ENC-Bench: A Benchmark for Evaluating Multimodal Large Language Models in Electronic Navigational Chart Understanding

Supplementary Material

Overview of the Appendix

This appendix provides additional details on dataset construction, evaluation protocols, and experimental analysis:

- **Sec. A: Electronic Navigational Chart Primer.** Background on IHO S-57 vector structure, standardized symbology for point/line/polygon features, operational lighting modes, and scale-dependent rendering.
- **Sec. B: Dataset Construction Details.** Semantic decoding of binary S-57 files, conflict-graph algorithm for density control, and task-specific generation: visible property filtering, analytical ground truth computation, and procedural scenario simulation.
- **Sec. C: Evaluation Prompts.** Complete zero-shot prompt templates for all 10 benchmark tasks.
- **Sec. D: More Analysis of Results on ENC-Bench.** Fine-grained accuracy at varying error tolerances (Acc@T), performance comparison across distance/bearing/coordinate tasks, and analysis of the symbolic grounding gap between pixel and geographic localization.
- **Sec. E: Qualitative Analysis Case Studies.** 30 annotated case studies (Figures 5–34) demonstrating five error categories—Visual Perception, Reasoning, Knowledge, Calculation, and Instruction Following—across lighting modes and scale levels.
- **Sec. F: Limitations and Broader Impact.** Limitations of the current benchmark and the broader societal implications of deploying AI in safety-critical maritime navigation.

A. Electronic Navigational Chart Primer

Electronic Navigational Charts (ENCs) differ fundamentally from natural images and consumer maps commonly used in computer vision. ENCs are safety-critical geospatial databases governed by the *International Convention for the Safety of Life at Sea* (SOLAS) and encoded following the IHO S-57 standard. This section provides essential background to understand the domain-specific challenges in **ENC-Bench**.

A.1. Vector-Based Data Structure

Unlike pixel-based raster images, ENCs store data as object-oriented vector features with explicit geometric primitives (points, lines, polygons) and semantic attributes. Figure 1 contrasts consumer maps with ENCs: the latter employs standardized vector symbology defined by IHO S-57, encoding navigational semantics through formal geometric primitives rather than photorealistic textures. This symbolic representation ensures unambiguous interpretation across different display systems but challenges vision models trained on natural images.

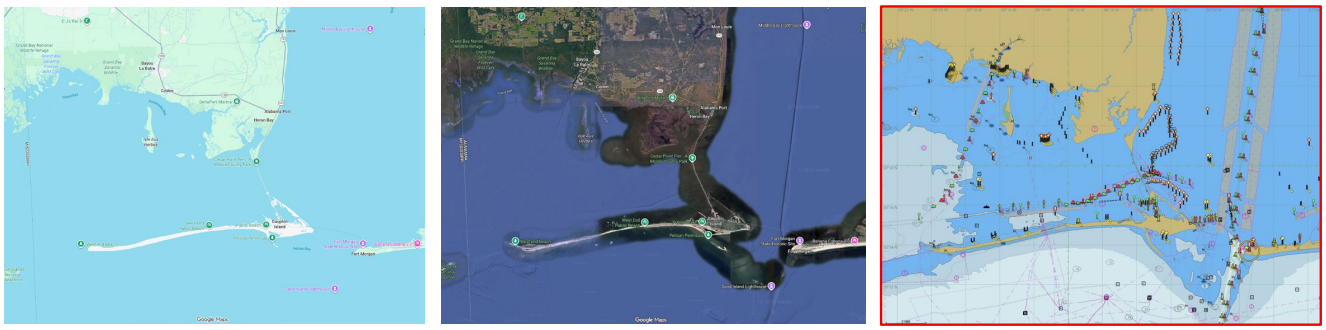
Figure 2 shows representative symbols for each geometric primitive type. Three feature types encode distinct navigational information:

- **Point Features:** Navigational aids (buoys, beacons, lights) are rendered based on categorical attributes. A single object class (e.g., "BOYCAR" for cardinal buoys) can manifest in numerous distinct visual symbols depending on cardinal direction (N/E/S/W), topmark configuration, color pattern, and light characteristics (color, rhythm, period). Models must map visual symbols to structured attribute combinations rather than recognizing holistic object appearance.
- **Linestring Features:** Linear objects encode both geometric constraints and directional semantics. Recommended tracks specify safe navigation paths through complex waters; submarine cable areas mark zones where anchoring risks infrastructure damage; depth contours indicate transitions between bathymetric zones. Critically, line direction often carries regulatory meaning: a traffic lane permits one-way vessel movement, while a bidirectional ferry route allows traffic in both directions. Interpreting these features requires associating geometric primitives with their regulatory meanings rather than detecting visual edges.
- **Polygon Features:** Polygons define legal and operational zones rather than physical boundaries. Traffic separation schemes mandate vessel routing patterns; anchoring areas specify permissible mooring locations; restricted zones prohibit or constrain entry. These regions represent operational constraints rather than visual objects, requiring models to reason about rule compliance instead of object segmentation.

A.2. Lighting Modes

Maritime navigation operates around the clock. To protect mariners' night vision during dark watches, ECDIS systems render charts in three distinct color schemes mandated by IHO S-52: **Day** , **Dusk** , and **Night**.

Figure 3 shows how the same chart transforms across these modes. Unlike adjusting screen brightness, mode switching involves systematic color remapping that creates



(a) Google Maps standard view (b) Google Maps satellite imagery (c) NOAA ENC

Figure 1. **Domain Contrast: Consumer Mapping vs. Professional Hydrography.** Comparison of the same geographic region across (a) Google Maps Standard View, (b) Google Maps Satellite Imagery, and (c) NOAA Electronic Navigational Chart (ENC). While consumer maps focus on road networks and vague water representations, ENCs illustrate a complex, vector-based hydrographic reality. Note how the ENC explicitly renders critical depth contours, shipping channels, and navigational aids absent in consumer views, prioritizing safety-critical information over visual realism.

two fundamental challenges for vision models:

- **Background Inversion:** Day mode employs bright backgrounds with darker symbols; Night mode reverses this to preserve night vision, using dark backgrounds with bright, high-contrast symbols. This inversion fundamentally changes visual patterns: the same buoy that appears as a dark icon in Day mode becomes a bright marker in Night mode. Models relying on consistent contrast polarity must adapt to these reversals.
- **Color Meaning Changes:** The S-52 standard defines distinct color palettes for each mode. Features do not simply darken or brighten—they undergo systematic color transformation to maintain discriminability against different backgrounds. Consequently, color alone becomes unreliable for feature recognition: a model must identify features through their geometric structure and symbolic form rather than learned color-category associations.

A.3. Scale-Dependent Rendering (SCAMIN)

In operational use, mariners frequently adjust chart scales—zooming out for regional route planning and zooming in for precise maneuvering. To maintain readability, the system implements scale-based feature filtering: less important objects hide at small scales and appear at large scales. This follows the IHO S-57 SCAMIN (Scale Minimum) attribute, which specifies the minimum display scale for each feature.

Figure 4 illustrates this mechanism at three representative scales. The information density varies systematically:

- **1:200k (zoomed out):** Major shipping channels, primary navigation aids, and critical depth contours appear. Minor buoys, individual depth soundings, and local hazards remain hidden.
- **1:100k (intermediate):** Additional buoys and secondary routes become visible. Depth information increases but detailed soundings remain sparse.
- **1:50k (zoomed in):** Full detail emerges—every buoy, individual depth measurements, submarine cables, and local restricted areas appear.

This scale-dependent visibility creates a fundamental challenge: the same location appears visually different at different scales. A region that looks ”clear” at 1:200k may reveal numerous hazards at 1:50k. Models must recognize that feature absence at small scales does not imply physical absence—features may simply be display-suppressed due to scale filtering.

ENC-Bench systematically samples six scale levels (1:50k, 1:70k, 1:100k, 1:130k, 1:200k, 1:300k) for the same geographic regions. This evaluates whether models can correctly interpret features at different scales, adjusting their reasoning based on which details should be visible at each zoom level—mirroring how human navigators mentally account for scale when reading charts.

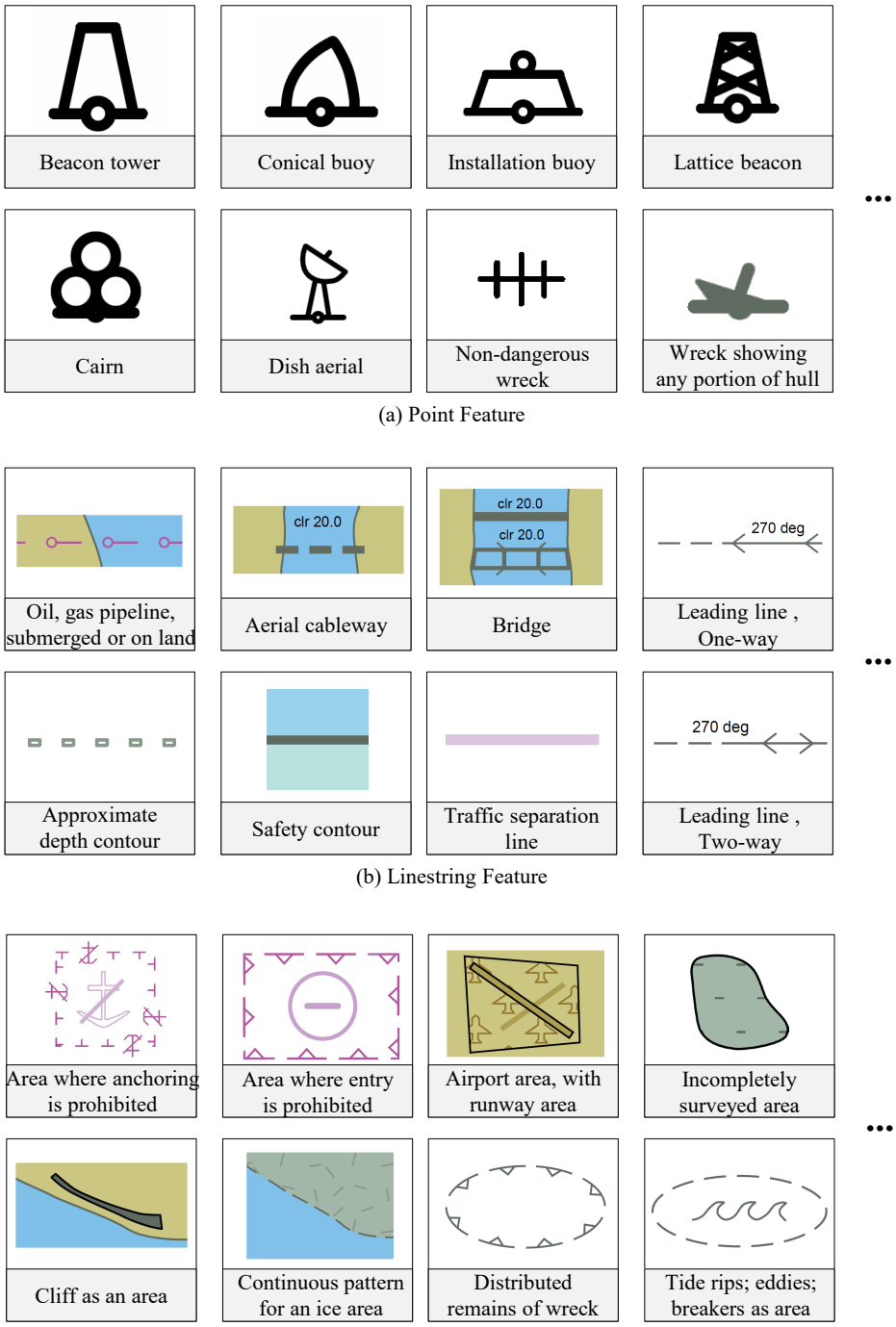
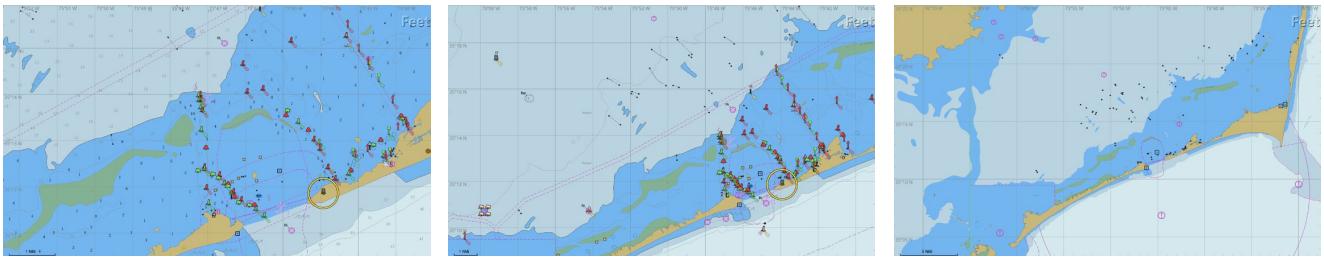


Figure 2. **Standardized IHO S-57 Symbology Types.** ENC features are classified into three geometric primitives with rigorous semantic definitions. **(a) Point Features:** Complex composite symbols where shape and topmark denote function (e.g., *Beacon tower*, *Non-dangerous wreck*). **(b) Linestring Features:** Define boundaries with directionality constraints, such as *Pipelines* or *Traffic separation lines*. **(c) Polygon Features:** Denote regional regulations, such as *Anchoring prohibited areas* or *Incompletely surveyed areas*. Recognizing these symbols requires distinguishing fine-grained visual details that carry heavy semantic weight.

(a) Day Mode (b) Dusk Mode (c) Night Mode

Figure 3. **Operational Lighting Modes.** Demonstration of the ECDIS standardized color palettes. **(a) Day Mode:** High contrast with white/blue backgrounds. **(b) Dusk Mode:** Reduced glare with grey backgrounds. **(c) Night Mode:** Black background with non-linear color shifts. Note how the blue shallow water in Day mode transforms into dark grey/black tones in Night mode, and text labels shift colors to maintain visibility. This drastic "palette swapping" challenges MLLMs reliant on natural image color statistics.



(a) Large Scale(1:50k) (b) Intermediate Scale (1:100k) (c) Small Scale (1:200k)

Figure 4. **Scale-Dependent Rendering and Cartographic Generalization.** The same chart region rendered at three standard scale levels. **(a) Large Scale (1:50k):** Maximum detail with dense soundings (e.g., depth values like *15* or *16* feet) and all navigational aids visible. **(b) Intermediate Scale (1:100k):** Partial generalization where minor soundings are suppressed to reduce clutter. **(c) Small Scale (1:200k):** High-level abstraction where only critical features remain, and dense depth numbers are removed. Models must handle this dynamic appearance where features logically "exist" but visually vanish based on zoom level.

B. Dataset Construction Details

The construction of **ENC-Bench** is governed by a rigorous, scientifically controlled pipeline designed to transform raw S-57 hydrographic data into a verifiable visual-language benchmark. Unlike datasets relying on crowdsourced annotations, our pipeline derives ground truth directly from the official IHO S-57 vector database, ensuring logical consistency and nautical plausibility.

B.1. Semantic Decoding and Entity Resolution

Raw ENC data is encapsulated in the ISO/IEC 8211 binary format, which optimizes storage but obscures semantics behind cryptic acronyms. To enable automated reasoning, we developed a custom semantic parsing engine to decode these binary structures into usable semantic primitives.

Attribute Expansion. We utilize the official IHO S-57 Object Catalogue lookup tables (specifically `s57objectclasses.csv`, `s57attributes.csv`, and `s57expectedinput.csv`) to map binary codes to human-readable semantics. For instance, the acronym `BOYLAT` is expanded to *Buoy, Lateral*, and the enumerated attribute `COLOUR:3` is mapped to *Red*. Depth values stored in meters (`VALSOU`) are standardized and converted to feet/fathoms where required to match the visual labels rendered on specific chart styles.

Cross-Layer Entity Resolution. A critical challenge in S-57 data is that a single maritime object is often fragmented across multiple geometric layers (e.g., a lighthouse represented as a point for the light and a separate polygon for the structure). We implement an entity resolution algorithm using the unique `LNAM` (Long Name) identifier. Features sharing `LNAM` or listed in `LNAM_REFS` are aggregated into a single semantic object. This ensures that questions query the holistic entity rather than disjoint geometric fragments.

B.2. Adaptive Density Control via Graph Coloring

Professional ENCs are visually dense. Naively sampling features for evaluation often leads to overlapping bounding boxes or ambiguous references (e.g., two buoys too close to distinguish). We solve this using an **Adaptive Density Control** strategy modeled as a Graph Coloring problem.

We construct a *Conflict Graph* $G = (V, E)$ where each node $v \in V$ represents a candidate feature. An undirected edge e_{ij} is drawn between two features if their projected pixel distance is below a visual threshold τ (set to 40 pixels in our implementation). We then apply a greedy graph coloring algorithm to partition V into k independent sets (groups). For a single chart view, we generate multiple distinct evaluation samples, where each sample contains only the features from one independent set. This mathematically guarantees that all targeted features in a given question (labeled A, B, C...) are visually separated and unambiguous.

B.3. Hierarchical Task Generation Logic

We employ distinct generation strategies for each of the three capability tiers, ensuring that ground truth is derived from precise analytical constraints rather than visual estimation.

B.3.1. L-1 Perception: Visible Property Filtering

A common pitfall in VQA dataset generation is "information leakage," where models access metadata present in the database but not visually rendered (e.g., the unique identifier or installation date of a buoy).

To prevent this, we implement a strict **Visible Property Filter**. Based on ECDIS rendering rules, we defined a whitelist of visually observable attributes for each feature class. For example, for a *Cardinal Mark*, we retain `COLOUR`, `BCNSHP` (shape), and `TOPSHP` (topmark), while explicitly stripping non-visual attributes like `OBJNAM` (Object Name) and `PEREND` (Period End). The VLM prompt generator is conditioned *only* on these filtered attributes, ensuring that the resulting QA pairs test genuine visual recognition.

B.3.2. L-2 Spatial Reasoning: Analytical Ground Truth

Spatial reasoning tasks are grounded in computational geometry using the precise geodetic coordinates extracted from the S-57 vector data.

- **Coordinate Localization:** We evaluate both geodetic (Latitude/Longitude) and pixel-space localization. Pixel coordinates are computed via an affine transformation matrix $\mathbf{M}$ calibrated using manually annotated control points for each chart, ensuring sub-pixel accuracy.
- **Distance Measurement:** Ground truth distance d is calculated using the **Haversine formula** with an Earth radius $R = 3440.065$ nautical miles. This accounts for the curvature of the earth, which is significant at the scales of maritime navigation.
- **Bearing Calculation:** True north bearings are calculated using the inverse geodetic problem ($\text{atan2}(\Delta\lambda, \Delta\phi)$), adjusted to the 0-360° compass convention.

B.3.3. L-3 Decision-Making: Procedural Simulation

For high-level tasks, we developed a simulation engine to synthesize navigation scenarios that require multi-constraint reasoning.

