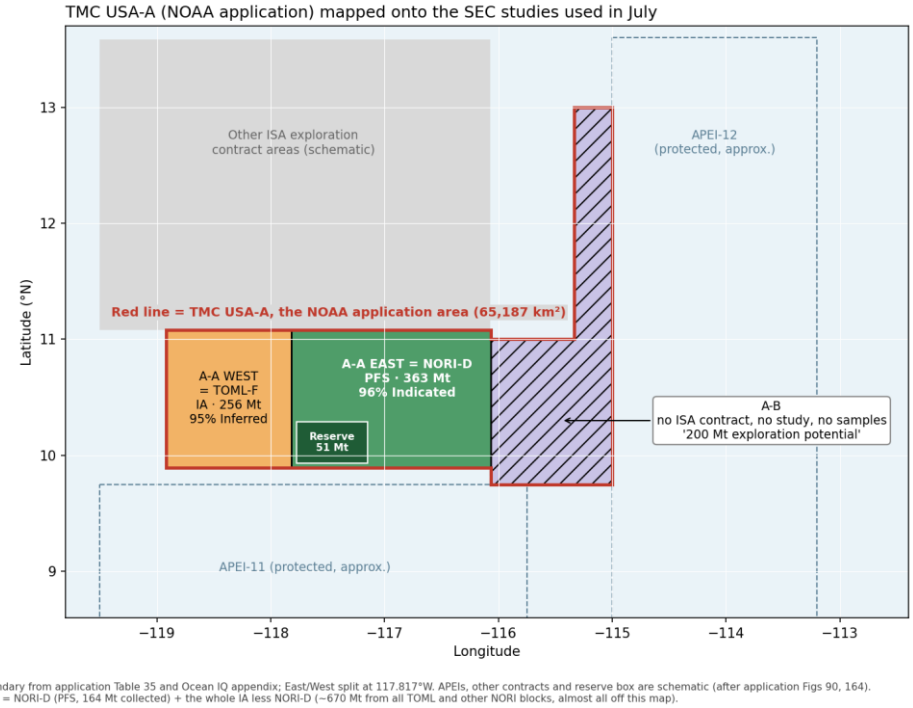


Figure B1. TMC USA-A as applied for, mapped onto the SEC studies. Boundaries from the application's coordinate tables; APEIs, neighbouring contract areas and the reserve box are schematic.

Sub-area	Study	Resource (Mt wet)	Classification	Reserve	Sampling
A-A East (NORI-D), ~25,200 km²	PFS	363	5 Measured, 347 Indicated, 11 Inferred	51 Mt Probable	287 box cores (PFS Tables 7.3–7.6); AUV over ~2.5%
A-A West (TOML-F), ~15,800 km²	IA	256	12 Indicated, 244 Inferred	None	25 TMC box cores, 4 dredges, Pioneer-era grabs
A-B, 24,179 km²	None	"200 Mt potential"	Not a resource	None	None

Table B1. The three sub-areas.

Appendix C. Survey history and instruments, 2012–2024

Year / campaign	Vessel	Contractor	What was done	Coverage
2012, Campaign 1	Mt. Mitchell	NORI	Hull-mounted Kongsberg EM120 multibeam: bathymetry and backscatter; dredge sampling	Whole of NORI-D at ~30 m cells
2017 (office)	—	—	Reprocessing of the 2012 backscatter, used in target selection for the 2018 AUV survey (PFS Table 7.1)	—
2018, Campaign 3	OSV Maersk Launcher	Fugro; MARGIN aboard	Hugin AUV: multibeam, side-scan, sub-bottom, camera at 6 m; 45 box cores on a 7 km grid	2,286 line km, ~375 km²
2019, Campaign 6A (19 Aug–3 Oct)	Maersk Launcher	Leap Energy, Bluefield	105 box cores on a 10 km grid; 299 line km AUV	—

Year / campaign	Vessel	Contractor	What was done	Coverage
2019, Campaign 6B (10 Nov–21 Dec)	Maersk Launcher	Leap Energy, Bluefield, ERIAS	101 box cores, most displaced from the grid (Finding 1)	—
2022, Campaigns 7A/7B	Hidden Gem	Allseas, TMC	Test mining with a 6 m collector: 4,500 t collected, 3,000 t lifted at 86 t/h; 22 pre- and 14 post-mining cores	Test field only
2023–24, Campaign 8	Maersk Launcher	THRE360, Bluefield	AUV over runs 19 and 20: 196 line km sonar, 245 line km camera; 6 cores	~246 km²

Table C1. The campaigns. Sources: PFS s.7 and Table 7.1; application s.2.

