



FACT SHEET: Paper Nautical Charts

Accuracy and reliability of Paper Nautical Charts

The accuracy and reliability of paper nautical charts are inherently variable and cannot be expressed in absolute terms. Rather than being simply categorised as accurate or inaccurate, charts must be understood as representations of data compiled from hydrographic surveys of differing quality, age and methodology. Mariners operating in unfamiliar waters must possess the skills needed to interpret chart information critically and appropriately.

Nautical charts are derived from multiple surveys conducted over extended periods using a range of technologies. As a result, the underlying data is not uniform in quality.

Areas subject to high volumes of commercial shipping are generally surveyed more frequently and to a higher standard, often reflecting modern positioning systems and comprehensive seabed coverage. Conversely, remote or infrequently trafficked areas may rely on older surveys, where positional accuracy and feature detection are comparatively limited.

A paper nautical chart should therefore be regarded as a composite product, integrating numerous individual surveys into a single representation of the marine environment. The reliability of any given area within the chart is dependent upon the characteristics of the surveys from which it is derived.

Zone of Confidence

To support the assessment of chart reliability, paper nautical charts incorporate the Zone of Confidence (ZOC) classification system. This system provides a standardised method of indicating the quality of survey data, based on four key criteria:

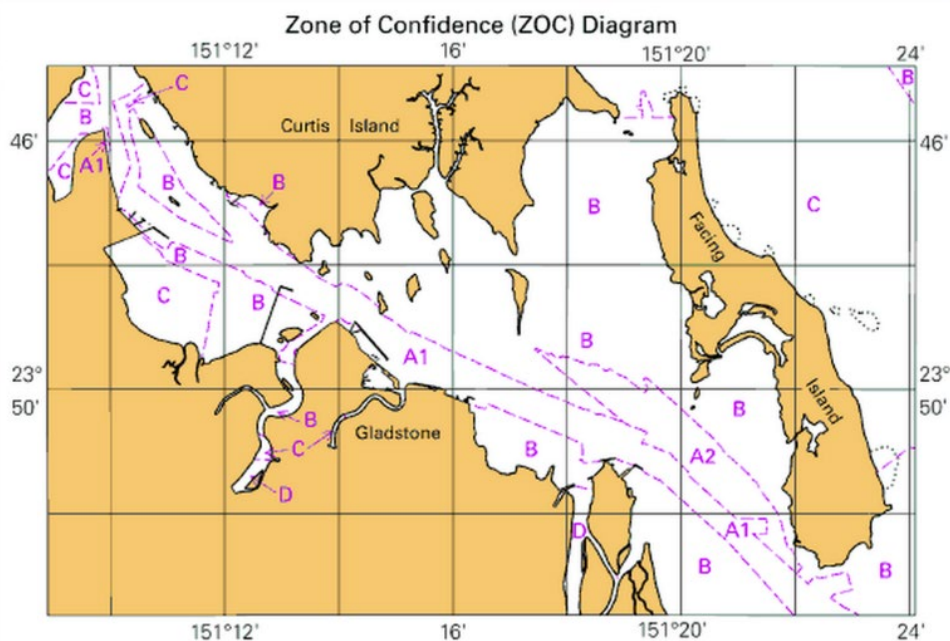
- horizontal (positional) accuracy
- vertical (depth) accuracy
- degree of seafloor coverage and feature detection
- survey methodology and characteristics

Of these, the most important is the assessment of seafloor coverage, as this determines how much clearance should be maintained between a ship's keel and the seabed in most areas, and where any additional precautions may need to be taken.

Each area of a chart is assigned a ZOC category based on the lowest-rated criterion, ensuring a conservative representation of confidence.

The principal ZOC categories are:

- **ZOC A1 and A2:** High-quality, modern surveys with near-complete seabed coverage and high positional accuracy. These areas provide a high degree of confidence, and the existence of uncharted hazards is considered unlikely.
- **ZOC B:** Surveys that are generally reliable for navigation; however, smaller seabed features may remain undetected. Appropriate safety margins should be maintained.
- **ZOC C:** Surveys of variable quality. The presence of uncharted hazards should be anticipated, particularly in areas of complex or dynamic seabed conditions.
- **ZOC D:** Data of poor quality or limited extent, often derived from historical or incomplete surveys. Significant hazards, including those extending toward the surface, may be present. ZOC D includes unsurveyed areas.
- **ZOC U:** Areas where data has not been formally assessed. These should be treated with the same level of caution as the lowest confidence categories.



ZOC CATEGORIES

(For details see Mariners Handbook for Australian Waters AHP 20)

ZOC	POSITION ACCURACY	DEPTH ACCURACY	SEAFLOOR COVERAGE
A1	±5m + 5% depth	=0.50m + 1% <i>d</i>	Significant seafloor features detected.
A2	±20m	=1.00m + 2% <i>d</i>	Significant seafloor features detected.
B	±50m	=1.00m + 2% <i>d</i>	Uncharted features hazardous to surface navigation are not expected but may exist.
C	±500m	=2.00m + 5% <i>d</i>	Depth anomalies may be expected.
D	Worse than ZOC C	Worse than ZOC C	Large depth anomalies may be expected.
U	Unassessed – The quality of the bathymetric data has yet to be assessed.		