Safety Passage Assessment. We generate queries "Can a vessel with draft D safely pass?" by spatially joining a procedurally generated random polygon with underlying depth layers (`DEPARE`, `SOUNDG`). The ground truth is determined by a strict inequality:

$$\text{Safe} \iff D + \delta_{safety} < \min(|d_{val}|) \tag{1}$$

where δ_{safety} is a fixed safety margin (set to 2.0 feet) and $\min(|d_{val}|)$ is the absolute minimum depth found within the

query polygon. This tests the model's ability to perform OCR on depth numbers and apply arithmetic logic.

Track Direction Recognition. This task tests adherence to traffic flow regulations. We extract `RCRTCL` (Recommended Track) features which contain an `ORIENT` attribute specifying the mandatory heading. For a track segment with endpoints a and a', we calculate the geometric bearing $\theta_{a \to a'}$ and its reciprocal $\theta_{a' \to a}$. The correct direction is identified by minimizing the angular distance to the database `ORIENT` value, forcing the model to visually correlate the line's orientation with implicit traffic rules.

Anchorage Selection. We synthesize emergency scenarios by digitally superimposing a red triangle symbol (representing a vessel) onto the chart image. The ground truth is computed by: 1. Querying all `MORFAC` (Mooring Facility) objects in the database. 2. Computing the geodesic distance from the synthetic vessel to each facility. 3. Selecting the nearest valid facility as the target. This requires the model to perform multi-hop reasoning: *detect vessel* $\rightarrow$ *detect anchorages* $\rightarrow$ *estimate distances* $\rightarrow$ *select minimum*.

C. Evaluation Prompts

To ensure reproducibility and facilitate future benchmarking, we detail the specific prompt templates used for ENC-Bench. All models were evaluated in a zero-shot setting, with task instructions and output formatting constraints directly embedded in the user query.

Table 1 presents the complete list of templates. Placeholders such as {`label`}, {`width`}, and {`options`} are dynamically filled with instance-specific data during evaluation.

D. More Analysis of Results on ENC-Bench

Due to space limitations, more in-depth analyses to advance MLLM research in specialized maritime domains are provided in this appendix. This section highlights the fine-grained performance of spatial reasoning capabilities.

Performance Sensitivity to Error Tolerance. As shown in Tables 2 and 3, model accuracy exhibits significant sensitivity to error tolerance thresholds. In the Distance Measurement task, while Gemini-2.5-Flash achieves 25.93% accuracy at the standard 20% tolerance, its performance declines to 6.92% at the stricter 5% threshold. This trend is consistent across all evaluated models, with even the top-performing Gemini-2.5-Pro failing to exceed 9% accuracy for high-precision measurement. This degradation suggests that current MLLMs rely primarily on approximate visual estimation rather than precise pixel-to-scale calibration, lacking the capability for sub-pixel measurement required in professional navigation contexts.

Impact of Reasoning Mechanisms on Directional Estimation. A notable divergence is observed in the Bearing Calculation task (Table 3). Unlike distance estimation, where extended reasoning models show marginal gains, the **Qwen3-VL-235B-Thinking** model achieves 55.64% accuracy at the 20° threshold, significantly outperforming its standard instruction-tuned counterpart (36.95%) and commercial SOTA models such as GPT-4o (25.15%). This indicates that directional orientation benefits substantially from geometric reasoning. Chain-of-thought processes likely enable the model to explicitly deduce relative positions (e.g., inferring cardinal directionality) before committing to a numerical bearing, thereby mitigating the stochastic generation of angular values common in standard MLLMs.

Disparity Between Visual and Symbolic Localization. We constructed a comparative analysis (Table 4) of coordinate localization performance across two modalities: *Geographic* (requiring OCR and grid interpolation) and *Pixel* (requiring pure visual localization). On ENC-Bench, MLLMs generally demonstrate lower proficiency in symbolic grounding compared to visual localization. For instance, GLM-4.5V achieves 14.38% accuracy in pixel space (Acc@200px) but decreases to 9.52% in geographic space. Similarly, Gemini-2.5-Pro performance drops from 21.43% (Pixel) to 17.36% (Geo). These results confirm that the primary bottleneck lies not in object detection, but in mapping visual detections to the semantic coordinate system defined by the chart's marginalia.

Constraints on Fine-Grained Feature Localization. Across all models, performance approaches near-zero ($<5\%$) at the strictest localization threshold (Acc@50px), as shown in Table 4. This limitation in fine-grained precision can be attributed to three primary factors:

1. **Sparse Feature Representation.** ENC symbols are often fine-grained (e.g., single-point features). Current visual encoders, typically optimized for global semantic alignment, may lack the spatial resolution to resolve these minute features with 50px tolerance.
2. **Text-Image Alignment Accuracy.** Geographic localization requires precise interpolation between grid lines. Misalignments between text embeddings (reading grid numbers) and patch embeddings (perceiving grid lines) can introduce cumulative errors.
3. **Input Resolution Limits.** Most models process images at fixed resolutions (e.g., 1024^2), necessitating downsampling that obscures the precise pixel location of small navigational aids, rendering sub-100px accuracy mathematically challenging for certain feature sizes.

Table 1. **Task-Specific Prompt Templates.** We provide distinct prompts for each task. Note that for Coordinate Localization, we evaluate both Geographic (Latitude/Longitude) and Pixel-space prediction using separate prompts.

Task	Prompt Template
	L-1 Perception
Symbol Recognition	The image displays a symbol used to represent ENC (Electronic Navigational Chart) data on an ECDIS. According to the description provided, this symbol specifically portrays what type of object or feature? Please choose the correct answer from the following options: {options} Please respond with only the letter (A, B, C, or D) of the correct answer.
Point Feature	What is the nautical symbol located above point labeled "{label}"? Please choose the correct answer from the following options: {options} Please respond with only the letter (A, B, C, or D) of the correct answer.
Linestring Feature	What does the linestring between point {label_start} and point {label_end} represent? Please choose the correct answer from the following options: {options} Please respond with only the letter (A, B, C, or D) of the correct answer.
Polygon Feature	What is the most likely meaning of the area {bbox_label}? Please choose the correct answer from the following options: {options} Please respond with only the letter (A, B, C, or D) of the correct answer.
	L-2 Spatial Reasoning
Coordinate Localization *(Geographic)*	Find the longitude and latitude of point {label} on this nautical chart. Respond with ONLY the coordinates in decimal degrees format: longitude,latitude Example: -152.085,60.344
Coordinate Localization *(Pixel)*	Identify the pixel coordinates (x, y) of point {label} in this {width}*{height} image. Respond with ONLY the pixel coordinates: x,y Example: 1867,353
Bearing Calculation	On this nautical chart, what is the bearing from point {label_start} to point {label_end}? Please provide your answer as a compass bearing in degrees (0-360°, where 0° is North, 90° is East, 180° is South, 270° is West). Respond with ONLY the numerical bearing value in degrees (0-360°). Example: 285.1°
Distance Measurement	On this chart, with reference to the scale, calculate the distance between point {label_start} and point {label_end}. Respond with ONLY the numerical distance value in nautical miles. Example: 1.46
	L-3 Maritime Decision-Making
Track Direction	What is the correct direction for vessel navigation in the navigable area shown? Please choose the correct answer from the following options: {options} Please respond with only the letter (A, B, or C) of the correct answer.
Safety Assessment	It is safe for a vessel with a maximum draft of {draft} feet to pass through the area indicated by the red box. This is a True/False question. Please answer strictly with a single word: True or False.
Anchorage Selection	A vessel has a failure at the red triangle location in the chart. Based on the chart information, where is the nearest mooring facility? Please look at the chart image carefully. The red triangle shows the vessel's failure location. The options are marked with letters A, B, C, D on the chart. Please identify the nearest anchorage to the red triangle location and respond with only the letter (A, B, C, or D).

Table 2. **Fine-Grained Distance Measurement Accuracy (Acc@T).** Evaluation of model performance across varying relative error tolerances. **Bold** indicates the best performance for each threshold.

Model	Acc@5%	Acc@10%	Acc@15%	Acc@20%
Gemini-2.5-Flash	6.92	11.76	17.99	**25.93**
Gemini-2.5-Pro	**8.76**	**12.99**	**19.64**	25.67
Qwen3-VL-235B-Thinking	6.10	10.50	15.20	20.33
GPT-4o	3.95	8.33	13.16	19.29
Qwen3-VL-235B-Instruct	5.95	9.52	13.69	16.71
InternVL-3-38B	3.50	6.80	10.20	13.09
Qwen3-VL-32B-Instruct	1.78	4.73	8.28	12.75
GLM-4.5V	0.60	3.31	6.33	9.04
Llama-4-Maverick-17B	0.93	3.10	5.20	7.41
Qwen3-VL-32B-Thinking	0.50	1.80	3.10	4.91

Table 3. **Fine-Grained Bearing Calculation Accuracy (Acc@T).** Evaluation of angular precision with error thresholds of $5^\circ, 10^\circ, 20^\circ$, and 30°. **Bold** indicates the best performance for each threshold.

Model	Acc@5°	Acc@10°	Acc@20°	Acc@30°
Qwen3-VL-235B-Thinking	**16.20**	**31.50**	**55.64**	**70.20**
Gemini-2.5-Pro	13.35	27.95	46.86	62.42
Qwen3-VL-32B-Thinking	11.50	24.80	44.10	59.50
InternVL-3-38B	10.80	22.50	41.09	56.80
Qwen3-VL-235B-Instruct	9.72	19.75	36.95	55.17
GLM-4.5V	5.52	12.99	28.60	52.60
Gemini-2.5-Flash	8.33	16.67	28.77	35.61
Qwen3-VL-32B-Instruct	7.29	11.85	26.44	41.64
GPT-4o	5.85	11.70	25.15	33.33
Llama-4-Maverick-17B	3.31	4.42	14.90	25.41

Table 4. **Comparative Analysis of Coordinate Localization Modalities (Geo vs. Pixel).** Accuracy at varying pixel error thresholds for Geographic (Geo) and Pixel-based (Pix) localization. **Geo** requires symbolic grid interpretation; **Pix** requires only visual localization. **Bold** indicates the best performance for each column.

	Acc@50px		Acc@100px		Acc@200px		Acc@500px	
Model	Geo	Pix	Geo	Pix	Geo	Pix	Geo	Pix
Gemini-2.5-Pro	0.00	2.07	**8.70**	**8.28**	**17.36**	**21.43**	56.52	50.34
Gemini-2.5-Flash	0.76	1.45	3.05	5.80	16.77	21.03	**58.02**	**56.52**
InternVL-3-38B	0.50	0.80	2.50	2.50	13.19	10.52	48.20	35.40
GPT-4o	0.00	1.74	1.22	2.61	12.20	6.94	50.00	43.48
Qwen3-VL-235B-Instruct	**4.29**	2.04	4.29	2.04	11.31	12.20	45.71	38.78
Qwen3-VL-235B-Thinking	3.80	**2.50**	4.10	3.10	11.01	12.90	44.50	41.20
GLM-4.5V	3.95	0.96	5.26	3.85	9.52	14.38	52.63	47.12
Llama-4-Maverick-17B	1.14	0.00	1.14	3.23	9.13	12.90	46.59	40.32
Qwen3-VL-32B-Thinking	0.00	0.00	0.80	0.50	6.94	7.34	25.40	18.50
Qwen3-VL-32B-Instruct	0.00	0.00	0.00	0.00	5.26	5.16	18.33	13.33

E. Qualitative Analysis Case Studies

In this section, we conduct a comprehensive case study analysis of the error types exhibited by three representative MLLMs (Gemini-2.5-Pro, GPT-4o, and Qwen3-VL-235B-Instruct) across the 30 qualitative examples in ENC-Bench. We categorize the errors into 5 distinct types based on the failure modes observed in the model outputs. Error Category Definitions:

- **Visual Perception Error:** The model fails to recognize basic chart features, misidentifies symbols, or fails to locate labeled points.
- **Reasoning Error:** The model correctly perceives visual elements but fails in the logical deduction required for the task.
- **Knowledge Error:** The model hallucinates the meaning of specialized IHO S-57 symbols.
- **Calculation Error:** In spatial tasks, the model fails to perform accurate numerical computation or pixel-to-geo mapping, resulting in large deviations in coordinates, bearings, or distances.
- **Instruction Following Error:** The model fails to adhere to the output format or specific constraints defined in the prompt.

Table 5 provides a detailed index of all 30 case figures, mapping each sub-task to the specific error categories observed for each model.

F. Limitations and Broader Impact

In this section, we discuss the limitations and potential societal impact of this work.

F.1. Potential Limitations

While ENC-Bench provides a comprehensive benchmark for evaluating MLLMs in professional maritime domains, there are several limitations to consider:

- **Geographic and Source Bias:** Our dataset is derived exclusively from NOAA (United States) Electronic Navigational Charts. Although these charts conform to the IHO S-57 standard, regional variations in charting practices exists across different hydrographic offices (e.g., UKHO, JHO). Consequently, findings based on this benchmark may not fully generalize to non-US waters or proprietary S-63 encrypted data formats used in commercial shipping.
- **Temporal and Dynamic Constraints:** Maritime navigation inherently involves continuous monitoring of temporal changes. As a static VQA benchmark, ENC-Bench evaluates snapshot interpretation capabilities but does not assess temporal reasoning (e.g., collision avoidance over time) or the integration of real-time sensor feeds such as Radar or AIS.
- **Simplified Decision Space:** To ensure rigorous evaluation, our L-3 decision-making tasks rely on closed-set options and explicit visual cues. Real-world operations involve open-ended decisions constrained by implicit factors—such as weather forecasts, tidal windows, and standing orders—that are not fully captured in visual charts alone.
- **Absence of Domain Adaptation:** This study focuses on the zero-shot evaluation of general-purpose MLLMs. We do not explore domain adaptation or instruction tuning on hydrographic data. While establishing a baseline for off-the-shelf capability, this may underestimate the potential of MLLMs when specifically aligned with maritime instructions.

F.2. Potential Societal Impact

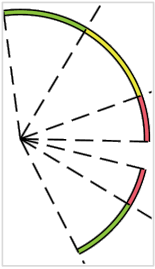
- **Safety Risks and Automation Bias:** Our results indicate that state-of-the-art MLLMs exhibit symbolic grounding gaps and reasoning hallucinations. In safety-critical domains where minor errors can lead to catastrophic outcomes, excessive reliance on these systems may lead to automation bias among operators. It is crucial to implement rigorous uncertainty quantification and maintain human supervision (Human-in-the-Loop) when deploying such models in operational environments.
- **Maritime Safety Advancement:** By establishing a rigorous standard for AI chart understanding, ENC-Bench supports the development of Intelligent Bridge Systems (IBS) and Maritime Autonomous Surface Ships (MASS). Reliable AI assistants can serve to cross-verify human decisions, potentially reducing accidents caused by human error or fatigue.

Table 5. **Index of case study figures by sub-tasks (L-1 to L-3) with associated error categories for representative MLLMs.** Errors are color-coded: Visual Perception Error, Reasoning Error, Knowledge Error, Calculation Error, and Instruction Following Error. **Correct** indicates a successful prediction.

Figure	L-1/2/3 Task	Specific Sub-task	Gemini-2.5-Pro	GPT-4o	Qwen3-VL
Fig. 5	L-1 Perception	Symbol Recognition	Reasoning Error	Visual Perception Error	Visual Perception Error
Fig. 6	L-1 Perception	Symbol Recognition (Cardinal)	Knowledge Error	Visual Perception Error	Knowledge Error
Fig. 7	L-1 Perception	Symbol Recognition (Area)	Knowledge Error	Knowledge Error	Knowledge Error
Fig. 8	L-1 Perception	Point Feature (Day)	Visual Perception Error	Visual Perception Error	Knowledge Error
Fig. 9	L-1 Perception	Point Feature (Dusk)	Visual Perception Error	Visual Perception Error	**Correct**
Fig. 10	L-1 Perception	Point Feature (Night)	**Correct**	Visual Perception Error	**Correct**
Fig. 11	L-1 Perception	Point Feature (Small Scale)	Visual Perception Error	Visual Perception Error	Visual Perception Error
Fig. 12	L-1 Perception	Linestring (Day)	Visual Perception Error	**Correct**	Knowledge Error
Fig. 13	L-1 Perception	Linestring (Dusk)	Knowledge Error	**Correct**	Visual Perception Error
Fig. 14	L-1 Perception	Linestring (Night)	Visual Perception Error	Visual Perception Error	Visual Perception Error
Fig. 15	L-1 Perception	Linestring (Small Scale)	Visual Perception Error	Visual Perception Error	Visual Perception Error
Fig. 16	L-1 Perception	Polygon (Day)	Visual Perception Error	Knowledge Error	Visual Perception Error
Fig. 17	L-1 Perception	Polygon (Dusk)	**Correct**	Knowledge Error	Visual Perception Error
Fig. 18	L-1 Perception	Polygon (Night)	Reasoning Error	Visual Perception Error	Visual Perception Error
Fig. 19	L-1 Perception	Polygon (Small Scale)	Visual Perception Error	Visual Perception Error	Visual Perception Error
Fig. 20	L-2 Spatial	Coordinate (Day)	Calculation Error	Calculation Error	Calculation Error
Fig. 21	L-2 Spatial	Coordinate (Dusk)	Calculation Error	Calculation Error	Calculation Error
Fig. 22	L-2 Spatial	Coordinate (Night)	Calculation Error	Calculation Error	Calculation Error
Fig. 23	L-2 Spatial	Bearing (Day)	Calculation Error	Calculation Error	Calculation Error
Fig. 24	L-2 Spatial	Bearing (Dusk)	Calculation Error	Calculation Error	Reasoning Error
Fig. 25	L-2 Spatial	Bearing (Night)	Calculation Error	Calculation Error	Reasoning Error
Fig. 26	L-2 Spatial	Distance (Day)	Calculation Error	Calculation Error	Calculation Error
Fig. 27	L-2 Spatial	Distance (Dusk)	Calculation Error	Calculation Error	Calculation Error
Fig. 28	L-2 Spatial	Distance (Night)	Calculation Error	Calculation Error	Calculation Error
Fig. 29	L-3 Decision	Track Direction (Large)	Visual Perception Error	Visual Perception Error	Reasoning Error
Fig. 30	L-3 Decision	Track Direction (Small)	Instruction Following Error	Visual Perception Error	Visual Perception Error
Fig. 31	L-3 Decision	Safety Assessment	Visual Perception Error	Reasoning Error	Visual Perception Error
Fig. 32	L-3 Decision	Safety Assessment (Small)	Visual Perception Error	Visual Perception Error	Visual Perception Error
Fig. 33	L-3 Decision	Anchorage Selection	Visual Perception Error	Reasoning Error	Visual Perception Error
Fig. 34	L-3 Decision	Anchorage Selection (Small)	Visual Perception Error	Reasoning Error	Knowledge Error

Symbol Recognition

Question: The image displays a symbol used to represent ENC (Electronic Navigational Chart) data on an ECDIS (Electronic Chart Display and Information System). According to the description provided, this symbol specifically portrays what type of object or feature?
A. Light, restricted
B. Light, danger
C. Light, directional
D. Light, obscured



Answer: A

Gemini-2.5-pro: D
Symbol on Electronic Charts Indicates an Obscured Light Source
The provided image displays a symbol used on Electronic Navigational Charts (ENC) to represent a light that is obscured from certain directions. This symbology is crucial for mariners using an Electronic Chart Display and Information System (ECDIS) for safe navigation.
The key features of the symbol are the dashed lines radiating from a central point and the broken, multi-colored arc. The dashed lines delineate the boundaries of different light sectors. The colors on the arc—green, yellow, and red—signify the different characteristics of the light visible within those sectors. For instance, a red sector often warns of a danger, such as shallow water or a hazard.
Most importantly, the distinct break in the arc indicates that the light is not visible from all angles within its range. This gap represents a sector where the light is blocked, for example by a landmass, a structure, or another obstruction. On electronic charts, an all-around light with a sector that is not visible is referred to as "Light, obscured".
Correct Answer: D. Light, obscured
× Reasoning Error

GPT-4o: C
The symbol in the image represents a Light, directional. The colored sectors (green, yellow, and red) depict the directions in which the light is visible and guide navigation accordingly, commonly used for directional navigation or alignment lights.
× Visual Perception Error
Answer: C. Light, directional

Qwen3-VL-235B-Instruct: C
The symbol shown in the image is a directional light as used in ECDIS (Electronic Chart Display and Information System) to represent ENC (Electronic Navigational Chart) data.
Breakdown of the Symbol:
The central point with radiating lines represents the light source.
× Visual Perception Error
The colored arcs (green, yellow, red) indicate the sectors of visibility — this is characteristic of a directional or sector light, where different colors denote different directions or sectors in which the light is visible (e.g., green for safe water, red for danger, etc.).
Correct Answer: C. Light, directional

Figure 5. A sample case of **Symbol Recognition**. The model must identify an ”Obscured Light” symbol.

