Typhoon Avoidance — a Weather-Routing Case Study

Isochrone optimisation vs a straight run through a typhoon, southwest Japan → East China Sea approaches, 5–8 Aug 2026.

ROUTE	**34°N 137°E → 28°N 122°E · 3 waypoints · laden**	PLAN	**Best-ETA · constant 14.0 kn STW · ETD 05 Aug 2026 ~08:00 UTC**
ENGINE BUILD	**WindMar v0.2.3 · b193 · Mode A (constant-power isochrone)**	FORCING	**NOAA GFS 0.25° winds · CMEMS WAV 1/12° seas · SMOC currents**

ROUTE	FUEL	Δ VS BASE	PASSAGE	DISTANCE	AVG SOG	MAX ROLL
Baseline — held through the system	71.9 MT	—	69.2 h	943 nm	13.6 kn	**33.9°**
Optimised — isochrone	68.4 MT	**−4.9% (−3.5 MT)**	69.0 h	981 nm (+38)	14.2 kn	**17.0°**

Both routes evaluated over the same weather at the same constant 14.0 kn STW. ETA 08 Aug 06:58 UTC (optimised) vs 07:10 UTC (baseline).

Storm state at analysis (forecast valid 07 Aug 2026). A compact, deepening **typhoon** lies southwest of the Ryukyu Islands near Okinawa, central pressure ≈ **968 hPa**. Sustained winds reach Force 10 (~50 kn) along the intended track and gust to ≈ **108 kn (Beaufort 12)** at the core, raising significant wave heights above 10 m. The centre sits astride the direct line between 34°N 137°E and 28°N 122°E, so the rhumb-line route crosses the core while the optimised track passes to its northwest.

What the case shows

- **The headline is seakeeping, not fuel.** The optimised track hard-avoids the typhoon core; peak significant roll falls **33.9°** → **17.0°** and crux-point Hs drops **7.4 m** → **5.8 m** (07 Aug 05:57 UTC). The −4.9% fuel is the honest bonus.
- **The saving is routing alone.** Engine speed is held constant (14.0 kn STW on every leg). The baseline is dragged to 13.6 kn avg SOG by added resistance in the seaway, so the +38 nm optimised track still arrives 0.2 h *earlier* on less fuel — calmer water, same power.
- **The dodge is a hard exclusion.** Wavefront cells inside the storm wall (Hs > 6 m / wind > 45 kn) are dropped from the search — the only reliable route-bender in the engine. The soft roll-resonance cost term biases tie-breaks only.
- **Validated on the shipped configuration.** Mode A, production flag set, a genuine free-drawn 3-waypoint route — it optimises, it does not degenerate to baseline.

Savings are quoted against a naive straight run held on the drawn track, never against an actual sailed voyage — a prudent master would also dodge. Not for navigation.