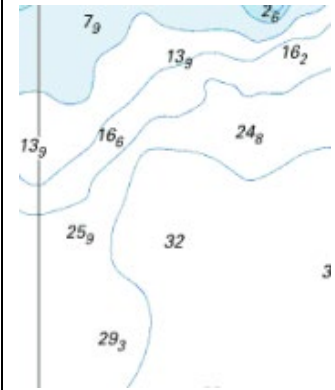

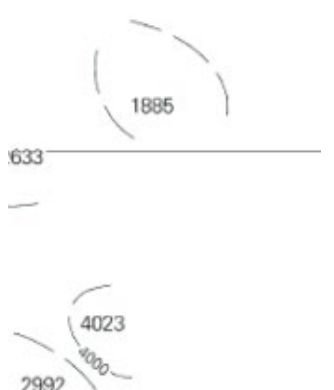

Interpretation and operational application

Effective use of paper nautical charts requires careful consideration of both ZOC classification and local seabed characteristics. In particular, the degree of seafloor coverage is critical, as it directly influences the likelihood of undetected hazards.

Mariners should adjust under-keel clearance and operational margins in accordance with the ZOC category, vessel characteristics, and prevailing environmental conditions. In areas of lower confidence (ZOC C, D and U), conservative navigation practices are essential. These may include increased safety margins, reduced speed, enhanced visual observation, and, where appropriate, supplementary reconnaissance measures.

Additional quality indicators on Paper Nautical Charts

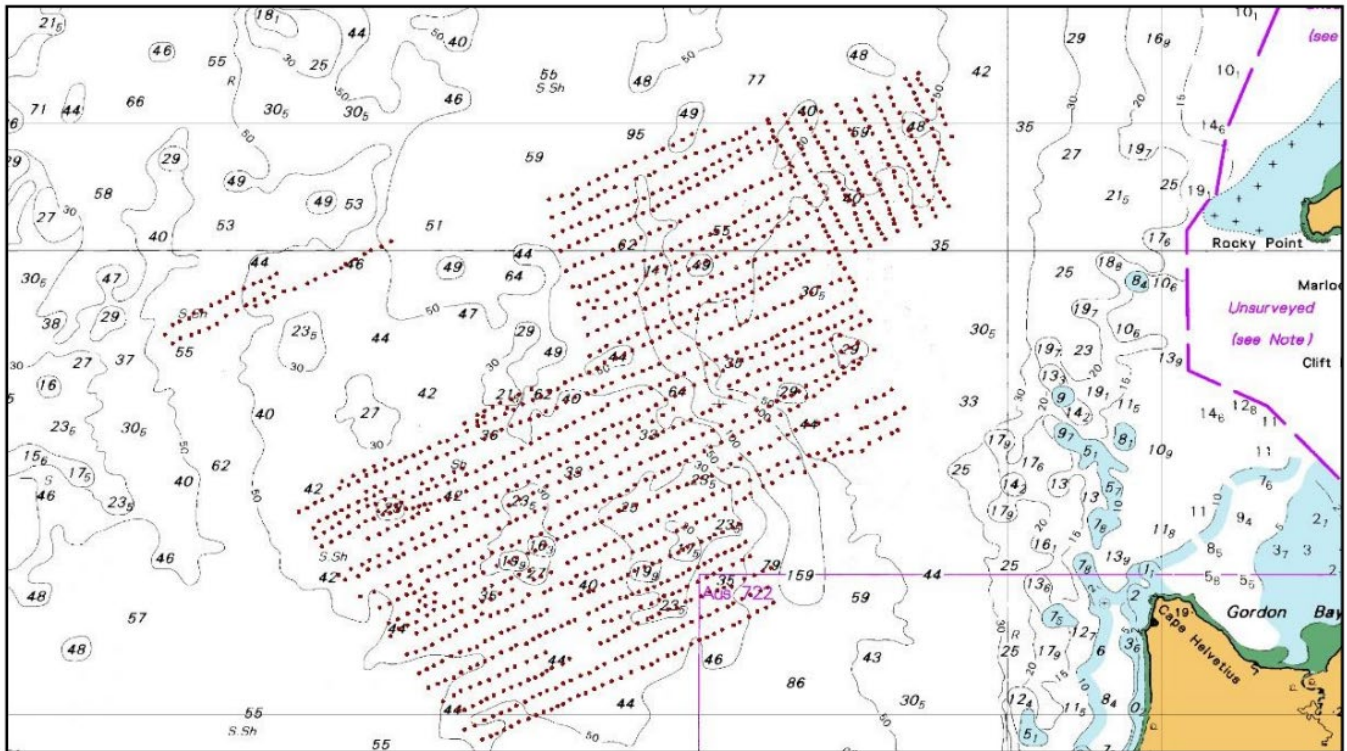
In addition to the ZOC classifications and diagrams, paper nautical charts incorporate further indicators to assist in assessing data reliability. The presentation of depths and depth contours provides supplementary information regarding the quality and precision of the underlying survey data. These cartographic conventions enhance the interpretation of the ZOC classification and should be considered by mariners when evaluating charted information.