Symbol Recognition

Question: The image displays a symbol used to represent ENC (Electronic Navigational Chart) data on an ECDIS (Electronic Chart Display and Information System). According to the description provided, this symbol specifically portrays what type of object or feature?
A. East cardinal virtual aid
B. North cardinal virtual aid
C. South cardinal virtual aid
D. West cardinal virtual aid

Answer: A

Gemini-2.5-pro: C
Symbol Represents South Cardinal Virtual Aid to Navigation
The symbol displayed in the image is used on Electronic Navigational Charts (ENC) to represent a South cardinal virtual aid to navigation (V-AIS).
Virtual Aids to Navigation are digital markers broadcast via the Automatic Identification System (AIS) to indicate hazards or safe passages on electronic chart displays without the presence of a physical buoy or beacon. These aids are depicted on an Electronic Chart Display and Information System (ECDIS) with a magenta circle and the label "V-AIS".
× Knowledge Error
The specific type of aid, such as a cardinal mark, is indicated by the symbol within the circle. Cardinal marks are used in conjunction with a compass to indicate the direction of safe water from a hazard. The configuration of the two triangles in the provided image—one pointing up and the other pointing down—is the internationally recognized symbol for a South cardinal mark. This indicates that the safest water is to the south of the marked point.

GPT-4o: C
Correct answer: C. South cardinal virtual aid
× Visual Perception Error
Explanation: The symbol uses two yellow triangles pointing downward, indicating a South cardinal mark. Additionally, the "V-AIS" text signifies it as a virtual aid to navigation provided via AIS (Automatic Identification System).

Qwen3-VL-235B-Instruct: B
The symbol shown — two yellow triangles (one pointing up, one pointing down) enclosed in a purple circle, with "V-AIS" next to it — is the standard IHO (International Hydrographic Organization) and IMO (International Maritime Organization) symbol for a North Cardinal Virtual Aid to Navigation displayed on an ECDIS.
Here's why:
Cardinal marks indicate the safe side of a hazard relative to the cardinal directions (N, S, E, W).
× Knowledge Error
The North cardinal mark is represented by two cones pointing upward (or, in simplified 2D symbology, two triangles pointing up and down — which is what you see here).
In ECDIS, when such a mark is virtual (i.e., transmitted via AIS and not physically present), it is enclosed in a purple circle and labeled "V-AIS".
This combination — two vertical triangles + purple circle + V-AIS — specifically denotes a North Cardinal Virtual Aid.
Correct Answer: B. North cardinal virtual aid

Figure 6. A sample case of **Symbol Recognition**. The model must distinguish between East and North cardinal marks.

Symbol Recognition

Question: The image displays a symbol used to represent ENC (Electronic Navigational Chart) data on an ECDIS (Electronic Chart Display and Information System). According to the description provided, this symbol specifically portrays what type of object or feature?
A. Anchorage area, symbolized
B. Harbor area, symbolized
C. Fishing area, symbolized
D. Restricted area, symbolized

Answer：B

Gemini-2.5-pro: A
Anchorage Area Symbol Identified on Electronic Navigational Charts **× Knowledge Error**
The symbol in the image, characterized by a horizontal line with a downward-pointing triangle that rotates, is used on Electronic Navigational Charts (ENC) to denote a symbolized anchorage area. This symbol is a component of the standardized set of symbols used in an Electronic Chart Display and Information System (ECDIS) for marine navigation.

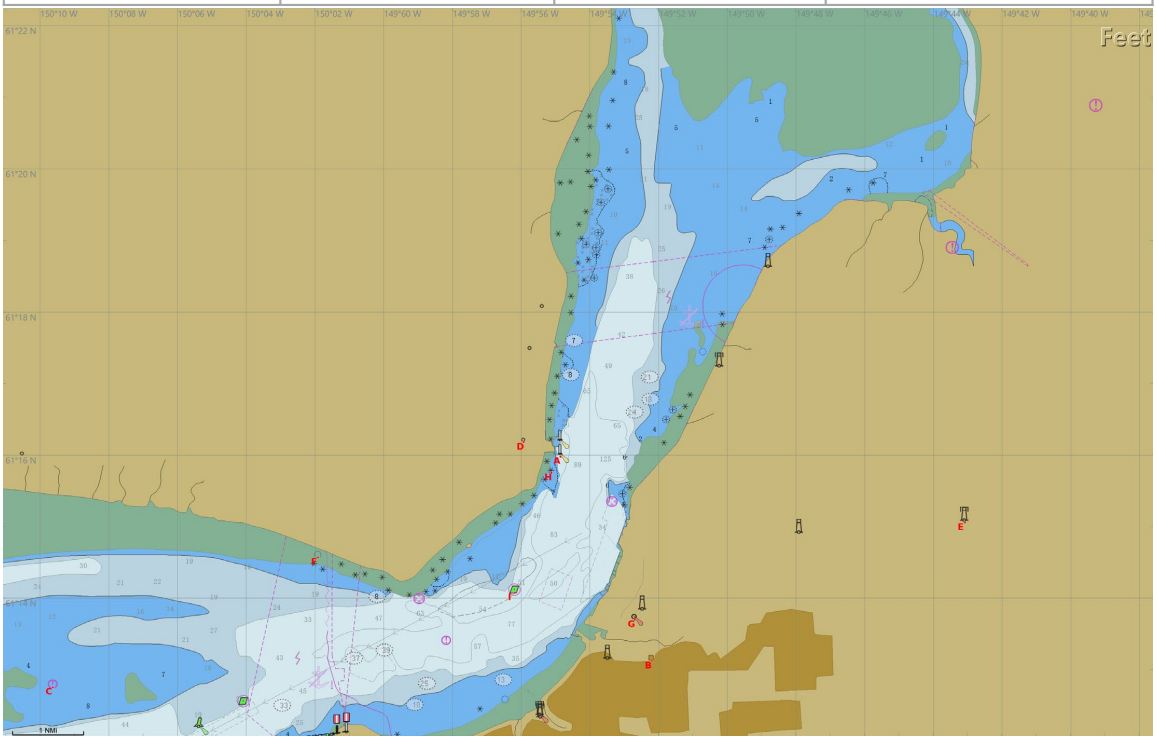
GPT-4o: A **× Knowledge Error**
The symbol shown is used in Electronic Navigational Charts (ENC) on an ECDIS system to depict Anchorage areas, symbolized.
Correct answer: A. Anchorage area, symbolized

Qwen3-VL-235B-Instruct: D
The symbol shown in the image — a series of inverted triangles (or chevrons) connected by a line, with the last one pointing diagonally — is the standard IHO (International Hydrographic Organization) symbol for a "Restricted Area" as displayed on an ECDIS using ENC data. **× Knowledge Error**
Correct Answer: D. Restricted area, symbolized

Figure 7. A sample case of **Symbol Recognition**. Identifying a symbolized Anchorage Area.

Point Feature Understanding

ENC_id: US3AK1DM	Lighting Modes: Day	Scale Levels: 1:50k	Resolution: 3838×2429



Question: What is the nautical symbol located above point labeled "C"?
A. Deep water channel with navigational buoys.
B. Caution area with no specific marks, indicating potential hazards.
C. Anchorage area with designated berthing zones.
D. No-go zone due to military exercises

Answer: B

Gemini-2.5-pro: B **× Visual Perception Error**
While there is no point explicitly labeled "C" on the provided nautical chart, the most prominent symbol that aligns with one of the given options is the area enclosed by a dashed magenta line. This symbol represents a caution area. Therefore, the correct answer is B. Caution area with no specific marks, indicating potential hazards.

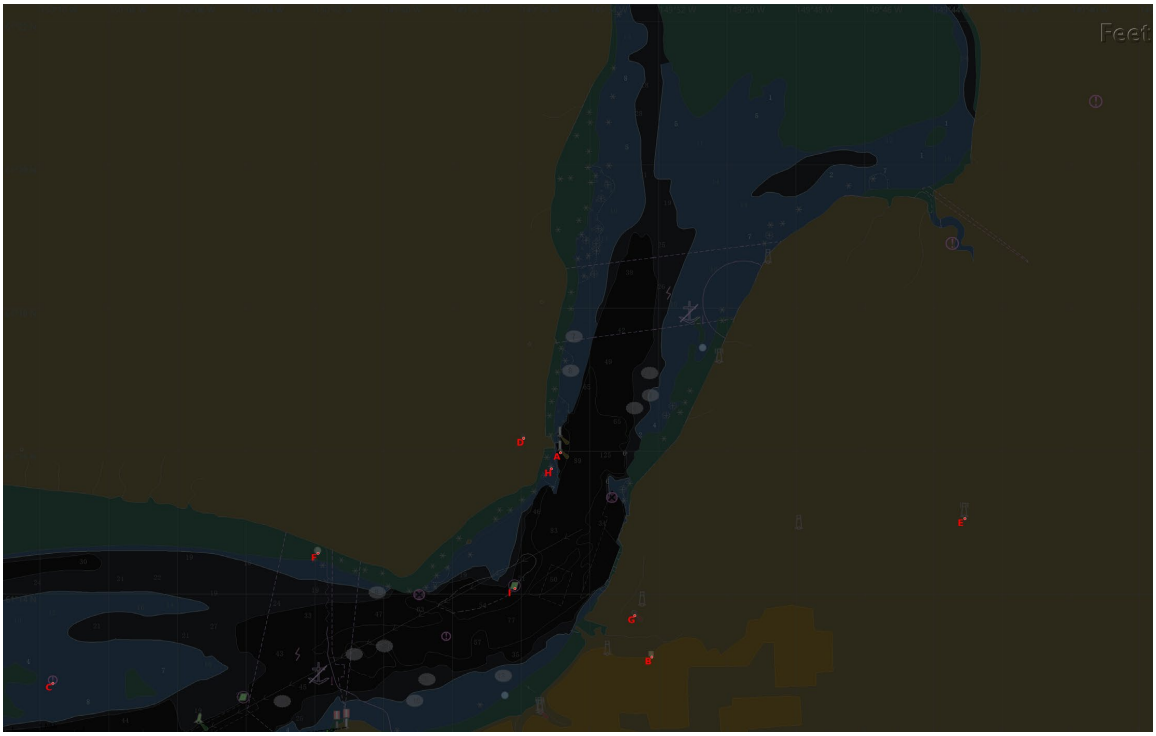
GPT-4o: C **× Visual Perception Error**
The nautical symbol located above the point labeled "C" on the chart is a magenta anchor symbol enclosed in a dashed circle. This is a standard nautical chart symbol that indicates an anchorage area.

Qwen3-VL-235B-Instruct: C **× Mixed-Language Generation**
Looking at the nautical chart provided, the point labeled "C" is located in a浅水区 (shallow water area), near the coastline, and is marked with a purple circle containing a white "C". **× Visual Perception Error**
This symbol — a circle with a letter inside — is a standard nautical chart symbol for an anchorage area. The letter inside often designates a specific anchorage (e.g., "A" for Anchorage A, "C" for Anchorage C). **× Knowledge Error**
Therefore, the correct answer is: C. Anchorage area with designated berthing zones.

Figure 8. A sample case of **Point Feature Understanding** (Day Mode). Identifying a Caution Area symbol.

Point Feature Understanding

ENC_id: US3AK1DM	Lighting Modes: Dusk	Scale Levels: 1:50k	Resolution: 3838×2429



Question: What is the nautical symbol located above point labeled "C"?
A. Deep water channel with navigational buoys.
B. Caution area with no specific marks, indicating potential hazards.
C. Anchorage area with designated berthing zones.
D. No-go zone due to military exercises

Answer：B

Gemini-2.5-pro: B **× Visual Perception Error**
Based on nautical chart standards, the symbol of a letter 'P' inside a circle or dashed circle located above point 'C' designates a Pilot boarding place. This is an area where a maritime pilot embarks or disembarks a vessel. Therefore, the symbol indicates a specific operational area that requires caution, making B the best available answer.

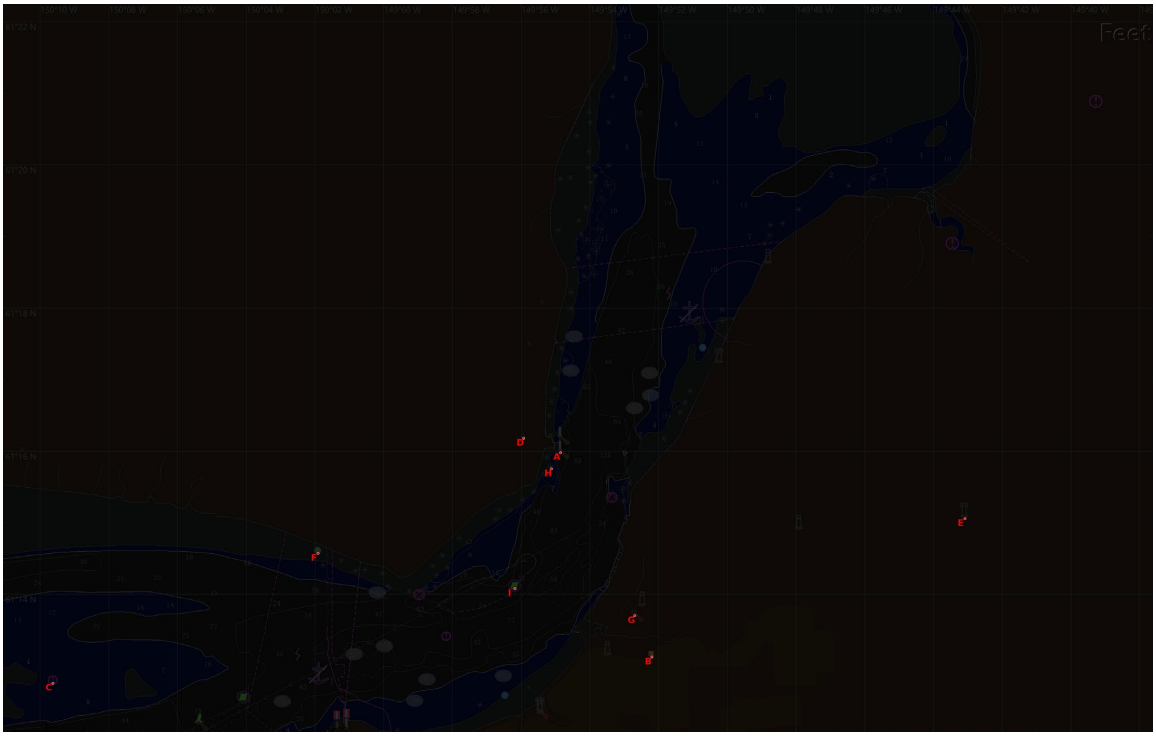
GPT-4o: C **× Visual Perception Error**
The nautical symbol located just above the point labeled "C" is: C. Anchorage area with designated berthing zones.
Explanation: The symbol above point "C" consists of a black anchor within a magenta circle, which is the standard nautical chart symbol for an anchorage area.

Qwen3-VL-235B-Instruct: B ✅
Looking at the nautical chart, the point labeled "C" is located in the lower-left portion of the image.
Directly above point C, there is a symbol: a purple circle with an exclamation mark inside (!).
In standard nautical chart symbology (like IHO or NOAA), this symbol represents a "Caution Area" or a "Danger Area". It indicates that there are potential hazards in the vicinity that are not specifically marked on the chart — such as submerged objects, strong currents, or other dangers to navigation. The exclamation mark is a universal warning symbol. This matches option B.

Figure 9. A sample case of **Point Feature Understanding** (Dusk Mode).

Point Feature Understanding

ENC_id: US3AK1DM	Lighting Modes: Night	Scale Levels: 1:50k	Resolution: 3838×2429



Question: What is the nautical symbol located above point labeled "C"?
A. Deep water channel with navigational buoys.
B. Caution area with no specific marks, indicating potential hazards.
C. Anchorage area with designated berthing zones.
D. No-go zone due to military exercises

Answer: B

Gemini-2.5-pro: B ✅
The correct answer is B. Caution area with no specific marks, indicating potential hazards.
The symbol in question, a magenta or purple circle with an exclamation mark, is used on nautical charts to designate a "Caution Area." This symbol alerts mariners that they should navigate with particular care in that vicinity due to potential hazards that may not be explicitly detailed by other specific symbols on the chart.

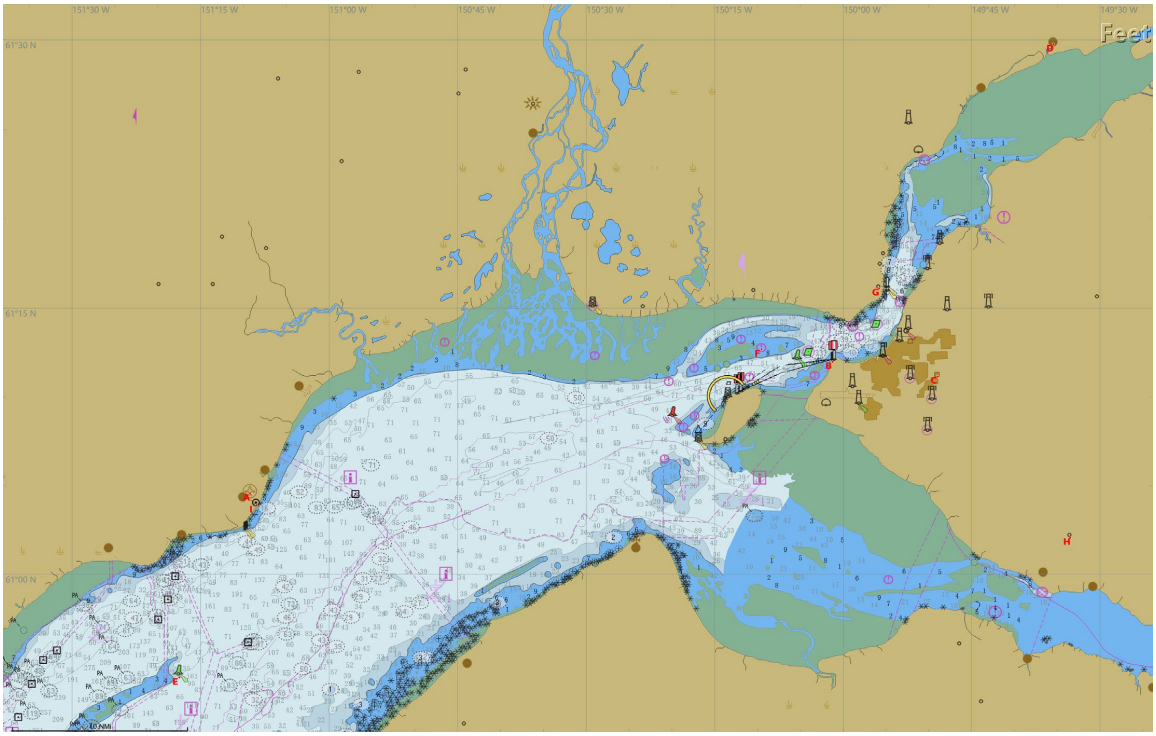
GPT-4o: C **× Visual Perception Error**
The nautical symbol located above the point labeled "C" is: C. Anchorage area with designated berthing zones.
Explanation: Looking at the chart above point "C", you can identify a black anchor symbol enclosed within a dotted or dashed boundary. This is the standard nautical chart symbol for an anchorage area—a designated zone where vessels are permitted to anchor.