Instrument	Height above seabed	Resolution	What it shows
Hull multibeam (EM120, 12 kHz), 2012	4,500 m	~30 m cells	Depth and slope; backscatter as a coarse proxy for hard, rough ground. Correlation with measured abundance 0.29 (PFS Figure 11.13): tells nodule fields from bare mud, not 12 from 25 kg/m²
AUV multibeam and side-scan, 2018–24	~50 m	~1 m	Terrain and geo-obstacles: pits, ridges, outcrop
AUV camera, 2018–24	6 m	centimetres, swath a few metres	Nodules counted and sized; weight estimated by regression on core weights (PFS s.7.2.10)
Box corer, 0.75 m²	On the seabed	One point	Nodules weighed wet on deck and ashore; assayed in duplicate (ALS, Bureau Veritas)

Table C2. What each instrument resolves. Radar does not penetrate seawater; only sound does, and no sonar resolves a 2–10 cm nodule from a hull.

Appendix D. Kriging in plain terms, with a worked example

Kriging answers the question: given a handful of measured cores around an unmeasured point, what weight should each core have in the estimate? The weights come from the variogram. Two cores close together are assumed to resemble each other; two far apart are not; and two cores close to each other but both far from the point being estimated share information, so together they earn less weight than two cores at the same distance in different directions.

Consider the estimation point at E490,000 N1,125,000, in the western reserve area, with the nearest cores 2 to 9 km away. Using the PFS variogram, the nearest core at 2.1 km receives a weight of 0.59; the next two, at about 5 km, receive 0.09 and 0.08; the remainder, at 6 to 9 km, share the rest. The estimate is 17.2 kg/m² with a kriging standard deviation of 4.4. The nearest core reads 18.9, so the estimate is pulled only part of the way from the block mean of 17.4 towards it.[38] Now move the estimation point to a panel with no core within 6 km, which is most of NORI-D at 10 km spacing. Every surrounding core is beyond the range; each gets roughly the same small weight; the estimate is the local average of the ring of cores, close to 17.4, with a standard deviation near the full sample spread.

[38]Ordinary kriging with the PFS Table 11.6 model expressed as covariance: 0.6 spherical (6 km) + 0.3 spherical (20 km) + 0.1 nugget, scaled to the sample variance. Koinon computation on the printed coordinates; the example is illustrative and not AMC's own run, whose full parameter set is not published.

The panel is reported at about the block mean not because anything was measured there but because nothing was.

That is why the map of 3.5 km panels shows no panel below 12 while individual cores read 0.1, 0.3 and 0.8. The panel value is a smoothed average of neighbours; the core is a measurement. Both are honest; they answer different questions. A reserve, which is tonnes over years, can rest on the first. A collection lane, which is 15 m wide, cannot.