1 · The threat

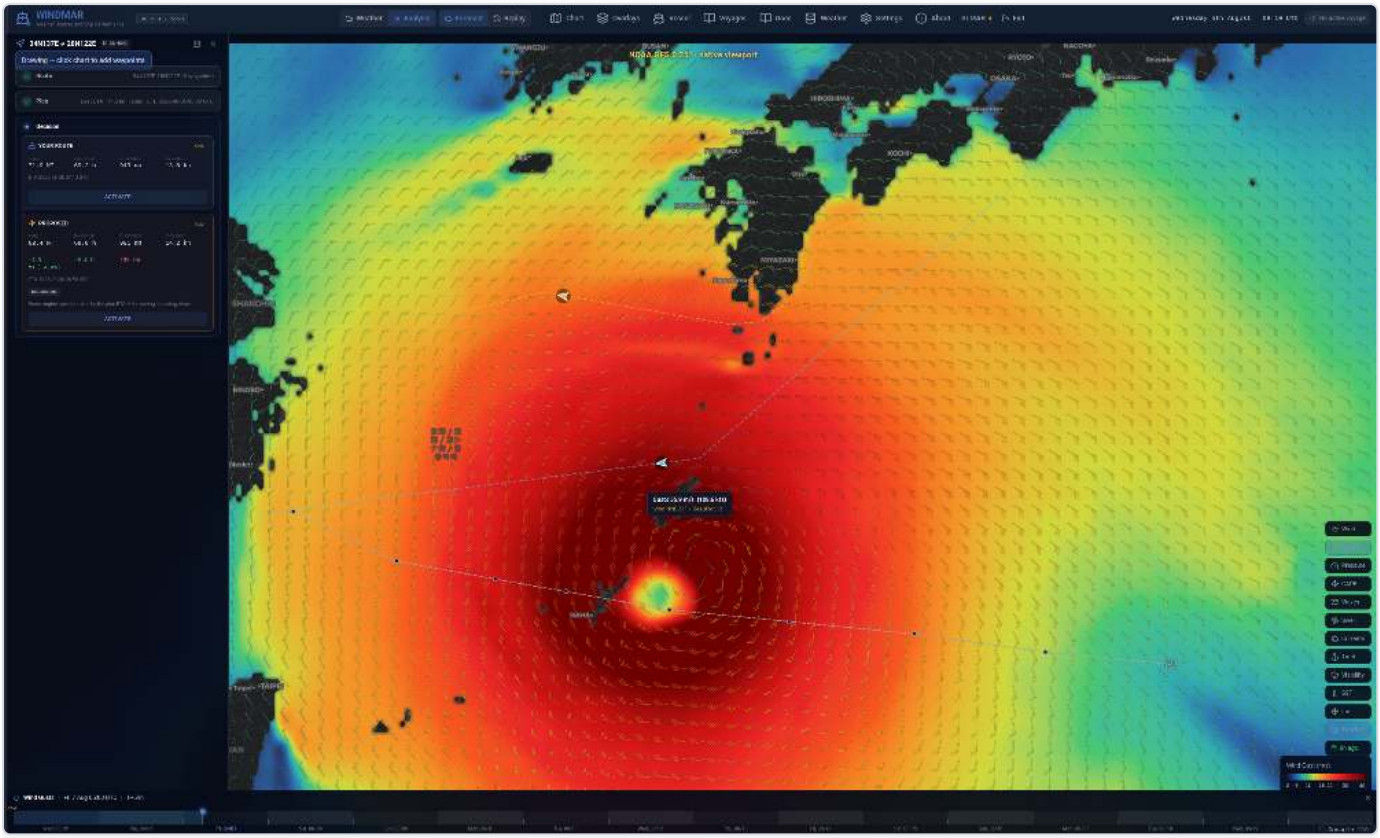

Fig 1 **Wind gusts at the core — Beaufort 12**

The forecast field for 07 Aug shows a compact, deepening typhoon off Okinawa with gusts of **55.9 m/s (108.6 kts, Beaufort 12)**. The operator's drawn track (blue, dashed) runs the vessel straight across the core; the isochrone proposal (amber) has not yet been activated.