Qwen3-VL-235B-Instruct: B ✅
Looking at the nautical chart, the point labeled "C" is located in the lower-left portion of the image.
Directly above point "C", there is a purple circle with an exclamation mark inside (!).
This symbol is a standard nautical chart symbol for a "Caution Area" or "Danger Area". It indicates that there may be hazards (such as submerged objects, strong currents, or uncharted dangers) in the vicinity, and mariners should proceed with caution.
Therefore, the correct answer is: B. Caution area with no specific marks, indicating potential hazards.

Figure 10. A sample case of **Point Feature Understanding** (Night Mode).

Point Feature Understanding

ENC_id:	US3AK1DM	Lighting Modes:	Day	Scale Levels:	1:200k	Resolution:	3838×2429



Question: What is the nautical symbol located above point labeled “F"?
A. Deep water channel with navigational buoys.
B. Caution area with no specific marks, indicating potential hazards.
C. Anchorage area with designated berthing zones.
D. No-go zone due to military exercises

Answer: B

Gemini-2.5-pro: B **× Visual Perception Error**
The correct answer is B. Caution area with no specific marks, indicating potential hazards.
Here's a breakdown of the nautical symbol above point "F": The Symbol: The feature in question is a rectangular area enclosed by a dashed magenta line. Color Magenta: On nautical charts, the color magenta is used to draw attention to special features and information. This includes regulated areas, notes, and navigational aids.

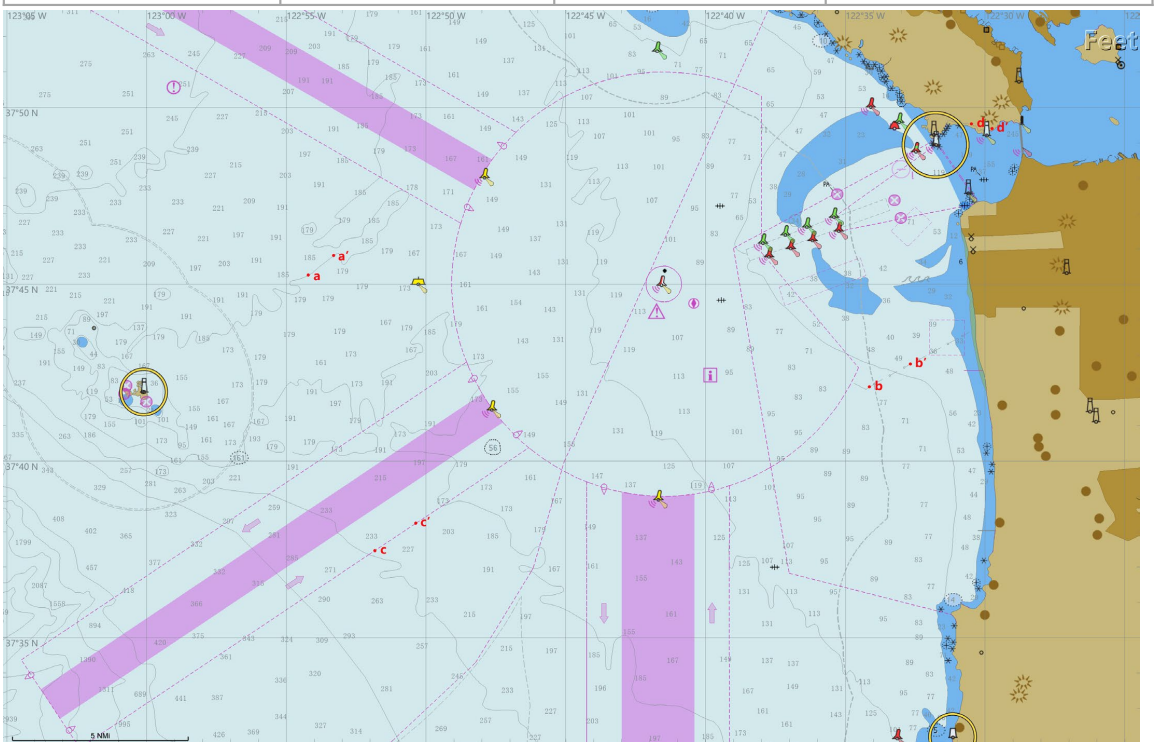
GPT-4o: B **× Visual Perception Error**
The nautical symbol located above the point labeled “F” on the chart is a magenta dotted area with a label “CAUTION AREA”, typically outlined and marked with cautionary symbols or notes.
Correct Answer: B.

Qwen3-VL-235B-Instruct: A **× Visual Perception Error**
Looking at the nautical chart, the point labeled “F” is located in a channel area with several navigational aids.
Directly above point “F”, you can see a series of pink circles with numbers inside them (e.g., 4, 8, 9) and dashed pink lines running along the channel. These are standard symbols on nautical charts indicating navigational buoys that mark the edges or centerline of a deep water channel.The numbers inside the circles typically indicate buoy numbers.The dashed lines often represent the recommended track or the limits of the channel.
This is consistent with a deep water channel marked for safe navigation, especially in an area with varying depths (as shown by the depth contours).This matches option A.

Figure 11. A sample case of **Point Feature Understanding** (Small Scale 1:200k).

Linestring Feature Understanding

ENC_id: US3CA14M	Lighting Modes: Day	Scale Levels: 1:100k	Resolution: 3849×2475



Question: What does the linestring between point b and point b' represent?
A. A submarine pipeline route
B. A slope topline
C. A depth contour line at 180 feet
D. A traffic separation scheme boundary

Answer: A

Gemini-2.5-pro: D **× Visual Perception Error**
Based on the features of the nautical chart, the linestring between point b and point b' represents a Traffic separation scheme boundary (D). In the provided chart, the dashed line between b and b' is part of a larger system of lines that organizes marine traffic near the coast.

GPT-4o: A ✅
The linestring between point b and point b' on the nautical chart represents: A. A submarine pipeline route
Explanation: The symbol used between point b and b' consists of a dashed line with small black circles at regular intervals, which is the standard symbol for submarine pipelines on electronic and paper nautical charts.

Qwen3-VL-235B-Instruct: C
Looking at the nautical chart, the linestring between point b and point b' is a dashed grey line that follows the contour of the seabed, connecting points with similar depth values.
The numbers along this line (e.g., 77, 83, 89) represent depths in feet, as indicated by the "Feet" label in the top right corner. Specifically, if you trace the numbers along the dashed line near points b and b', you'll see it aligns with the 83-foot depth contour. **× Knowledge Error**
Since C is the only option mentioning a depth contour, I'll select it.

Figure 12. A sample case of **Linestring Feature Understanding** (Day Mode). Identifying a Submarine Pipeline.

Linestring Feature Understanding

ENC_id: US3CA14M	Lighting Modes: Dusk	Scale Levels: 1:100k	Resolution: 3849×2475

Question: What does the linestring between point b and point b' represent?
A. A submarine pipeline route
B. A slope topline
C. A depth contour line at 180 feet
D. A traffic separation scheme boundary

Answer: A

Gemini-2.5-pro: C × **Knowledge Error**
Based on the visual information from the nautical chart and standard cartographic symbols, the dashed line between points b and b' represents a depth contour line.
The line is a depth contour, which connects points of equal depth. On nautical charts, a dashed contour line often indicates that the survey data is old or incomplete, so the line's position is approximate.

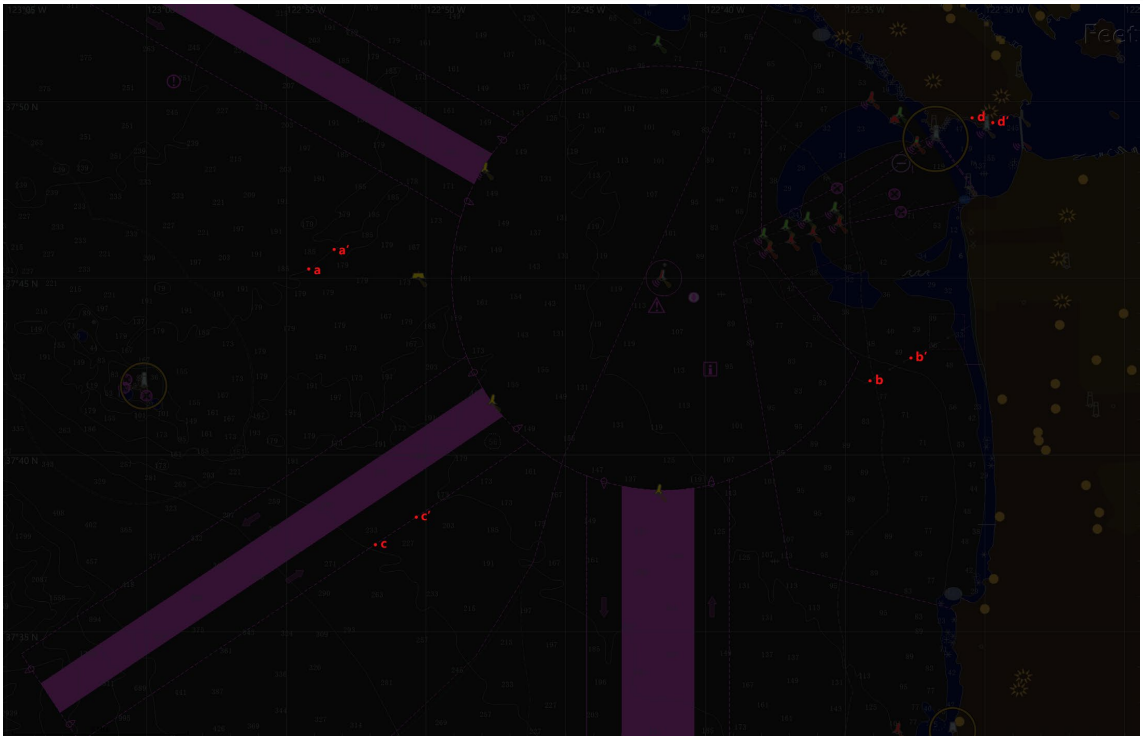
GPT-4o: A ✅
The line connecting point b and point b′ in the image represents: A. A submarine pipeline route
Reasoning: The line between b and b′ is a dashed line with small black dots (or very short dashes), a common symbology in nautical charts used to depict submarine pipelines.

Qwen3-VL-235B-Instruct: D × **Visual Perception Error**
The line between b and b' is a dashed line that runs parallel to the coastline and appears to mark a boundary. In fact, it looks very similar to the boundaries of the Traffic Separation Scheme (TSS) shown elsewhere on the chart (the wide purple bands with arrows).
The line between b and b' is dashed, and it separates the deeper water from the shallower coastal area. It also aligns with other dashed lines marking traffic lanes.
Final Answer: D. A traffic separation scheme boundary

Figure 13. A sample case of **Linestring Feature Understanding** (Dusk Mode).

Linestring Feature Understanding

ENC_id: US3CA14M	Lighting Modes: Night	Scale Levels: 1:100k	Resolution: 3849×2475



Question: What does the linestring between point b and point b' represent?
A. A submarine pipeline route
B. A slope topline
C. A depth contour line at 180 feet
D. A traffic separation scheme boundary

Answer: A

Gemini-2.5-pro: D Based on the symbology used in the provided nautical chart, the linestring between point b and point b' represents a traffic separation scheme boundary. **× Visual Perception Error**
D. A traffic separation scheme boundary: On nautical charts, magenta (a purple-pink color) is used to highlight important navigational features. Traffic Separation Schemes (TSS) are systems of recommended shipping lanes in congested areas, and their boundaries are depicted with dashed magenta lines, just as seen in the image.

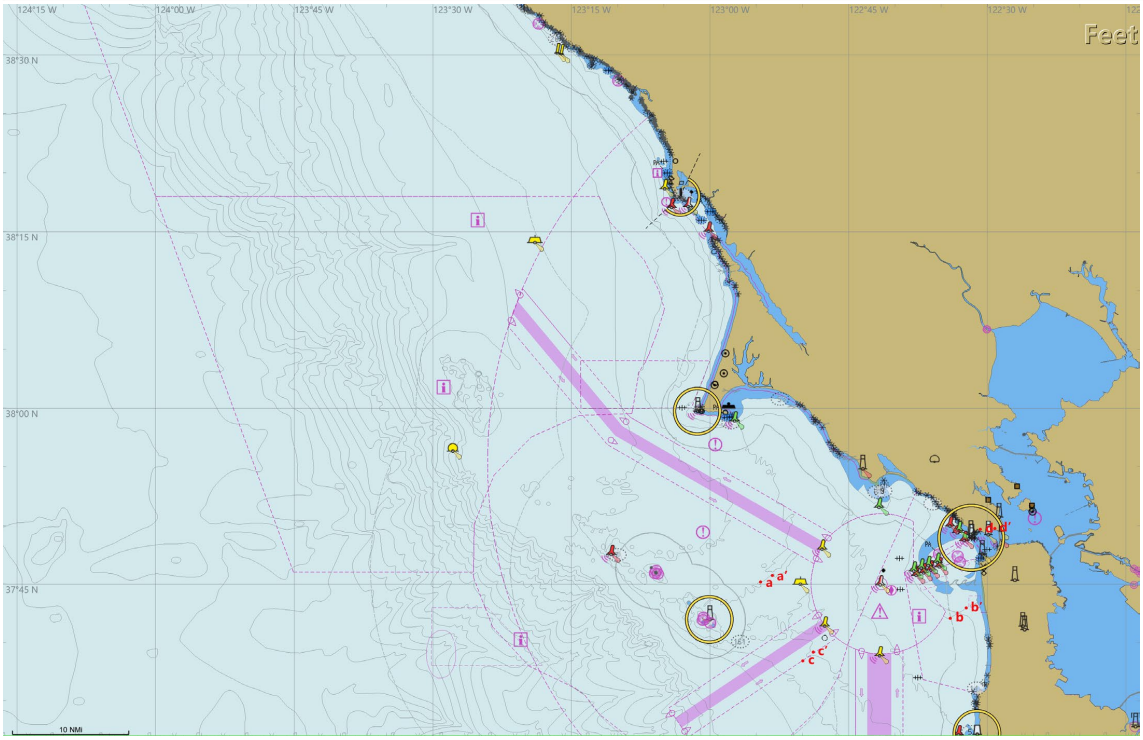
GPT-4o: C
The line between point b and point b' represents C. A depth contour line at 180 feet. **× Visual Perception Error**
In the image, contour lines like the one between b and b' typically show depth variations and are marked on nautical charts to indicate specific depth levels (in this case, 180 feet). Depth contour lines are critical for navigation and understanding underwater topography.

Qwen3-VL-235B-Instruct: D Based on the provided nautical chart, the linestring between point b and point b' is a dashed line that connects two points located over water, running roughly parallel to the coastline and contour lines.
D. A traffic separation scheme boundary – Traffic separation schemes (TSS) are marked with dashed or dotted lines, often with arrows indicating direction of traffic flow. In the chart, we see purple shaded areas with arrows (indicating traffic lanes), and dashed lines marking their boundaries. The line from b to b' appears to be one such boundary line separating a traffic lane from adjacent waters. **× Visual Perception Error**
Therefore, the correct answer is: D. A traffic separation scheme boundary

Figure 14. A sample case of **Linestring Feature Understanding** (Night Mode).

Linestring Feature Understanding

ENC_id: US3CA14M	Lighting Modes: Day	Scale Levels: 1:300k	Resolution: 3848×2475



Question: What does the linestring between point b and point b' represent?
A. A submarine pipeline route
B. A slope topline
C. A depth contour line at 180 feet
D. A traffic separation scheme boundary

Answer: A

Gemini-2.5-pro: D × **Visual Perception Error**
The correct answer is D. A traffic separation scheme boundary.
The linestring between points 'b' and 'b" on the provided nautical chart represents a lane within a Traffic Separation Scheme (TSS). These schemes are established in busy maritime areas to organize vessel traffic and prevent collisions. On nautical charts, Traffic Separation Schemes are depicted using magenta lines and symbols. The arrows along the linestring from 'b' to 'b" indicate the mandatory direction of traffic flow for that lane.

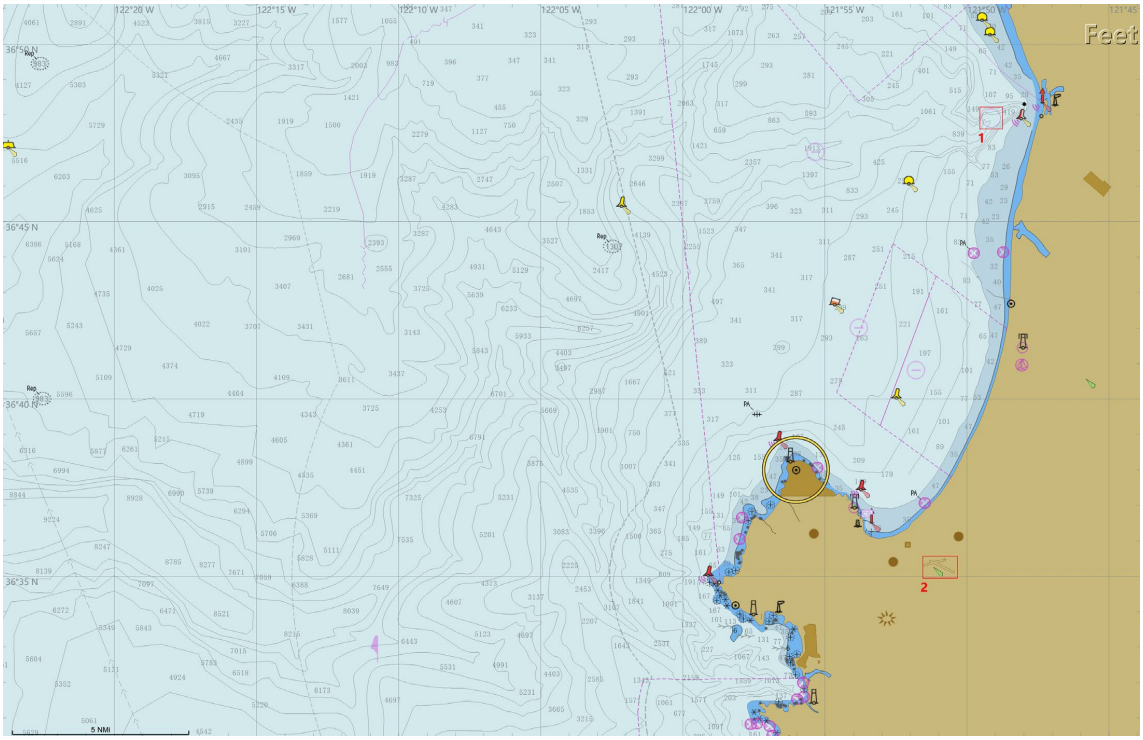
GPT-4o: D × **Visual Perception Error**
The magenta dashed line between points b and b' represents D. A traffic separation scheme boundary.
This is indicated by the color, style, and placement of the dashed magenta line, which are typical for traffic separation scheme (TSS) boundaries on nautical charts.