Normal depth sounding symbology	Approximate depth sounding symbology		
ZOC A1, A2, B, good ZOC C	Poor ZOC C and all ZOC D		
3₇	3₇	3₇	
Continuous depth contours ZOC A1, A2, B, good ZOC C	Dashed depth contours Poor ZOC C	Broken and discontinuous depth contours ZOC D	Unsurveyed area ZOC D
			

Evolution of hydrographic surveys

Early surveys (pre-1940s)

Early hydrographic surveys relied on manual positioning methods, such as sextant observations, and depth measurements obtained using lead lines. These techniques were subject to significant positional uncertainty, with potential errors of several hundred metres. In addition, seabed coverage was limited to discrete sounding lines, increasing the likelihood that hazards between survey tracks remained undetected.



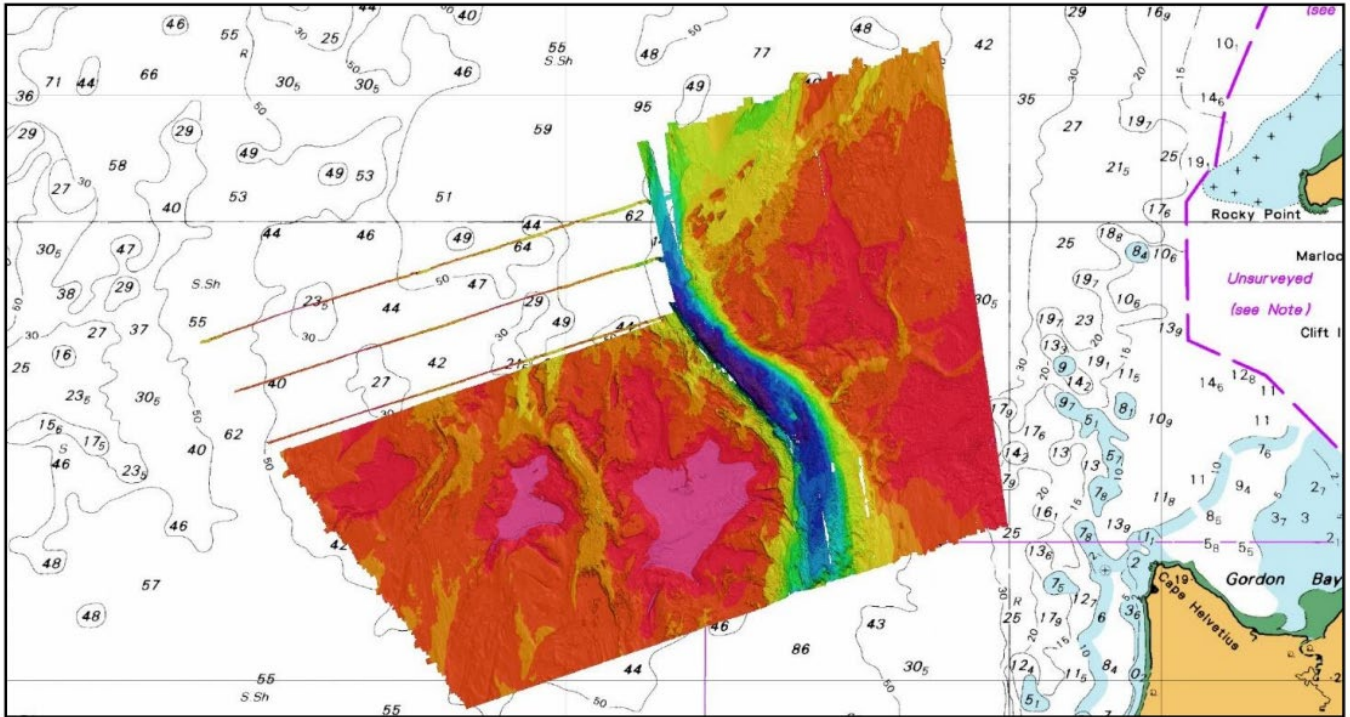
1945 single beam survey, approaches to Darwin

Mid-20th century surveys (1950s–2000)

Advancements in electronic positioning systems and echo sounding significantly improved survey accuracy from the mid-20th century onwards. The introduction of sonar technologies enhanced the detection of seabed features; however, full seabed coverage was not consistently achieved, and some uncertainty remained regarding undetected hazards.

Modern surveys

Contemporary hydrographic surveys employ advanced technologies, including multi-beam echo sounders and airborne laser systems. These methods provide high-resolution, near-complete seabed coverage, with dense data acquisition and precise positioning. As a result, modern surveys significantly reduce the likelihood of undetected features and provide the highest levels of navigational confidence currently achievable.



Modern multi-beam survey, approaches to Darwin

Conclusion

Paper nautical charts remain a fundamental component of safe navigation; however, their reliability is dependent on the quality and extent of the underlying survey data. The ZOC framework provides an essential tool for interpreting this variability. Safe navigation requires not only the use of charts, but also a comprehensive understanding of their limitations.