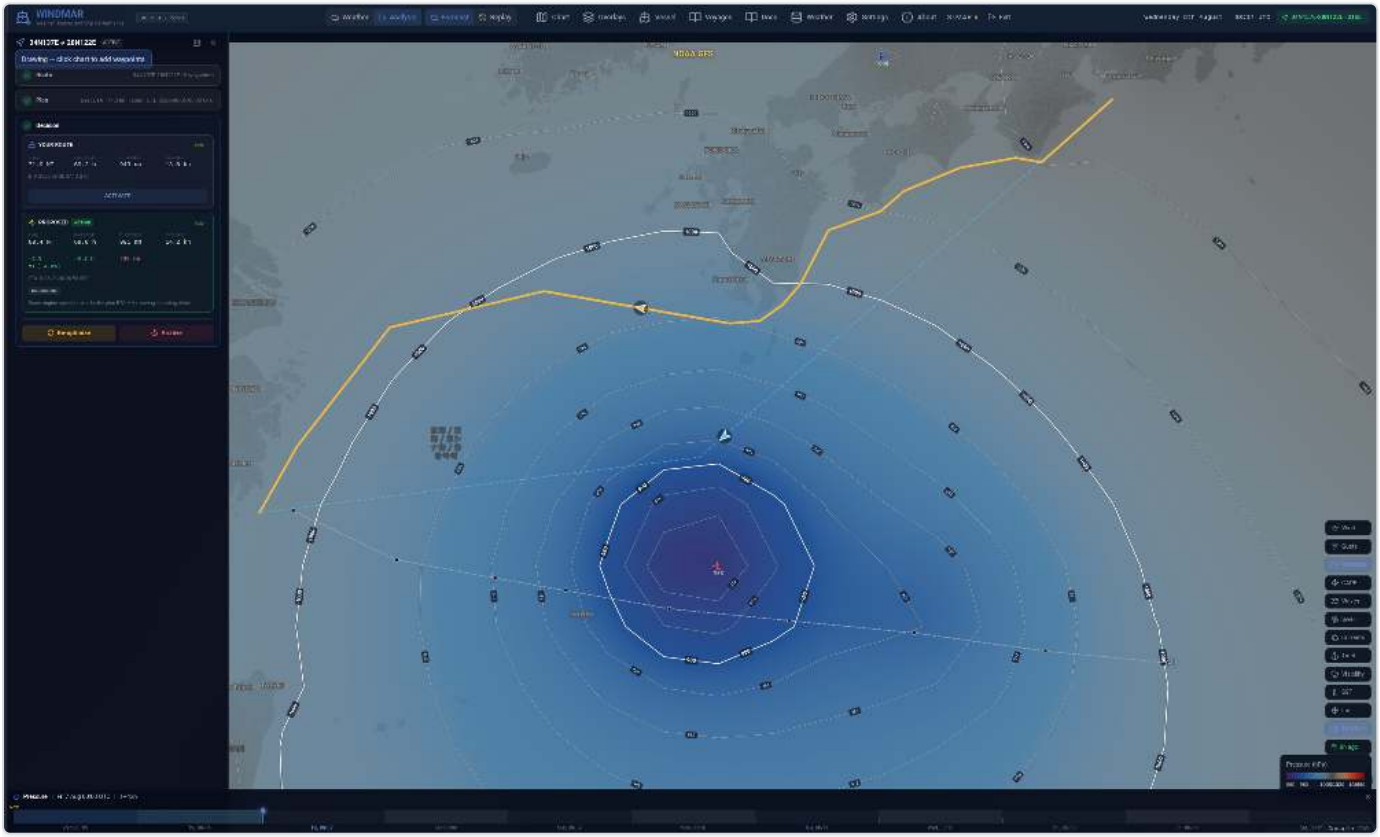

Fig 2 **Mean-sea-level pressure — a 968 hPa low**

The same system as concentric isobars around a **968 hPa** centre. The baseline threads the 968–980 hPa core; the optimised track holds out near the 1000 hPa isobar, north and west of the centre.