Qwen3-VL-235B-Instruct: D × **Visual Perception Error**
Looking at the nautical chart provided, the linestring between point b and point b' is part of a pink/purple shaded area that runs parallel to the coastline and extends offshore. This shaded area is bounded on both sides by dashed or solid lines — one of which is the line connecting b and b'.
The line between b and b' forms the boundary of this TSS.
Therefore, the correct answer is: D. A traffic separation scheme boundary

Figure 15. A sample case of **Linestring Feature Understanding** (Small Scale 1:300k). Identifying a Traffic Separation Scheme boundary.

Polygon Feature Understanding

ENC_id: US3CA52M	Lighting Modes: Day	Scale Levels: 1:100k	Resolution: 3848×2475



Question: What is the area bbox1 most likely to be?
A. A cable protection zone
B. A dumping ground with historical survey data
C. A dredged area with maintained depths
D. An obstruction with unknown depth

Answer: B

Gemini-2.5-pro: D
The area in bbox1 is most likely D. An obstruction with unknown depth.
Here's a breakdown of the evidence from the nautical chart: **× Visual Perception Error**
Unknown Depth: Crucially, there is no specific depth figure placed directly on or next to the hazard symbol within the dashed line. On nautical charts, if the exact depth over an obstruction is known, it is explicitly charted. The absence of such a number indicates the depth is unknown.

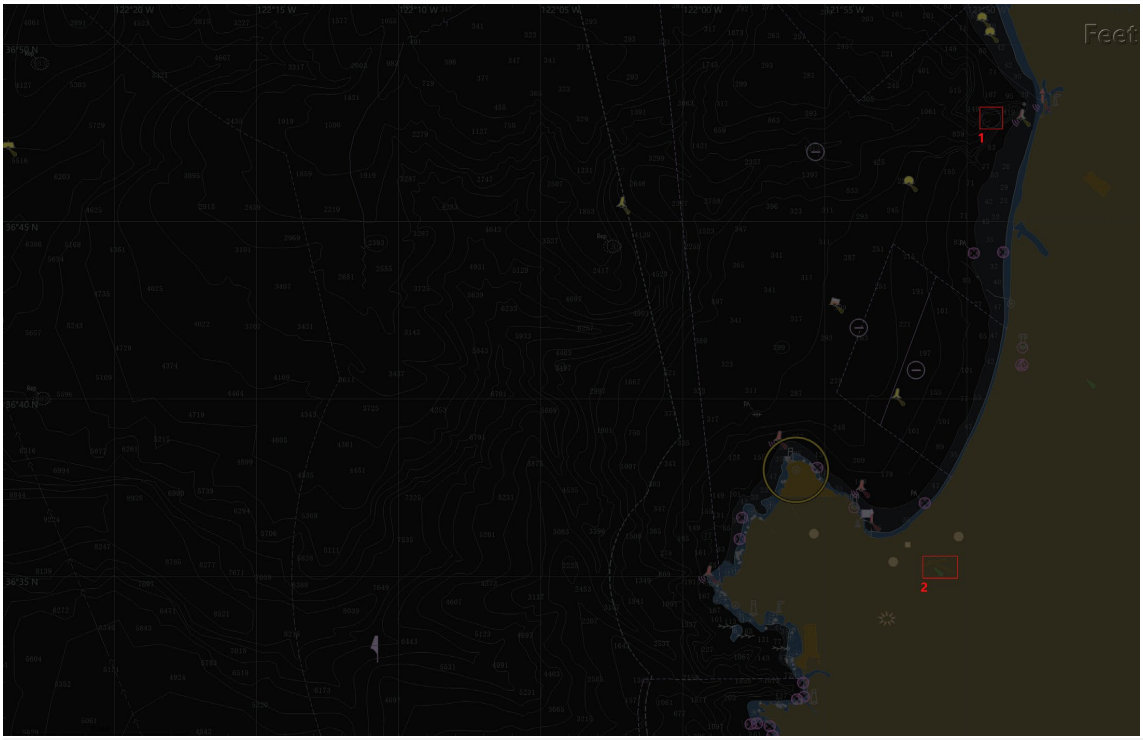
GPT-4o: C **× Knowledge Error**
The area marked as bbox1 in the chart appears to fall in a dredged or maintained area, indicated by the dashed border and maintained depth annotations. This is consistent with markings used for dredged areas on a nautical chart.
So, the answer is most likely: C. A dredged area with maintained depths.

Qwen3-VL-235B-Instruct: C **× Visual Perception Error**
Based on the nautical chart provided, bbox1 is located in a shallow coastal area near a harbor entrance, marked with contour lines indicating depths of 42, 71, 83, and 107 feet. The area within bbox1 shows:
A relatively smooth, shallow seabed compared to surrounding areas. Proximity to navigational aids (buoys) and a channel. No symbols indicating obstructions, wrecks, or dumping grounds. Depth contours that suggest maintained or uniform depth, typical of dredged channels or turning basins.
Correct Answer: C. A dredged area with maintained depths

Figure 16. A sample case of **Polygon Feature Understanding** (Day Mode). Identifying a Dumping Ground.

Polygon Feature Understanding

ENC_id: US3CA52M	Lighting Modes: Dusk	Scale Levels: 1:100k	Resolution: 3848×2475



Question: What is the area bbox1 most likely to be?
A. A cable protection zone
B. A dumping ground with historical survey data
C. A dredged area with maintained depths
D. An obstruction with unknown depth

Answer: B

Gemini-2.5-pro: B
The area in Bbox1 is most likely a dumping ground with historical survey data. Here's a breakdown of the symbols in the image: Dashed Circle: On nautical charts, a dashed line typically outlines a specific area with unique characteristics, such as a spoil area, fish haven, or dumping ground.
Areas designated as "foul ground" are often the result of previous activities, such as being a historical dumping site for waste, old construction materials, or other refuse.

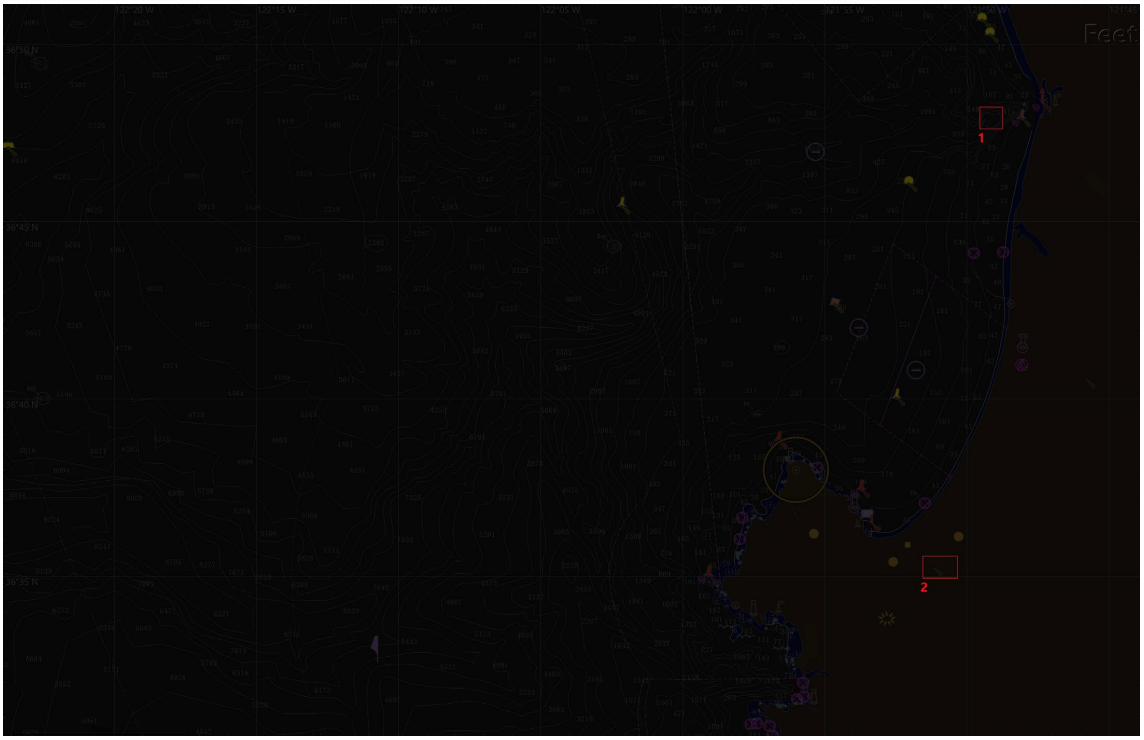
GPT-4o: C **× Knowledge Error**
Based on the context provided and the positioning of bbox1 in the chart, C. A dredged area with maintained depths is the most likely answer. Bbox1 appears to highlight a region near the shore where depths are carefully managed for navigation purposes, often characteristic of dredged areas in nautical charts.

Qwen3-VL-235B-Instruct: C **× Visual Perception Error**
Based on the provided nautical chart, let's analyze the area marked as bbox1.
The area in question is located near the coastline, adjacent to a harbor or port entrance. The key visual cues are: Contour Lines: The contour lines (isobaths) in this area are very close together and form a distinct, somewhat circular or oval shape with a central depression. This indicates a significant change in depth over a small area. Depth Values: The numbers on the contour lines show depths decreasing from around 149 feet outside the feature to much shallower depths inside it (e.g., 83, 71, 53, 42, 29 feet). The shallowest point appears to be around 29 feet.
Therefore, the most likely identification for the area in bbox1 is: C. A dredged area with maintained depths

Figure 17. A sample case of **Polygon Feature Understanding** (Dusk Mode).

Polygon Feature Understanding

ENC_id: US3CA52M	Lighting Modes: Night	Scale Levels: 1:100k	Resolution: 3848×2475



Question: What is the area bbox1 most likely to be?
A. A cable protection zone
B. A dumping ground with historical survey data
C. A dredged area with maintained depths
D. An obstruction with unknown depth

Answer: B

Gemini-2.5-pro: D **× Reasoning Error**
Based on the symbols shown on the nautical chart, the area in bbox1 is most likely A. A cable protection zone. Here's a breakdown of the visual evidence that supports this conclusion: Dashed Magenta Line: The area is enclosed by a dashed magenta line. Dashed lines are commonly used to define the limits of areas like cable areas, restricted zones, or dumping grounds. Submarine Cable Symbol: To the right of bbox1, along the coastline, there is a wavy line with a lightning bolt or zigzag symbol, which indicates the presence of a submarine cable.

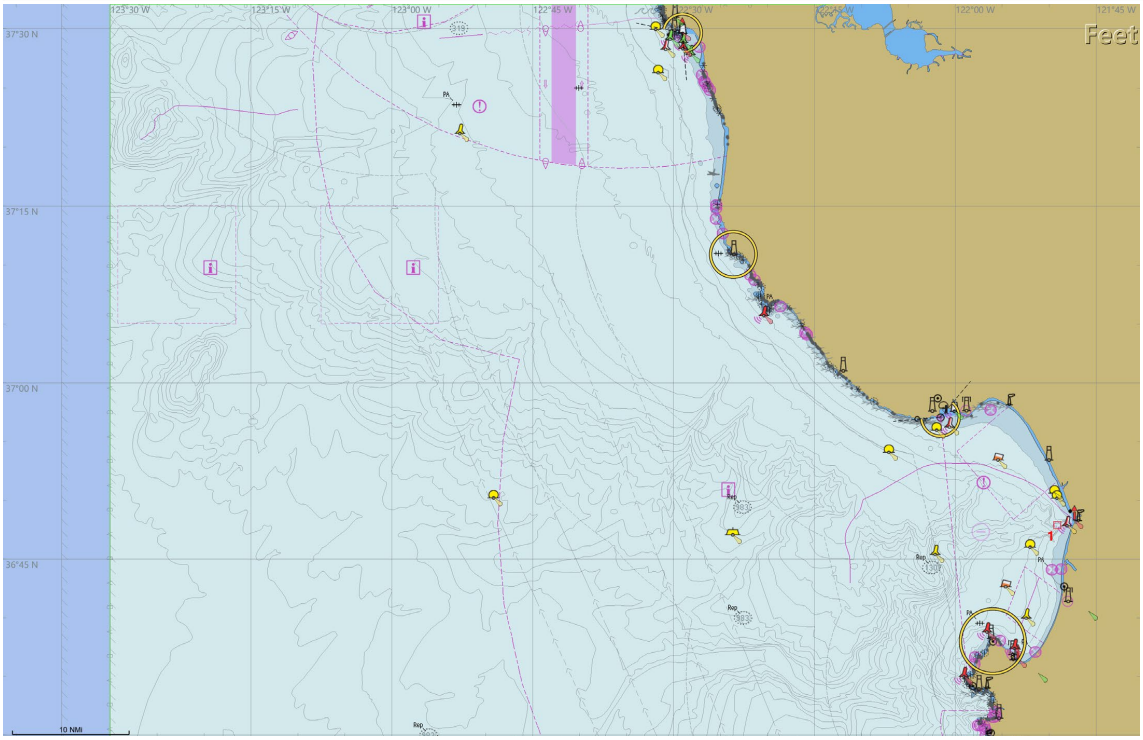
GPT-4o: C **× Visual Perception Error**
Based on the context of the chart and the rectangle labeled as "bbox1," the most likely option is: A
The area labeled "bbox1" is marked near the coast and contains characteristics commonly found in cable protection zones (such as areas marked for submarine cables, typically indicated with specific chart symbols).

Qwen3-VL-235B-Instruct: C **× Visual Perception Error**
Based on the provided nautical chart and the location of bbox1, the most likely identification is: C. A dredged area with maintained depths. Reasoning: Location: Bbox1 is situated in a coastal area, very close to what appears to be a harbor entrance or channel (indicated by the dense concentration of navigational aids, buoys, and controlled waterways nearby). Depth Contours: The depth soundings within and around bbox1 are relatively shallow and consistent (e.g., 42, 71, 83, 107, 149 feet), and the contour lines are smooth and regular — typical of areas that have been dredged to maintain safe navigation depths for vessels.

Figure 18. A sample case of **Polygon Feature Understanding** (Night Mode).

Polygon Feature Understanding

ENC_id: US3CA52M	Lighting Modes: Day	Scale Levels: 1:300k	Resolution: 3848×2475



Question: What is the area bbox1 most likely to be?
A. A cable protection zone
B. A dumping ground with historical survey data
C. A dredged area with maintained depths
D. An obstruction with unknown depth

Answer: B

Gemini-2.5-pro: D
The correct option is D. An obstruction with unknown depth. **× Visual Perception Error**
Here's a breakdown of the symbols within the highlighted area on the nautical chart that lead to this conclusion: Obstruction Symbol: The chart shows several plus-like symbols (+++). This is a common symbol used on nautical charts to indicate an obstruction. Obstructions are hazards to navigation that should be avoided. "PA" Abbreviation: The letters "PA" are visible, which stand for "Position Approximate." This notation indicates that the exact location of the charted feature has not been precisely determined.

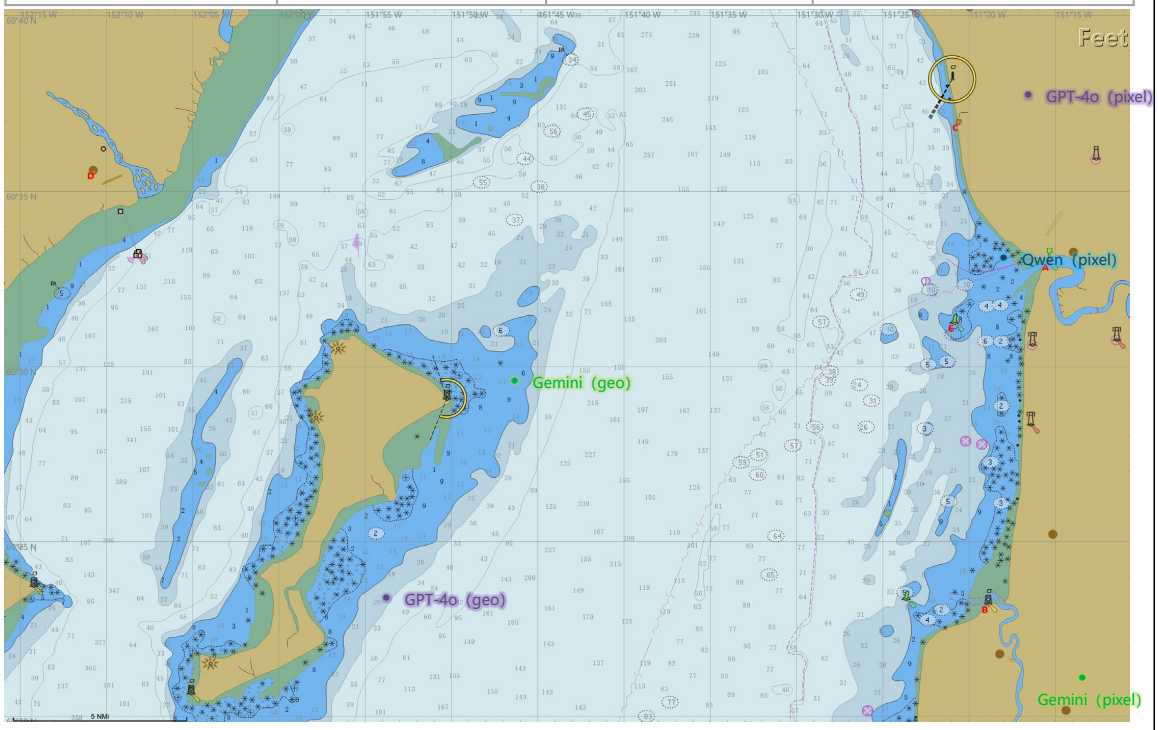
GPT-4o: C **× Visual Perception Error**
From the nautical chart provided, the area labeled as bbox1 shows features consistent with C. A dredged area with maintained depths. This is indicated by the detailed depth markings and contour lines within the area, which are commonly associated with such maintained zones for safe navigation.