Appendix E. Methods and accuracy of Koinon's computations

- Core positions: PFS Tables 7.3–7.8, UTM zone 11N as printed; converted to latitude and longitude by a plane approximation (positions good to about 1 km on the geographic maps; exact in the UTM map of Figure 6).
- Lattice fits: least-squares fit of a rotated square lattice (orientation, two spacings, origin) to each cruise by Nelder–Mead from a grid of starts; departure is the distance from each core to its nearest lattice node. Random-point baselines were fitted the same way and give 2–3 km RMS.
- Pair counts and semivariance: all 37,128 pairs of the 273 pre-mining cores; semivariance is half the squared difference of abundance, averaged by distance bin.
- Territory shares: each point of a 500 m grid over the convex hull of the cores coloured by the cruise of its nearest core (Voronoi); the hull, 21,200 km², is a proxy for the block. Shares are of nearest influence, not survey boundaries.
- Reserve polygon: the cyan hatch of application Figure 90 extracted by colour, its convex hull taken, and the figure frame fitted to the A-A East boundary; area 6,511 km² against the application's "approximately 25%" of the resource. Accuracy 1–2 km. Production strip: the green strip of application Figure 73 extracted by colour and georeferenced on the figure's printed UTM grid; accuracy about 0.5 km.
- Conditional simulation (section 4.4): Gaussian random fields on a 1 km grid over the hull of the cores (21,200 km²), generated by circulant embedding with spherical covariances; point variance set to the sample variance of the 273 pre-mining cores (27.7); conditioned on the cores by adding the kriged residual, so that each field passes through every core at its measured value; clipped at zero. Scenario A: 70% of variance at 4.2 km (the geometric mean of the PFS's 6 km and 3 km directional ranges, the field being isotropic), 20% at 20 km (the PFS's second structure is 140 km by 70 km; the shorter range gives Scenario A somewhat less continuity than TMC's model), 10% nugget; B: 70% at 20 km, 20% at 60 km; C: 70% at 1 km, 20% at 4 km; D: 90% at 0.7 km, 10% at 4 km. Twenty draws per scenario; fifty for the scenario A panel statistics. The 1 km grid under-resolves scenario D. Lane simulation: the traced runs 19–20 centreline resampled at 1 km, abundance read from each simulated field, annual yield = track length per year (0.4 m/s × 75% of hours × 85% field efficiency) × 15 m × mean abundance × 77%.
- Schedule attribution (Figure 7, Table 8): application Table 44 annual quantities, assigned in order to runs 19–20 (3 Mt), the rest of the reserve (to 51 Mt), NORI-D outside the reserve at the application's 46% conversion (to 164 Mt) and TOML-F/A-B (the remainder). The order is the application's own sequence; the split of the last 39 Mt is Koinon's.

Appendix F. Sources and about this note

AMC Consultants Pty Ltd, Technical Report Summary of Prefeasibility Study of NORI Area D, Clarion Clipperton Zone, effective 4 August 2025 (TMC Form 10-Q Exhibit 96.1). AMC Consultants Pty Ltd, Technical Report Summary, Initial Assessment of TOML and NORI Properties, Clarion-Clipperton Zone, effective 4 August 2025 (Exhibit 96.2). TMC USA LLC, Consolidated Application for an Exploration License and Commercial Recovery Permit, TMC USA-A, as published by NOAA 19 August 2026,

NOAA-NOS-2026-1751-0002. 15 CFR Parts 970 and 971; 17 CFR 229.1300–1305. Parianos, Lipton and Nimmo, Aspects of Estimation and Reporting of Mineral Resources of Seabed Polymetallic Nodules, 2021. Koinon Consulting, Case Not Proven: The Economics of Deep-Sea Mining, July 2026, and model DSMKoinon v20. Emerman, S.H., Implications of The Metals Company Pre-Feasibility Study for Next Steps by the Company, report commissioned by the Deep Sea Mining Campaign, Greenpeace International and MiningWatch Canada, Malach Consulting, Spanish Fork, Utah, 21 January 2026, revised 25 February 2026. Iceberg Research, The Pre-feasibility Study Assumptions Confirm that TMC's Economics don't Work, 18 August 2025, and The Metals Company — A Remake of the Nautilus Fiasco, 27 May 2025. Barnard, M. and Trytten, L., A techno-economic assessment of seabed mining — American Samoa and global implications, National Ocean Protection Coalition, August 2025. CIM, Estimation of Mineral Resources and Mineral Reserves Best Practice Guidelines, 2019; JORC Code, 2012.

About this note. Koinon Consulting has advised more than fifteen governments on mining contracts and fiscal terms. It has no relationship with any seabed minerals contractor and holds no interest in any seabed minerals project. This note was prepared for the Natural Resources Defense Council. Koinon's prior work on deep-sea mining economics, on which it draws, was carried out with the Oceano Azul Foundation, Oceans North, the Deep Sea Conservation Coalition and IUCN, each of which publicly supports a moratorium. We state this plainly because readers are entitled to weigh it. The test we invite is whether the documents say what we report them as saying.