2 · Avoiding the seaway

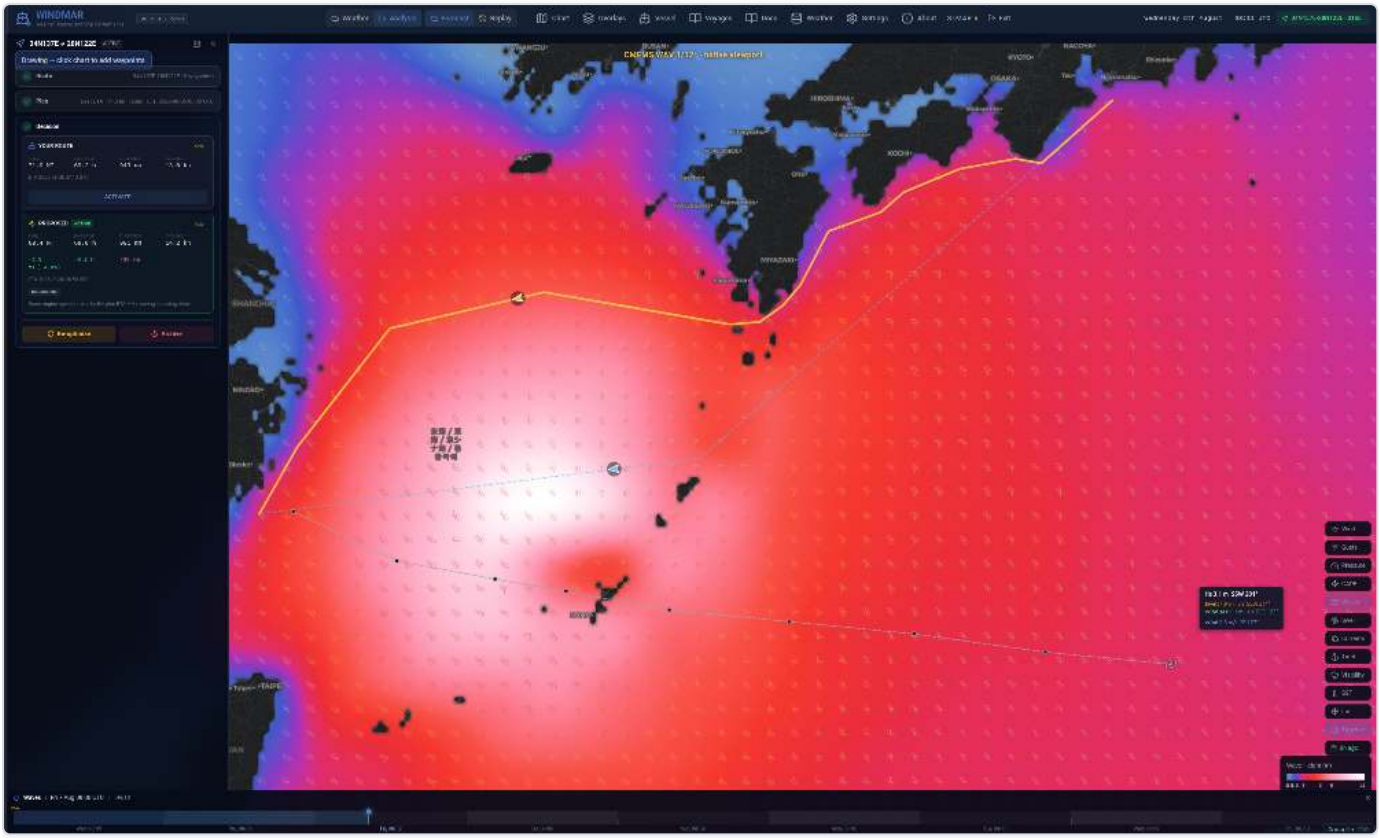

Fig 3 **Significant wave height (CMEMS WAV 1/12°)**

With the proposal activated, the optimised track (amber) bows northwest to skirt the high-Hs core (white), while the baseline (blue) drives through it. At the crux the two routes see **5.8 m vs 7.4 m** Hs.

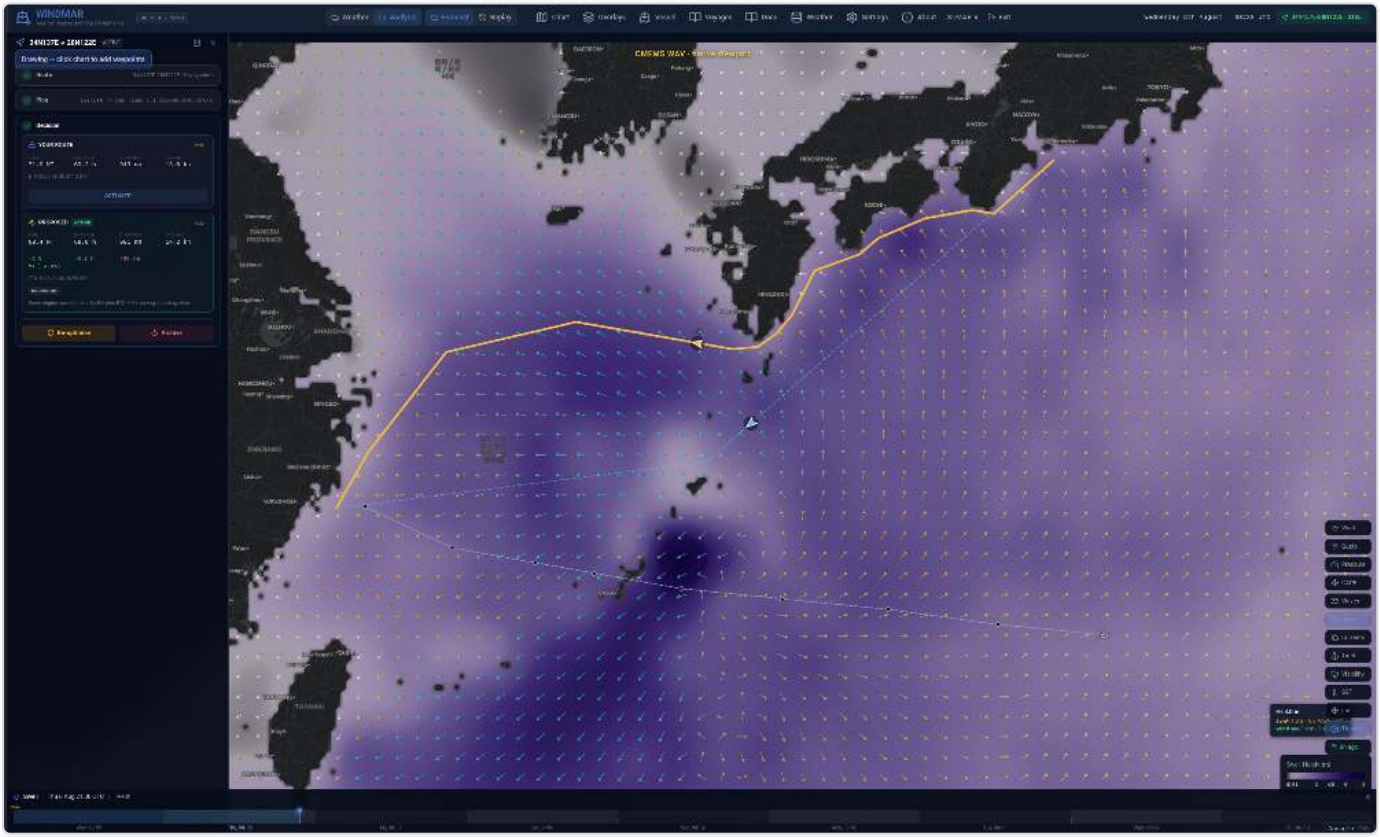

Fig 4 **Swell field — the same avoidance**

The swell component (CMEMS WAV) tells the same story: the optimised track stays in the lighter band while the baseline runs into the dark, high-swell water south of the centre near Naha.