Qwen3-VL-235B-Instruct: C **× Visual Perception Error**
Based on the nautical chart provided, bbox1 (the area highlighted by the yellow circle in the lower right) is located within a harbor or port entrance, characterized by: Dense concentration of navigational aids: Buoys (yellow and red), beacons, and light structures are clustered here, which is typical for a channel or fairway. Man-made structures: The presence of piers, docks, and possibly breakwaters suggests this is a developed port area.
Correct Answer: C. A dredged area with maintained depths

Figure 19. A sample case of **Polygon Feature Understanding** (Small Scale 1:300k).

Coordinate Localization - (Geo\Pixel)

ENC_id: US3AK1DM	Lighting Modes: Day	Scale Levels: 1:70k	Resolution: 3838×2429



Question (geo):
Find the longitude and latitude of point B on this nautical chart.
Respond with ONLY the coordinates in decimal degrees format: longitude, latitude.
Example: -152.085, 60.344

Answer: -151.315, 60.387

Question (pixel):
Identify the pixel coordinates (x, y) of point B in this 3838*2429 image.
Respond with ONLY the pixel coordinates: x, y
Example: 1867, 353

Answer: 3353, 2023

Gemini-2.5-pro: -151.775, 60.493(geo) \ 3649, 2288(pixel)

Error: 1789.0 px **Error: 397.3 px** ⭐

GPT-4o: -151.895, 60.391(geo) \ 3489, 322(pixel)

Error: 2044.2 px **Error: 1706.4 px**

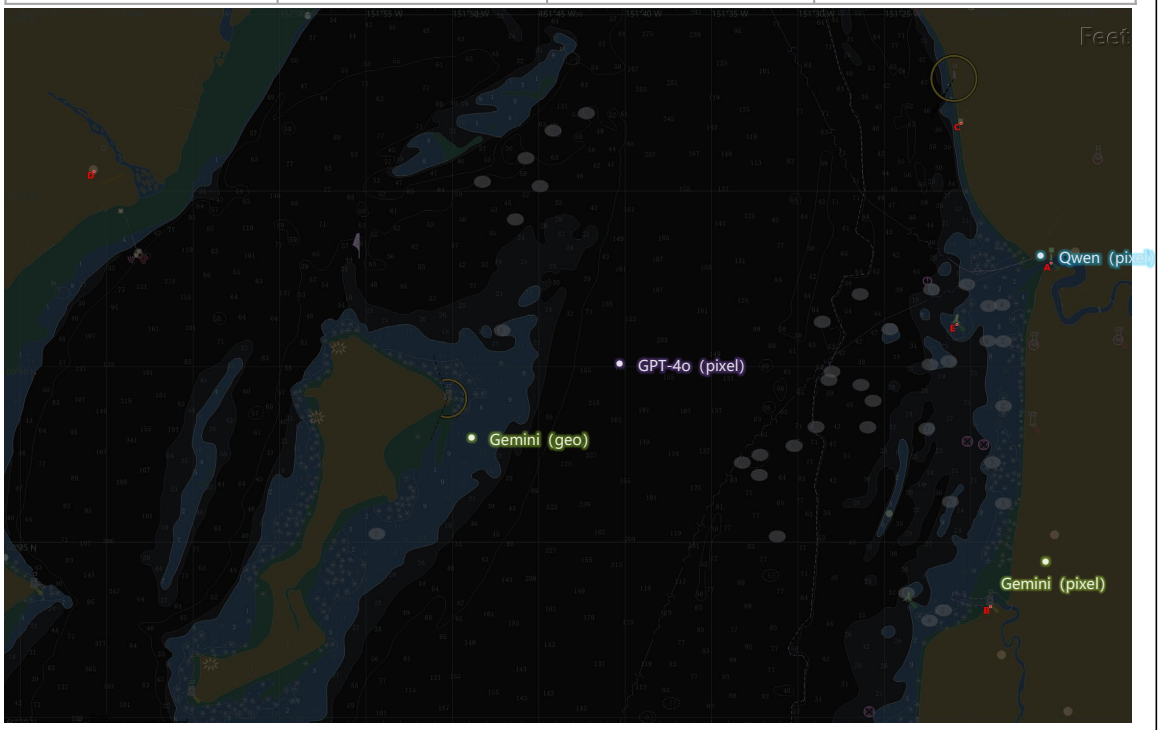
Qwen3-VL-235B-Instruct: -151.267, 60.283(geo) \ 3412, 837(pixel)

Error: 768.1 px **Error: 1187.5 px**

Figure 20. A sample case of **Coordinate Localization** (Day Mode). Comparison of Geographic vs. Pixel localization errors.

Coordinate Localization - (Geo\Pixel)

ENC_id: US3AK1DM	Lighting Modes: Dusk	Scale Levels: 1:70k	Resolution: 3838×2429



Question (geo):
Find the longitude and latitude of point B on this nautical chart.
Respond with ONLY the coordinates in decimal degrees format: longitude, latitude.
Example: -152.085, 60.344

Answer: -151.315, 60.387

Question (pixel):
Identify the pixel coordinates (x, y) of point B in this 3838*2429 image.
Respond with ONLY the pixel coordinates: x, y
Example: 1867, 353

Answer: 3353, 2023

Gemini-2.5-pro: -151.816, 60.464(geo) \ 3552, 1864(pixel)

Error: 1848.4 px **Error: 254.7 px** ⭐

GPT-4o: -151.953, 60.039(geo) \ 2094, 1210(pixel)

Error: 3360.6 px **Error: 1498.7 px**

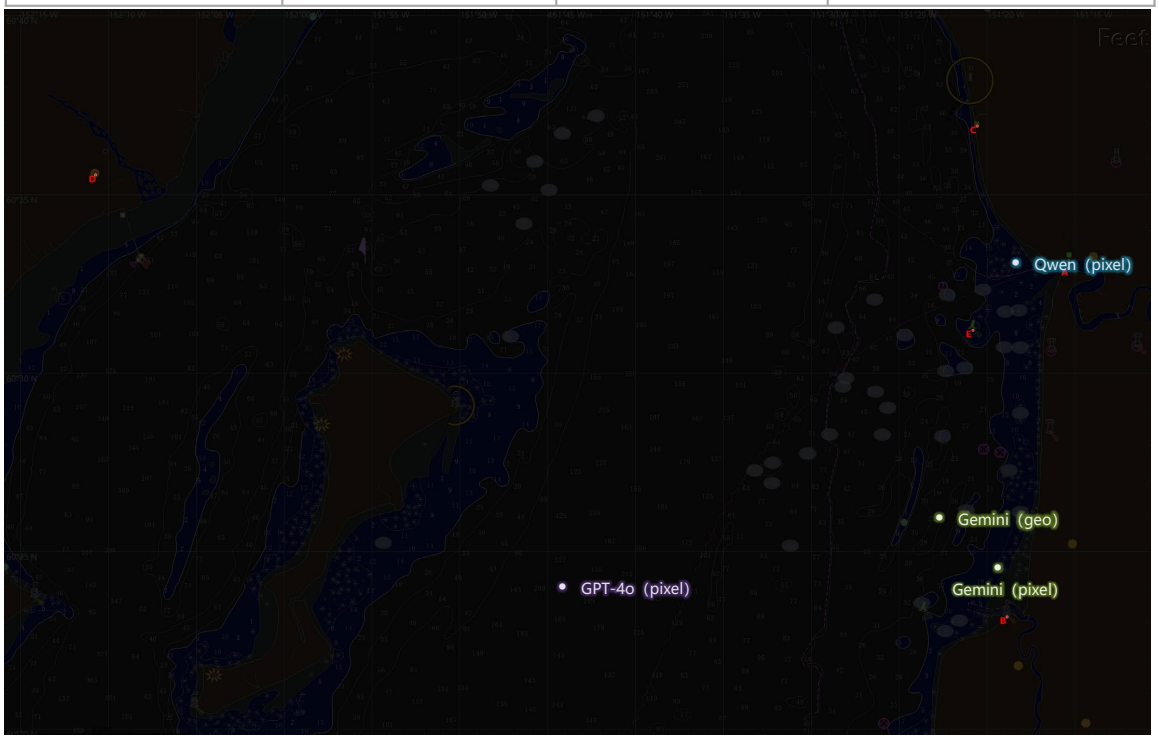
Qwen3-VL-235B-Instruct: -151.238, 60.275(geo) \ 3528, 837(pixel)

Error: 850.7 px **Error: 1198.8 px**

Figure 21. A sample case of **Coordinate Localization** (Dusk Mode).

Coordinate Localization - (Geo\Pixel)

ENC_id: US3AK1DM	Lighting Modes: Night	Scale Levels: 1:70k	Resolution: 3838×2429



Question (geo):
Find the longitude and latitude of point B on this nautical chart.
Respond with ONLY the coordinates in decimal degrees format: longitude, latitude.
Example: -152.085, 60.344

Answer: -151.315, 60.387

Question (pixel):
Identify the pixel coordinates (x, y) of point B in this 3838*2429 image.
Respond with ONLY the pixel coordinates: x, y
Example: 1867, 353

Answer: 3353, 2023

Gemini-2.5-pro: -151.380, 60.432(geo) \ 3324, 1864(pixel)

Error: 393.5 px **Error: 161.6 px** ⭐

GPT-4o: -151.368, 60.285(geo) \ 1850, 1945(pixel)

Error: 757.2 px **Error: 1505.0 px**

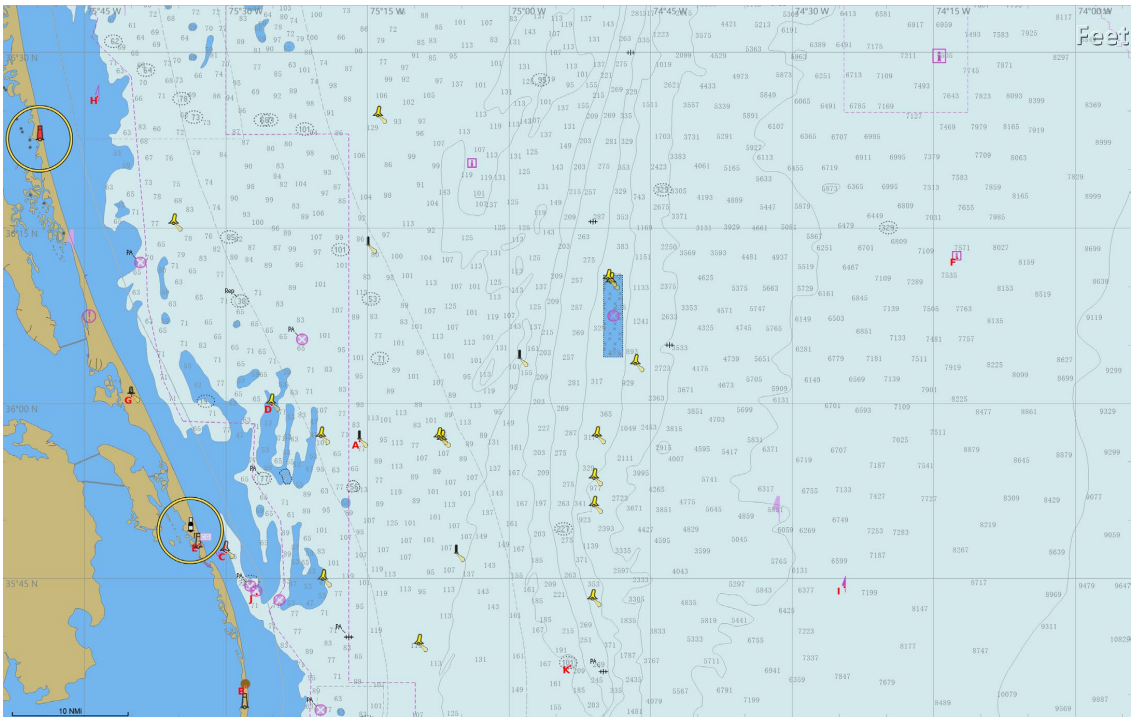
Qwen3-VL-235B-Instruct: -151.283, 60.233(geo) \ 3402, 836(pixel)

Error: 1112.8 px **Error: 1188.0 px**

Figure 22. A sample case of **Coordinate Localization** (Night Mode).

Bearing Calculation

ENC_id: US3DE01M	Lighting Modes: Day	Scale Levels: 1:300k	Resolution: 3598×2269



Question:
What is the compass direction from point K to point B on this chart? Express your answer as a bearing in degrees (0-360°, where 0° is North, 90° is East, 180° is South, 270° is West).

Answer: 267.0°

Gemini-2.5-pro: × **Calculation Error: 32°**
Based on the provided nautical chart, the compass direction from point K to point B is approximately 299°.

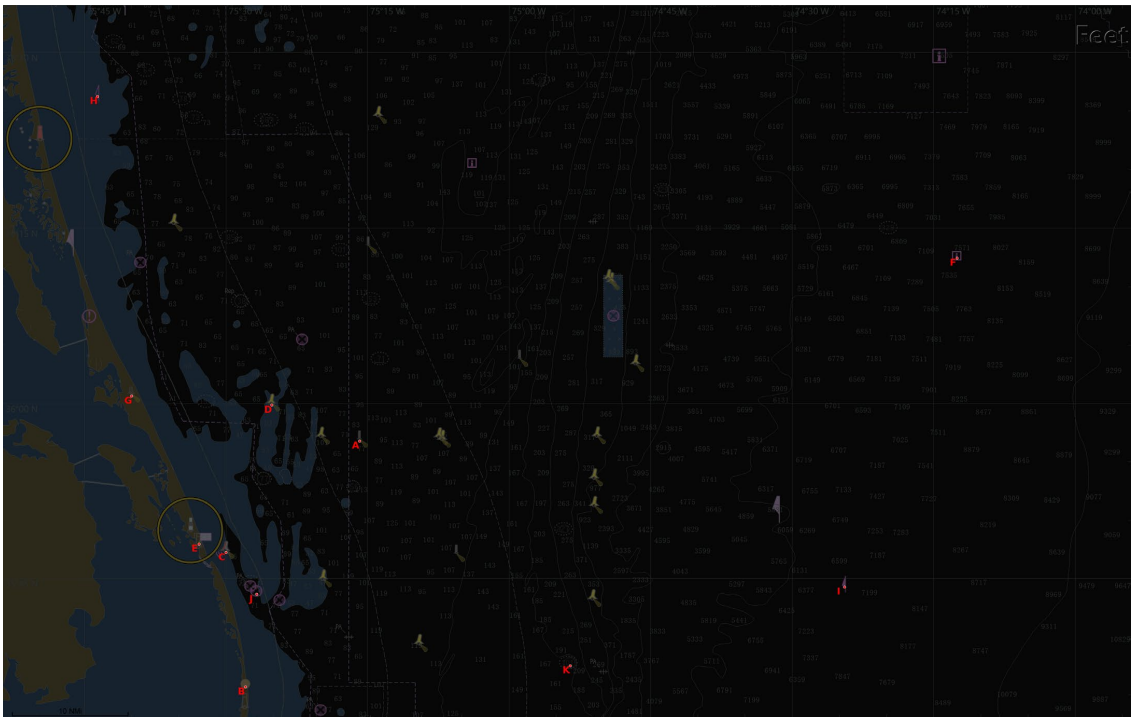
GPT-4o: × **Calculation Error: 51°**
The compass bearing from Point K to Point B is approximately 318°.

Qwen3-VL-235B-Instruct:
To determine the compass direction (bearing) from point K to point B, we need to:
Locate Point K: It is marked with a red "K" near the bottom center of the chart, just off the coast, around latitude 35° 45' N and longitude 75° 00' W.
Locate Point B: It is marked with a red "B" at the very bottom left corner of the chart, on the coastline, around latitude 35° 30' N and longitude 75° 15' W. × **Calculation Error: -42°**
Given the approximate equal distances south and west, the bearing is very close to 225°.

Figure 23. A sample case of **Bearing Calculation** (Day Mode).

Bearing Calculation

ENC_id: US3DE01M	Lighting Modes: Dusk	Scale Levels: 1:300k	Resolution: 3598×2269



Question:
What is the compass direction from point K to point B on this chart? Express your answer as a bearing in degrees (0-360°, where 0° is North, 90° is East, 180° is South, 270° is West).

Answer: 267.0°

Gemini-2.5-pro: × **Calculation Error: -16°**
Based on a detailed analysis of the nautical chart, the compass direction from point K to point B is approximately 251 degrees. This bearing represents the true course, calculated by determining the approximate latitude and longitude of points K and B from the chart's grid lines and then applying navigational calculations for a rhumb line (a line of constant compass bearing).

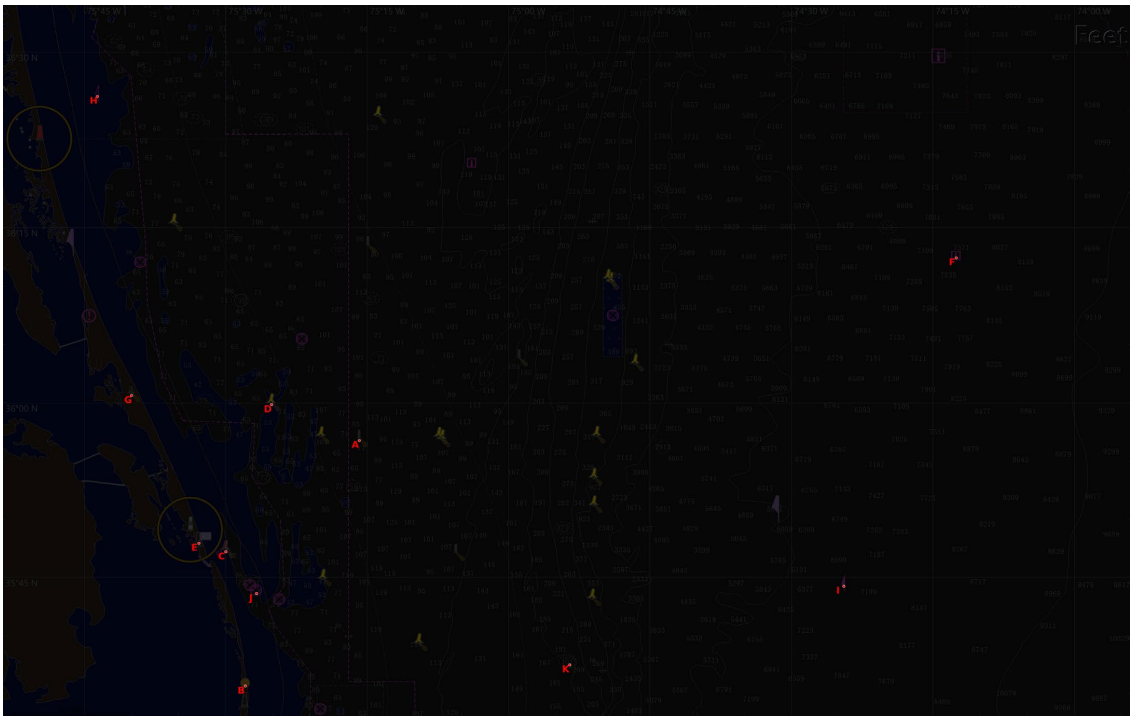
GPT-4o:
Locate Point K and Point B: K is located in the bottom-right quadrant of the chart (southeast). B is located in the middle-left portion of the chart (west-central). Draw an Imaginary Line: Draw a straight line from K to B. Visually, the direction from K to B trends northwestward.
Estimated Bearing: ~310° × **Calculation Error: 43°**

Qwen3-VL-235B-Instruct:
To determine the compass bearing from point K to point B, we need to analyze their relative positions on the nautical chart.
Given that B is nearly due south of K, but slightly west, the bearing should be slightly more than 180°.
Final Answer: 189° × **Reasoning Error**

Figure 24. A sample case of **Bearing Calculation** (Dusk Mode).