3 · Wind exposure along the two tracks

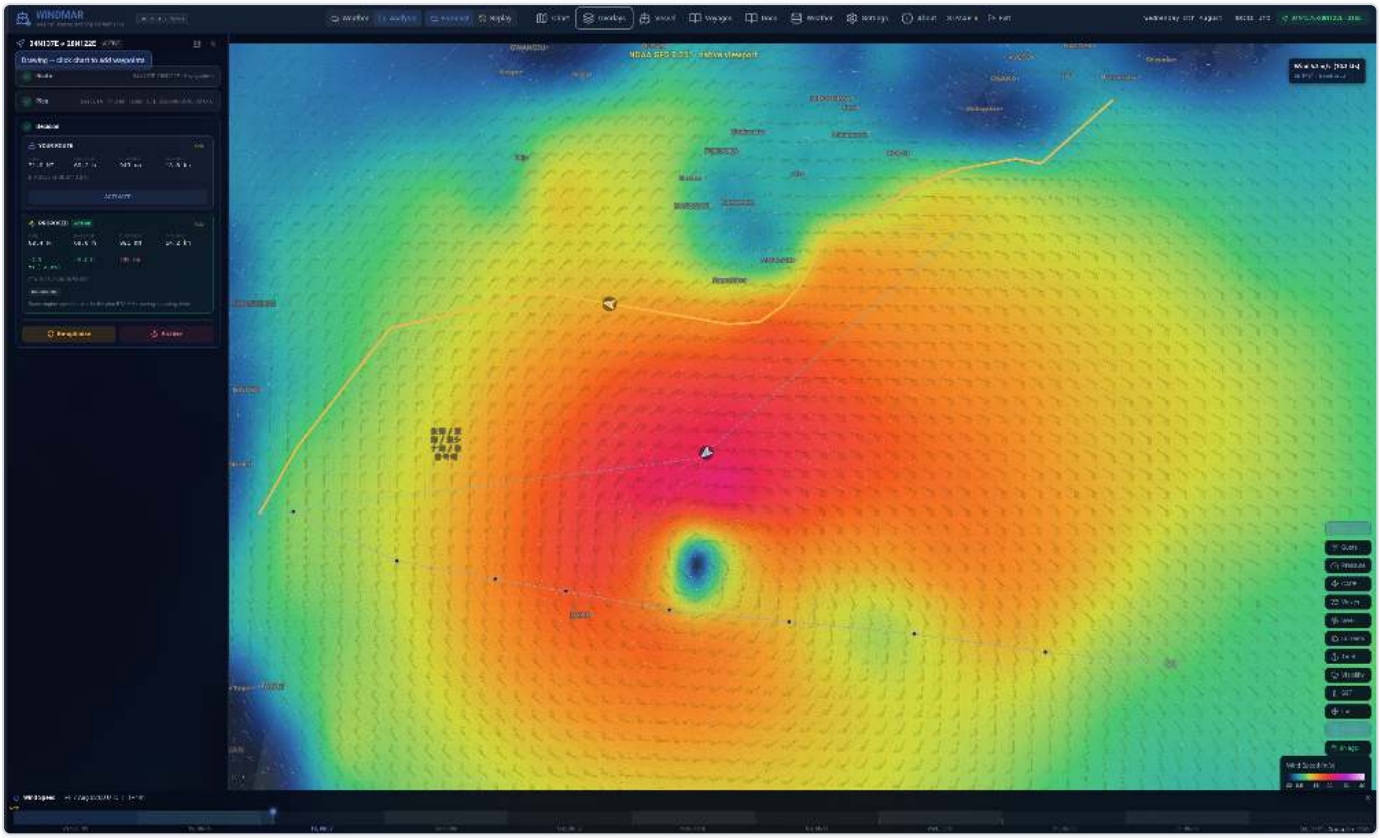

Fig 5 **Wind speed — the eye**

Sustained wind speed (NOAA GFS 0.25°) resolves a clean eye. The optimised track keeps the vessel in the yellow–green margin; the baseline crosses the red wall on both approach and departure legs.