Bearing Calculation

ENC_id: US3DE01M	Lighting Modes: Night	Scale Levels: 1:300k	Resolution: 3598×2269



Question:
What is the compass direction from point K to point B on this chart? Express your answer as a bearing in degrees (0-360°, where 0° is North, 90° is East, 180° is South, 270° is West).

Answer: 267.0°

Gemini-2.5-pro: **× Calculation Error: 26°**
Based on a detailed analysis of the nautical chart, the compass direction from point K to point B is approximately 293° True (T).

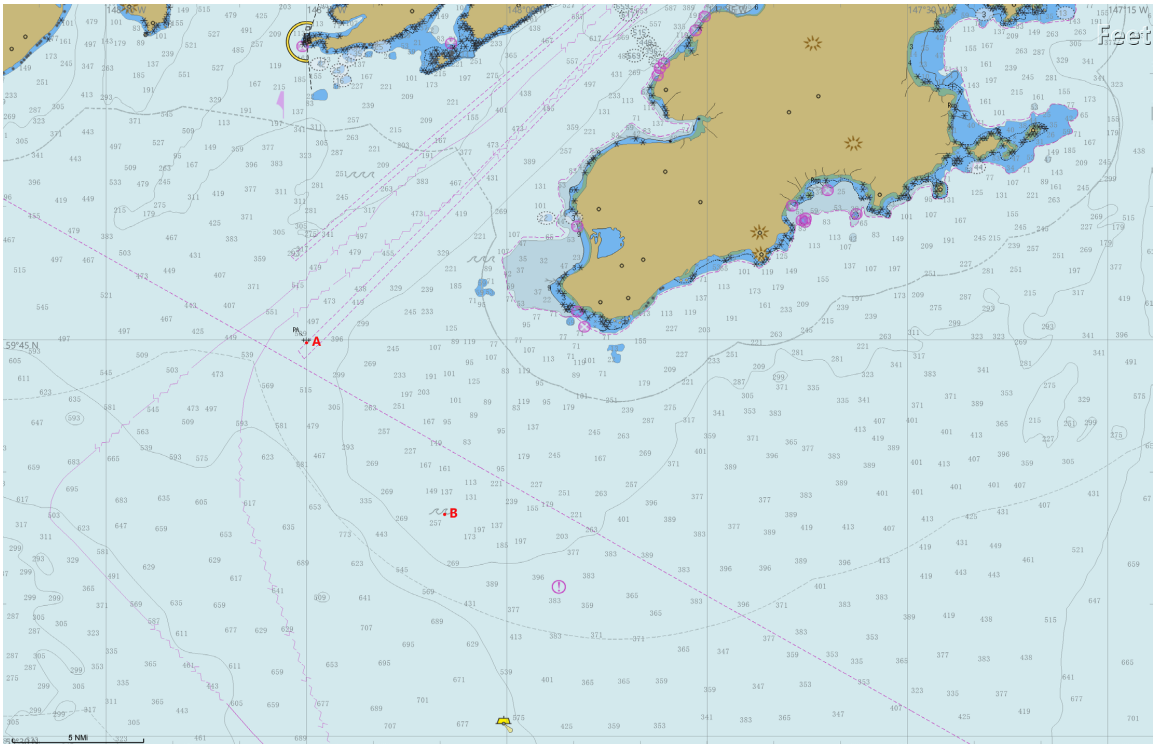
GPT-4o: **× Calculation Error: -35°**
Point K is around 35° 45'N, 75° 00'W, and point B is near 35° 30'N, 75° 30'W. Moving from K to B means heading southwest. Using the bearing formula, the compass direction is approximately 232°, measured clockwise from true north.

Qwen3-VL-235B-Instruct: **× Reasoning Error**
Point B is nearly directly south of Point K on the chart. The bearing from K to B is approximately 180°, as they lie almost on the same longitude line with minimal westward deviation. Visual inspection confirms a due-south direction. No precise tools are available, but the alignment strongly supports 180°.

Figure 25. A sample case of **Bearing Calculation** (Night Mode).

Distance Measurement

ENC_id: US3AK2HM	Lighting Modes: Day	Scale Levels: 1:130k	Resolution: 3598×2314



Question:
Using the scale indicator on this chart, determine the distance between point A and point B.

Answer: 8.3 NMi

Gemini-2.5-pro:
The distance between point A and point B is approximately 12.2 nautical miles. **× Calculation Error: 47.0%**
This is calculated using the chart's scale bar in the bottom-left corner, which indicates that a specific length represents 5 nautical miles (NMi). By measuring the straight line between A and B and comparing it to this scale, the distance is found to be about 2.44 times the length of the 5 NMi reference bar. Multiplying 2.44 by 5 results in a total distance of 12.2 nautical miles, a standard unit for maritime navigation..

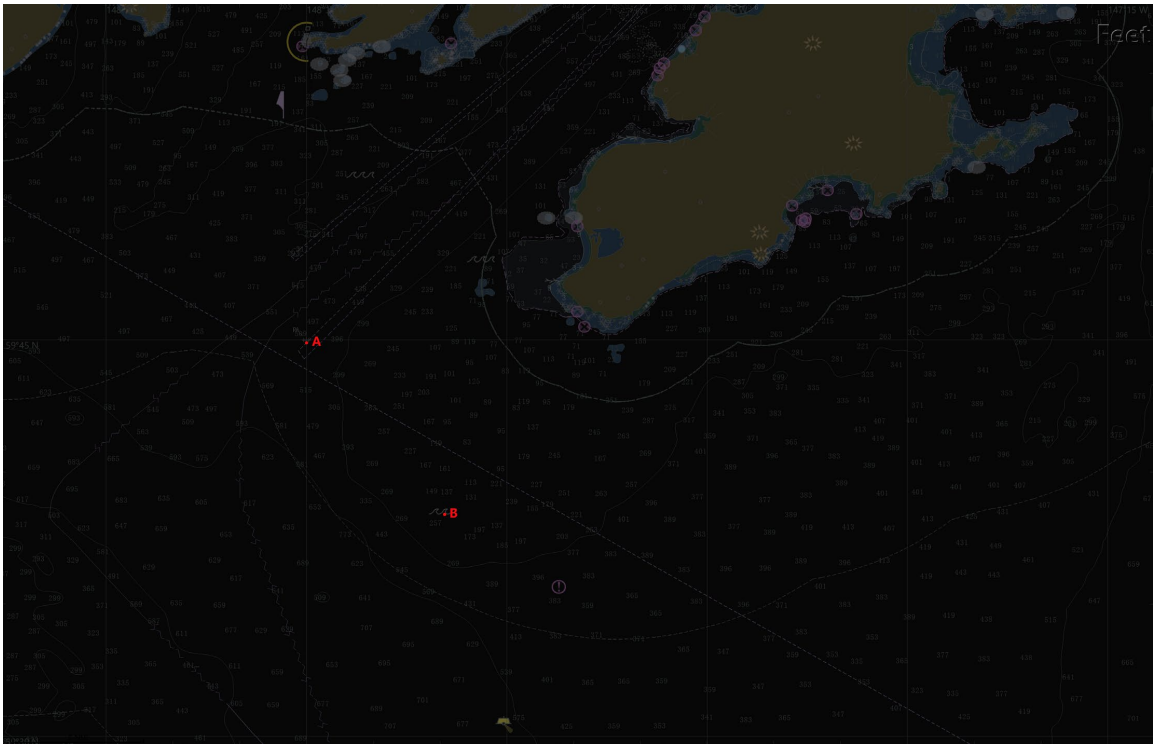
GPT-4o: **× Calculation Error: 33.7%**
To determine the distance between point A and point B using the scale indicator on the chart:
The indicator shows the scale 5 nautical miles (NM). Comparing the distance between A and B visually with the scale marker, the approximate distance is 5.5 NM.

Qwen3-VL-235B-Instruct:
Using the 5 NMi scale bar in the chart's bottom-left, measure the distance between points A and B. The straight-line distance spans about 4.5 segments of the 1 NMi divisions. Therefore, the distance is approximately 4.5 Nautical Miles. **× Calculation Error: 44.6%**

Figure 26. A sample case of **Distance Measurement** (Day Mode).

Distance Measurement

ENC_id: US3AK2HM	Lighting Modes: Dusk	Scale Levels: 1:130k	Resolution: 3598×2314



Question:
Using the scale indicator on this chart, determine the distance between point A and point B.

Answer: 8.3 NMi

Gemini-2.5-pro: × **Calculation Error: 9.6%**
Based on the chart's scale indicator, the distance between point A and point B is approximately 7.5 nautical miles. This was determined by locating the scale bar in the bottom-left corner, which represents 5 nautical miles (NMi). By visually comparing the distance between A and B to this scale, it is roughly one and a half times the length of the bar. Therefore, multiplying 1.5 by 5 NMi gives an estimated distance of 7.5 nautical miles.

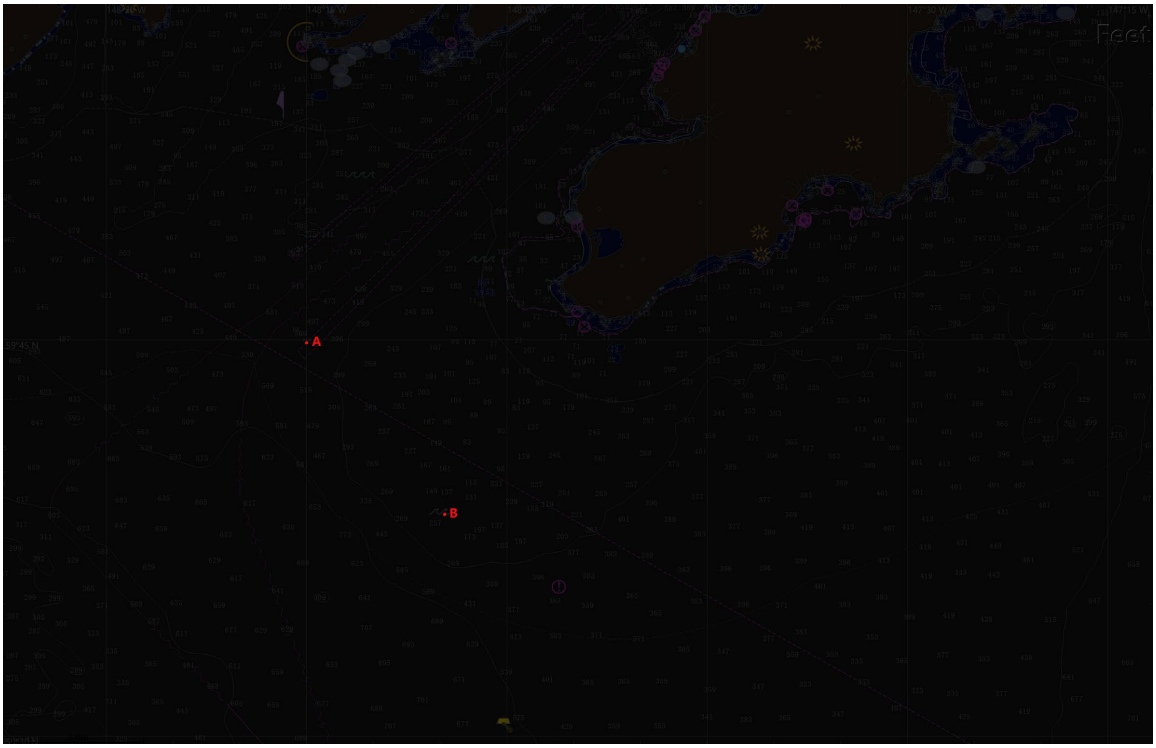
GPT-4o: × **Calculation Error: 21.7%**
Using the scale indicator at the bottom left of the chart (5 nautical miles), you can calculate the approximate distance between points A and B. Measure the straight-line distance between the two points using the scale, or compare visually—it appears to be slightly more than 5 nautical miles, possibly around 6.5 nautical miles.

Qwen3-VL-235B-Instruct:
Using the 5 NMI scale bar in the chart's bottom-left corner, the distance between points A and B is visually about twice the bar's length. Therefore, the distance is approximately 10 Nautical Miles. This is a direct visual estimation based on the provided scale indicator.
× **Calculation Error: 20.5%**

Figure 27. A sample case of **Distance Measurement** (Dusk Mode).

Distance Measurement

ENC_id:	US3AK2HM	Lighting Modes:	Night	Scale Levels:	1:130k	Resolution:	3598×2314



Question:
Using the scale indicator on this chart, determine the distance between point A and point B.

Answer: 8.3 NMi

Gemini-2.5-pro:
Based on the chart's scale, the distance between point A and point B is approximately 7.1 nautical miles.
This was calculated by using the 5 nautical mile (NMi) scale bar at the bottom of the image as a reference. The straight-line distance between A and B measures roughly 1.42 times the length of that scale bar. By multiplying 1.42 by 5 NMi, we arrive at the total estimated distance of 7.1 nautical miles. **× Calculation Error: 14.5%**

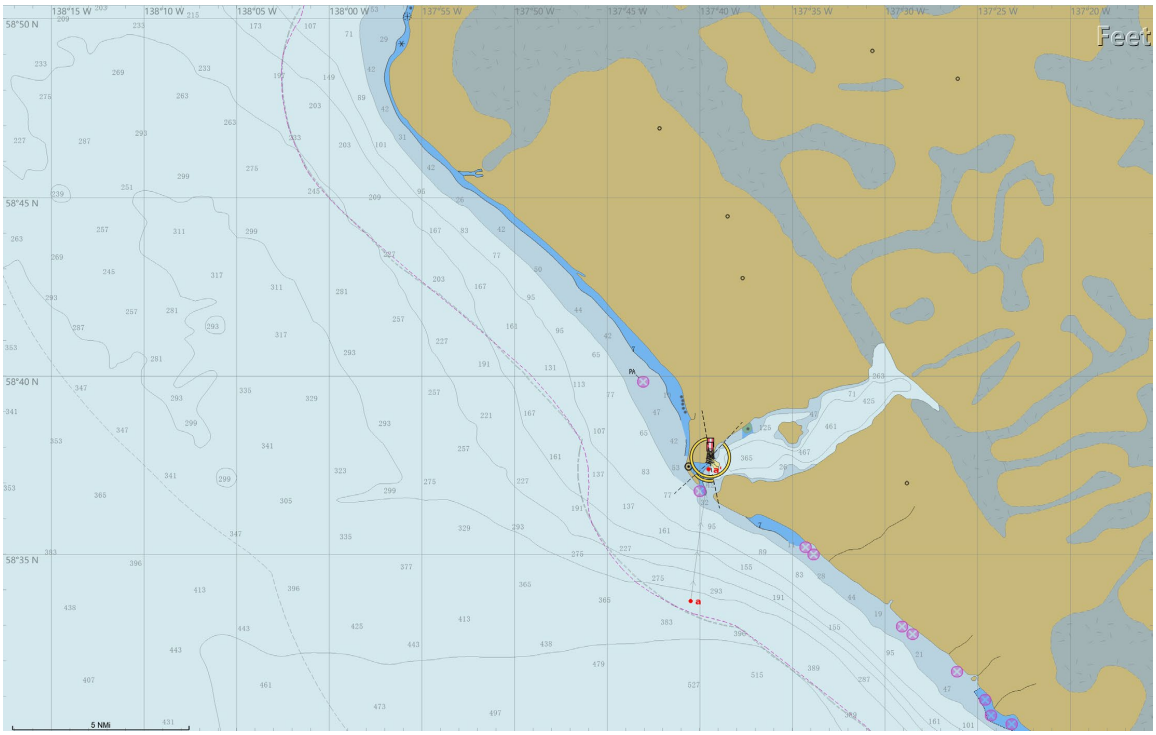
GPT-4o: **× Calculation Error: 3.8%**
Based on the scale bar in the chart (5 nautical miles as the reference), the approximate distance between point A and point B appears to be about 8 nautical miles.

Qwen3-VL-235B-Instruct:
Using the 5 NM scale bar in the chart's bottom-left corner, measure the distance between points A and B. The straight-line distance is roughly 1.5 times the scale bar's length. Thus, the distance is approximately 7.5 nautical miles. This estimation is based on visual comparison with the provided scale. **× Calculation Error: 9.6%**

Figure 28. A sample case of **Distance Measurement** (Night Mode).

Track Direction Recognition

ENC_id:	US3AK38M	Lighting Modes:	Day	Scale Levels:	1:100k	Resolution:	3598×2269



Question: In the navigable area shown in the chart, what direction should the vessel maintain?
A. Navigation is not possible in the area shown
B. From point a' to point a
C. From point a to point a

Answer: C

Gemini-2.5-pro: B
× Visual Perception Error
Based on the nautical chart provided, the correct direction for a vessel to maintain is from point a' to point a.
The key indicator for the recommended direction of travel is the magenta arrow located between points a' and a. On nautical charts, such an arrow is used to show the established or recommended direction of traffic flow. In this case, the arrow clearly points from the narrower channel at point a' towards the more open water at point a. This indicates that the intended route proceeds outwards from the inlet.

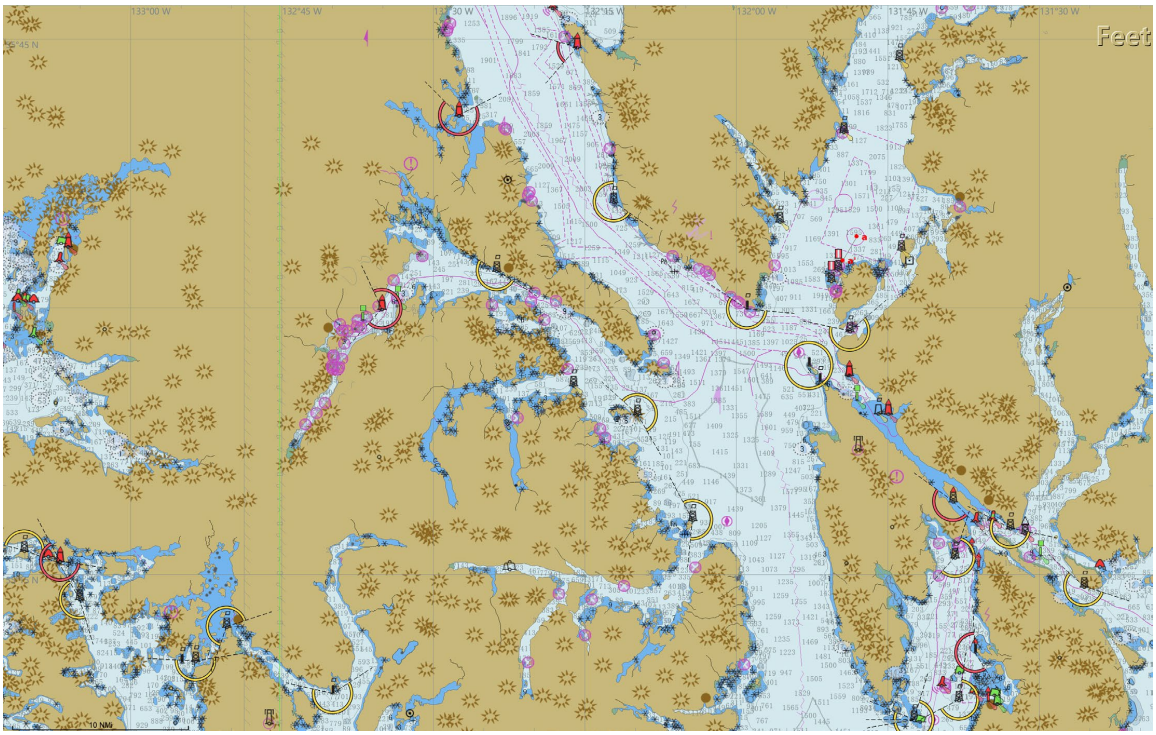
GPT-4o: B
× Visual Perception Error
Based on the chart, navigation is possible in the shown area from point a' to point a, ensuring the vessel follows the navigable blue channel marked on the chart to avoid shallow and non-navigable areas.