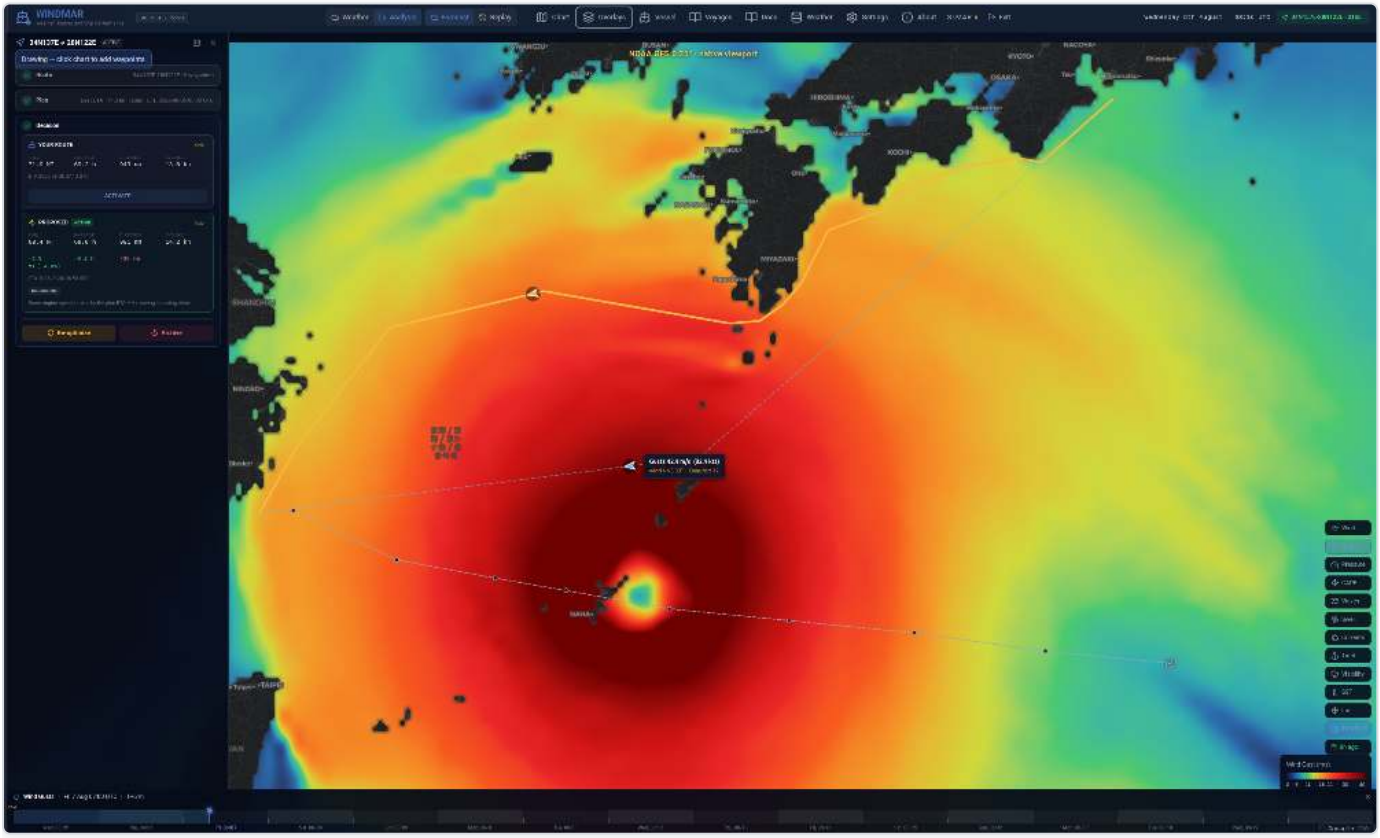

Fig 6 **Gust exposure on the baseline**

Sampling the baseline near the centre returns **42.4 m/s (82.4 kts, Beaufort 12)** — sustained storm-force exposure the optimised route removes entirely.

4 · Outcome & seakeeping

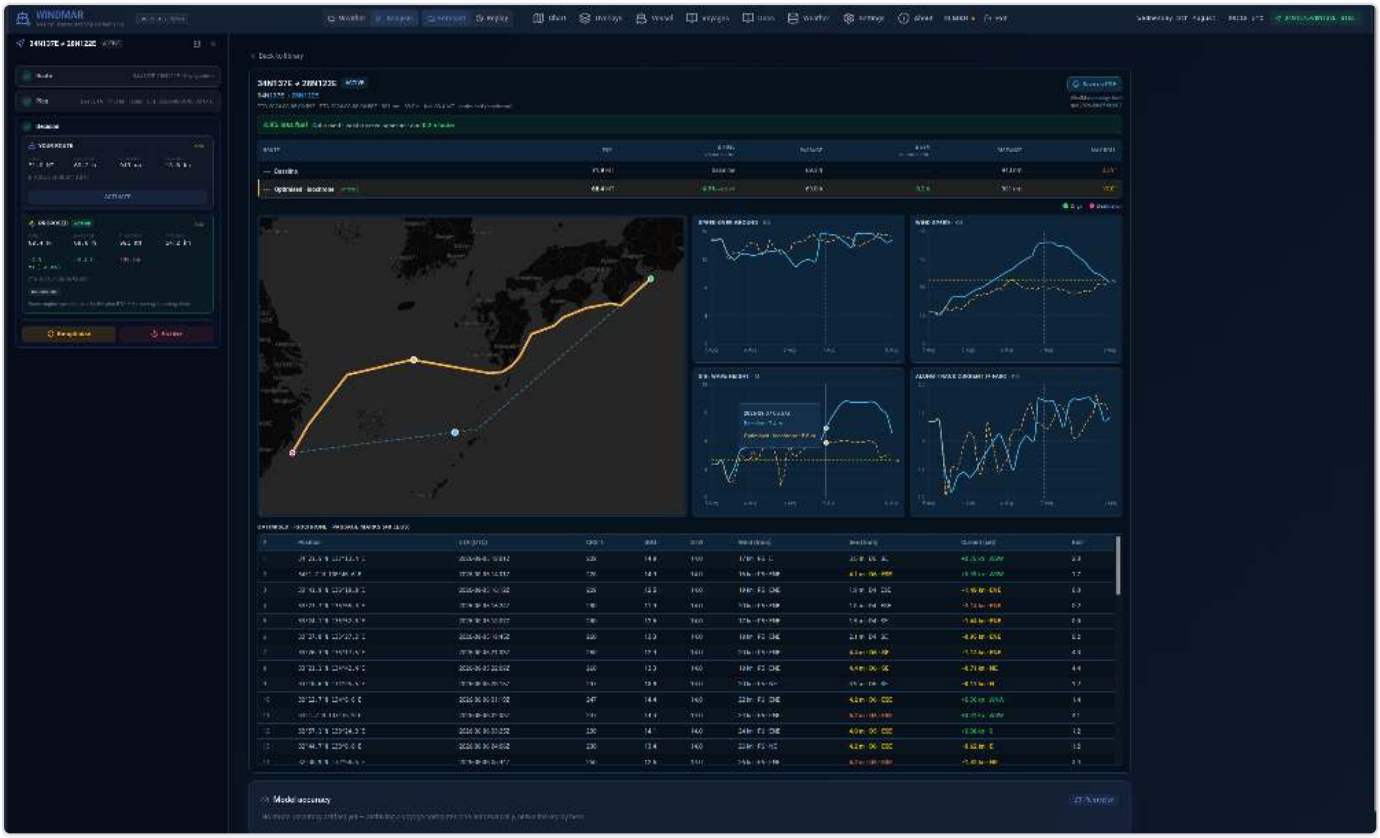

Fig 7 **Passage brief — per-leg accounting**

The comparison brief: −4.9% fuel and 0.2 h faster at constant STW. The 48-leg table and the SOG / wind / Hs / current profiles are computed on one consistent per-segment surface, so the two routes are directly comparable.