Qwen3-VL-235B-Instruct: B
Vessels should navigate from point a' to point a. The blue line marks the deep, safe channel. Point a' (with yellow circle) is near the channel's entrance; point a is further downstream. Depth soundings confirm deeper water along this route. Avoid pink "X" hazards. This direction follows the natural flow from open water into the constricted area, as standard for nautical charts.
× Reasoning Error

Figure 29. A sample case of **Track Direction Recognition** (Large Scale). Determining legal traffic flow direction.

Track Direction Recognition

ENC_id: US3AK42M	Lighting Modes: Day	Scale Levels: 1:200k	Resolution: 3598×2269



Question: In the navigable area shown in the chart, what direction should the vessel maintain?
A. Navigation is not possible in the area shown
B. From point a' to point a
C. From point a to point a

Answer: C

Gemini-2.5-pro: × **Instruction Following Error**
This nautical chart displays a Traffic Separation Scheme (TSS), marked by magenta lines and arrows. A TSS manages maritime traffic to prevent collisions. The large magenta arrows indicate the mandatory direction of travel within designated lanes. The chart details, such as depth soundings and buoys, confirm the area is navigable. Therefore, a vessel must follow the course indicated by these arrows, proceeding in the specified direction. Following this established route ensures safe passage.

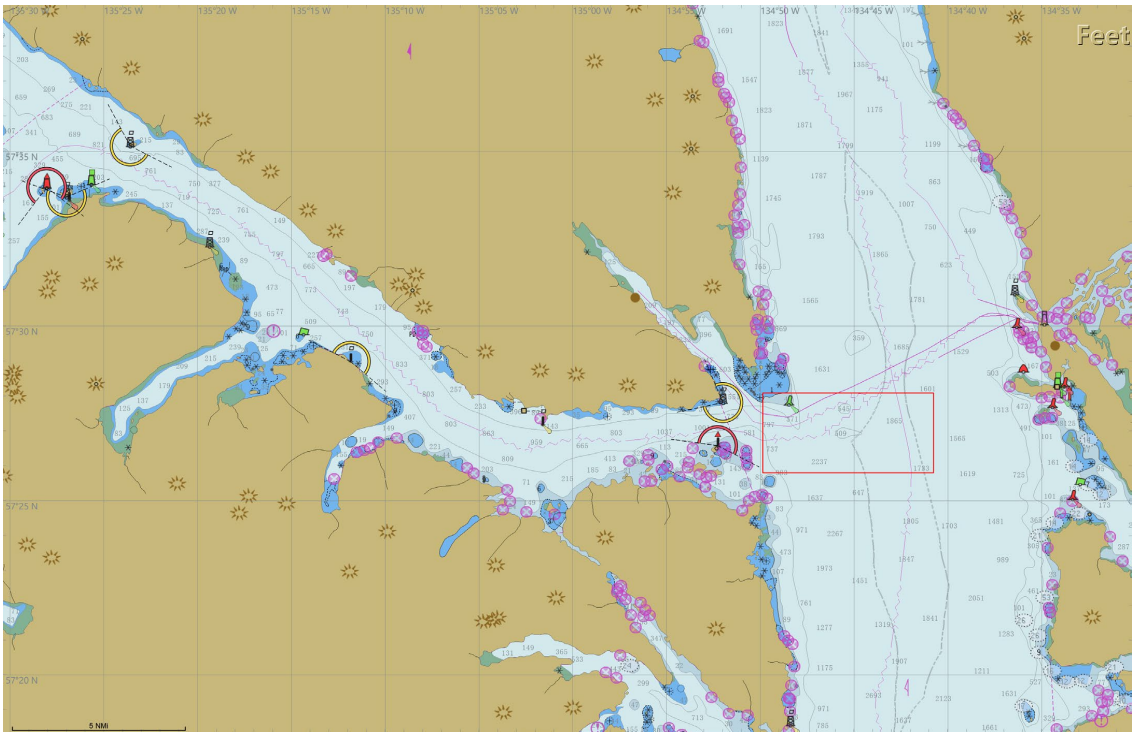
GPT-4o: × **Visual Perception Error**
The specific locations of point a and point a' are not clearly identified in this image, making it difficult to ascertain proper vessel direction without additional details.

Qwen3-VL-235B-Instruct: B × **Visual Perception Error**
The vessel should proceed from point a' to point a. The pink dashed line indicates the recommended channel route. Point 'a" (lower) is upstream/entrance; point 'a' (upper) is downstream/exit. Buoy placement follows IALA Region A: red buoys mark starboard side when returning from sea, confirming direction from lower to upper point along the channel.

Figure 30. A sample case of **Track Direction Recognition** (Small Scale).

Safety Passage Assessment

ENC_id: US3AK3BM	Lighting Modes: Day	Scale Levels: 1:100k	Resolution: 3598×2314



Question: A vessel with a maximum draft of 30 feet can safely proceed through the red-bounded area.
This is a True/False question.

Answer: False

Gemini-2.5-pro: True **× Visual Perception Error**
The numbers on the nautical chart represent water depth. According to the top-right corner of the full image, these depths are measured in feet. Within the red-bounded area, the charted soundings include depths like 409, 597, 647, and 737 feet. All of these recorded depths are significantly deeper than the vessel's 30-foot maximum draft. This provides a substantial margin of safety, confirming the vessel can proceed through the area without risk of grounding.

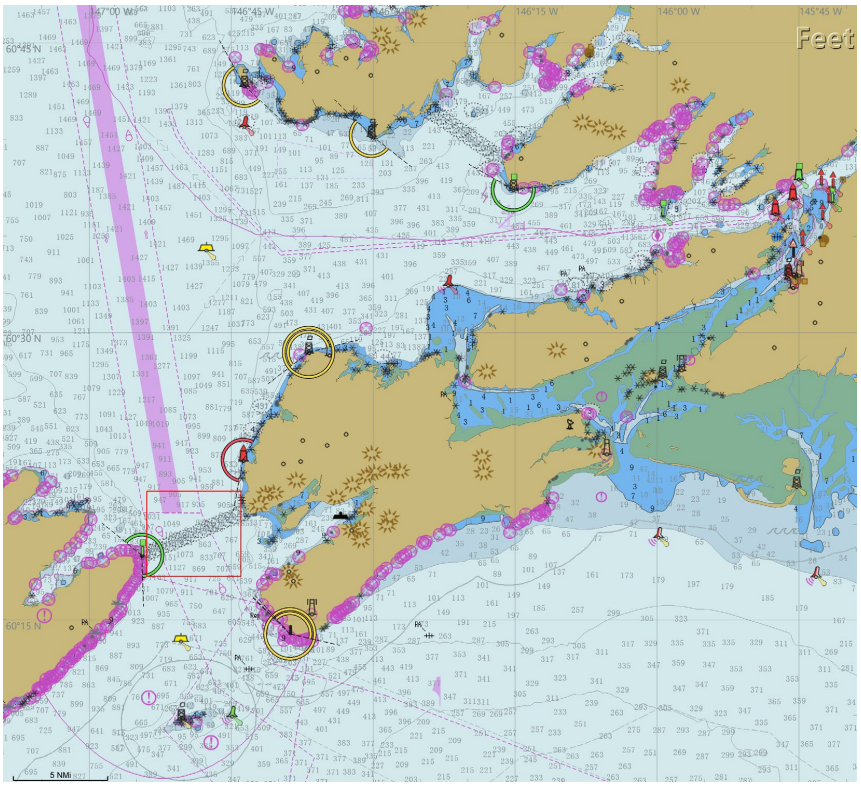
GPT-4o: True **× Reasoning Error**
The charted depths within the red-bounded area are well over 30 feet (indicated by soundings such as 2237 feet and 1865 feet), providing a safe passage for a vessel with a maximum draft of 30 feet.

Qwen3-VL-235B-Instruct: False **× Visual Perception Error**
The red-bounded area on the nautical chart contains depth soundings that are less than 30 feet. For example, within the box, you can see numbers like 17, 21, 69, and 101 — these represent depths in feet. A vessel with a maximum draft of 30 feet requires at least 30 feet of water to safely proceed. Since parts of the red-bounded area have depths as shallow as 17 feet, it is not safe for such a vessel to proceed through that area. Therefore, the statement is False.

Figure 31. A sample case of **Safety Passage Assessment**. Evaluating depth constraints for a vessel draft.

Safety Passage Assessment

ENC_id: US3AK21M	Lighting Modes: Day	Scale Levels: 1:200k	Resolution: 2479×2254



Question: A vessel with a maximum draft of 30 feet can safely proceed through the red-bounded area.
This is a True/False question.

Answer: True

Gemini-2.5-pro: True × **Visual Perception Error**

The numbers within the red-bounded area on the nautical chart, such as 917 and 935, represent water depths in feet. With charted depths of over 900 feet, there is more than sufficient clearance for a vessel with a 30-foot draft. The area is also clear of any marked navigational hazards, such as rocks or wrecks, that would pose a threat. Therefore, the vessel can safely proceed through the designated area.

GPT-4o: False × **Visual Perception Error**

In the red-bounded area, the charted depths include areas shallower than 30 feet. Proceeding through this area with a vessel that has a draft of 30 feet could pose safety risks.

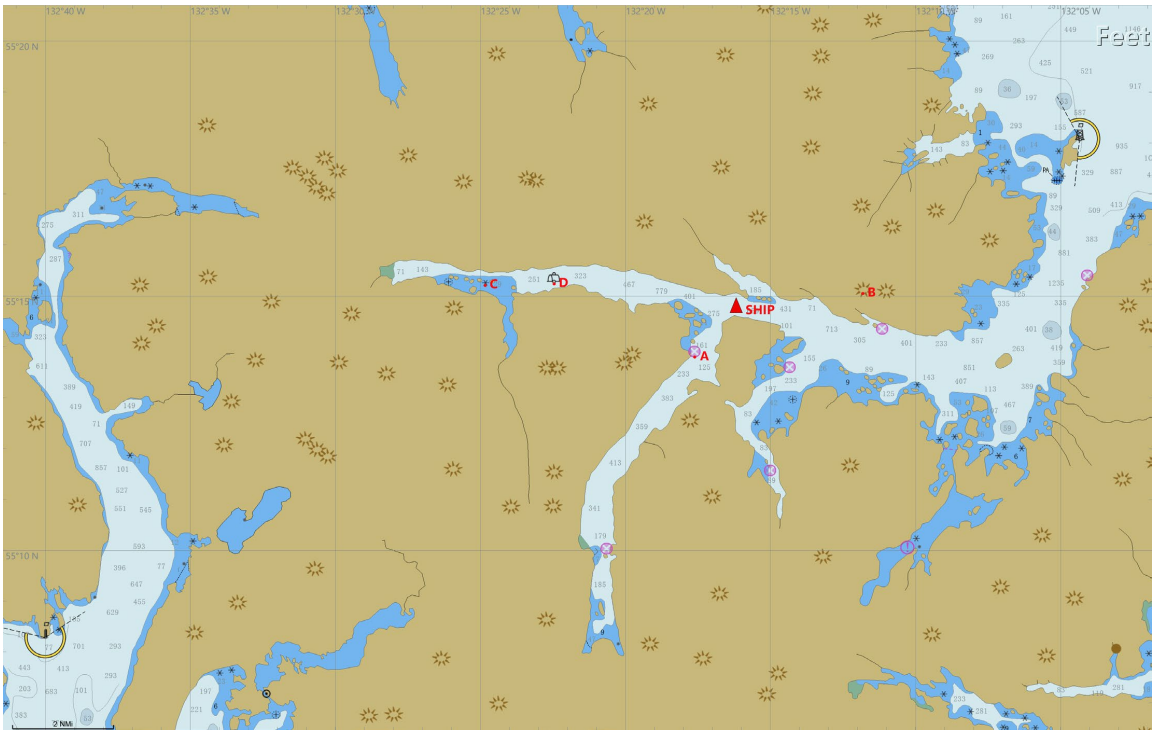
Qwen3-VL-235B-Instruct: False × **Visual Perception Error**

The red-bounded area contains depths as shallow as 17 feet, shown by soundings inside the box. A vessel with a 30-foot draft requires at least 30 feet of water to navigate safely. Since the area's depths are far less than 30 feet, the vessel cannot proceed through it without risk of grounding. Thus, the statement is false.

Figure 32. A sample case of **Safety Passage Assessment** (Small Scale).

Anchorage Selection

ENC_id: US3AK42M	Lighting Modes: Day	Scale Levels: 1:70k	Resolution: 3598×2314



Question: A vessel has a failure at the red triangle location in the chart. Based on the chart information, where is the nearest mooring facility? (The options are marked with letters A, B, C, D on the chart.)

Answer: D

Gemini-2.5-pro: A × Visual Perception Error

Based on the provided nautical chart, the nearest mooring facility to the vessel's location (the red triangle) is A.
On a nautical chart, the anchor symbol represents a designated anchorage area, which is a type of mooring facility.
Both locations A and D are marked with this anchor symbol, indicating they are suitable for a mooring facility.
By visually comparing the distances on the chart, it is clear that location A is significantly closer to the ship's position than location D.

GPT-4o: A × Reasoning Error

Based on the chart and the location of the vessel at the red triangle marker, the nearest mooring facility is A.

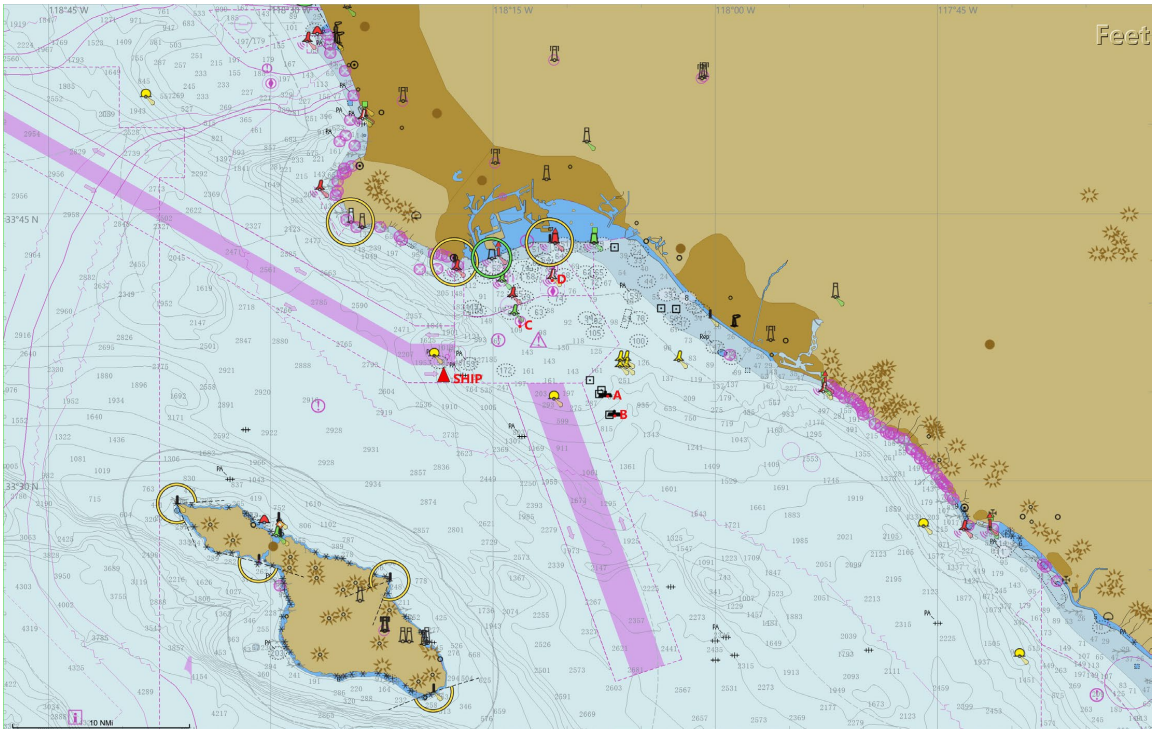
Qwen3-VL-235B-Instruct: A

The vessel is at the red triangle. Among options A, B, C, D: × Visual Perception Error
A shows an anchor/mooring symbol in a protected cove — clearly a mooring facility. B is on land — not usable.
C has a cross symbol — likely a wreck or obstruction. D shows a bell buoy — a navigational aid, not for mooring.
Visually, A is also the closest to the vessel's position. Therefore, A is the nearest and only valid mooring facility among the choices.

Figure 33. A sample case of **Anchorage Selection**. Choosing the nearest valid anchorage in an emergency.

Anchorage Selection

ENC_id: US3CA70M	Lighting Modes: Day	Scale Levels: 1:200k	Resolution: 3924×2475



Question: A vessel has a failure at the red triangle location in the chart. Based on the chart information, where is the nearest mooring facility? (The options are marked with letters A, B, C, D on the chart.)

Answer: A

Gemini-2.5-pro: B × Visual Perception Error

Based on the provided nautical chart, the nearest mooring facility to the vessel's location is B.
The vessel is at the red triangle marked "SHIP". Locations A and B are indicated by yellow special-purpose buoys. On nautical charts, these buoys often designate mooring areas, anchorages, or other features requiring special attention. Location C is a red and white vertically striped buoy, which is a "Safe Water Mark." This buoy signifies that there is open, navigable water around it and is used for navigation, not for mooring. × Reasoning Error
By visually assessing the chart, it is clear that mooring buoy B is the closest available facility to the ship's position at the red triangle.

GPT-4o: C × Reasoning Error

Based on the chart and the location of the red triangle, the nearest mooring facility is the one labeled C.

Qwen3-VL-235B-Instruct: D × Visual Perception Error

The vessel is at the red triangle. Of options A, B, C, D, only D is a true mooring facility — located in a sheltered harbor with docks and piers. A and B are offshore platforms, not for general mooring. C is a buoy, not a facility. Visually, D is also the closest suitable location to the vessel's position. Thus, D is both the nearest and most appropriate mooring option. × Knowledge Error

Figure 34. A sample case of **Anchorage Selection** (Small Scale).