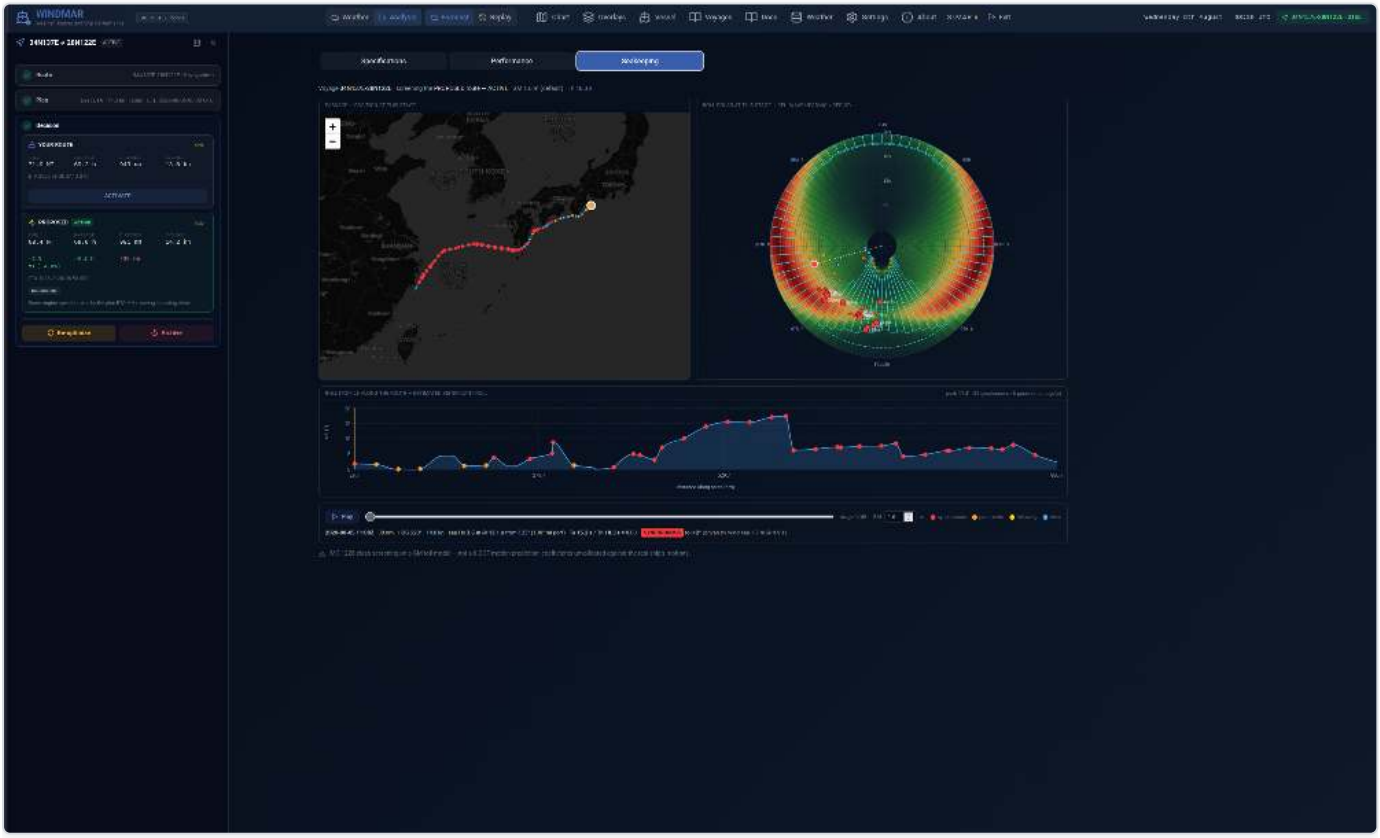

Fig 8 **Seakeeping screening of the chosen route**

IMO-1228-class roll screening (GM 1.6 m, Tn 18.3 s): peak **17.4°**, with 32 synchronous + 6 parametric stages concentrated in the first ~250 nm (Te/Tn ≈ 0.83). A resonance indicator, not a 6-DOF prediction.

Method & honesty notes

What the baseline is

The baseline is the operator's **drawn three-waypoint track held through the system**, weather-evaluated at the same constant 14.0 kn STW as the optimised route. It is a naive straight run, **not an actual sailed voyage** and not a rhumb-vs-great-circle artefact (the route carries three genuine waypoints). Every saving in this study is quoted against that straight run — never against what a prudent master would sail, who would also avoid the storm.

Why less fuel over a longer track

Engine order is unchanged — 14.0 kn STW on every leg of both routes. In the seaway the baseline loses speed to added resistance (13.6 kn avg SOG); the optimised track holds ~14.2 kn in calmer water. So the +38 nm route arrives 0.2 h earlier on 3.5 MT less fuel. The saving is routing, not slow-steaming.

How the route is bent

The isochrone wavefront prunes survivors by distance-to-destination; a graded cost penalty only breaks ties. The storm dodge is therefore produced by the **hard severity wall** — cells with Hs > 6 m or wind > 45 kn are dropped from the search, a hard exclusion equivalent to extending the land mask. The soft roll-resonance term (weighted into search cost) refines the chosen path but does not, on its own, reliably divert.

What the seakeeping figure is — and is not

The 17.4° peak roll is **IMO-1228-class screening on a GM roll model** — a synchronous / parametric resonance indicator computed from the route's heading, speed and encountered sea. It is **not a 6-DOF motion prediction, and its coefficients are unvalidated against the real ship's motions.** Read it as a relative safety margin (half the baseline's peak), not an absolute guarantee.

Configuration

WindMar v0.2.3, build b193, Mode A constant-power isochrone, on the shipped production flag configuration (Mode B dark). Winds NOAA GFS 0.25°; seas CMEMS WAV 1/12°; currents SMOC. Forecast vintage 05 Aug 2026 08:06 UTC. Figures are screenshots of the live application at that vintage.